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GRADO EN INGENIERÍA EN TECNOLOGÍAS INDUSTRIALES

BACHELOR THESIS

PLANNING OF AN INFRASTRUCTURE PROJECT

CZECH TECHNICAL UNIVERSITY IN PRAGUE
MASARYK INSTITUTE OF ADVANCED STUDIES

AUTHOR: MIRIAM MEDINA OCAÑA

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PRAGUE, CZECH REPUBLIC

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[ES] Declaro, bajo mi responsabilidad, que el Proyecto presentado con el título

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PLANNING OF AN INFRASTRUCTURE PROJECT

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ABSTRACT

Introduction

The subject of the project is the study and insight into the management of a large infrastructure project. The bachelor thesis will consist of two parts: the theoretical and practical chapters. The subject of the theoretical part will be to introduce the issue of large infrastructure projects and the basis of project management, and it is the result of the research. The subject of the practical part will be the full study of the management of a real infrastructure project from practice, provided by Mott MacDonald.

Keywords: Project management, Infrastructure, Czech Republic.

Definition of the Project

In 2017, the Government of the Czech Republic approved the Programme for the Development of Fast Rail Connections. The state railway infrastructure administration, Správa Železnic (SŽ) oversees the process of construction of the new high-speed railway lines in the country. The strategic location of the Czech country in the middle of the continent is what makes it necessary for the European railway network to be upgraded in this area. An overview map of the project is represented in Figure 1.

After two years, the first sections turn into the preliminary design stage, with Praha-Běchovice – Poříčany section going first. This section is a main electrified triple-track line, heavily overutilized by older trains, long-distance services, and freight trains. It gets in contact with populated areas, and it runs through an environmentally sensitive forest near Prague. Therefore, the problem must be solved, and its capacity enhancement is unfeasible. The technical facts are listed in Table 1.

The most effective way to solve the capacity issue on the existing network is by the segregation of fast services from other businesses, shrinking travel times, and improving connection from major cities to regions.

Mott MacDonald is a technical advisor company that is part of the joint venture responsible for the project management of the Poříčany section.

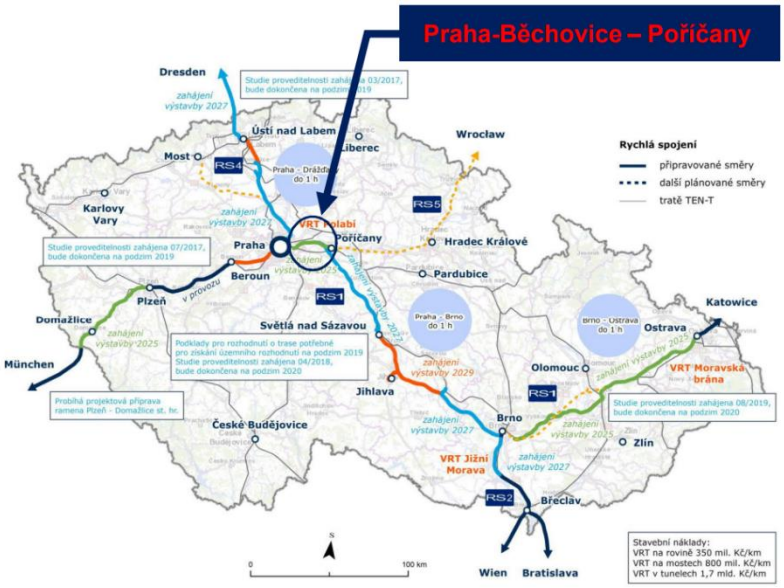

Figure 1: Map of the HSR in the Czech Republic (Praha (Běchovice) to Poříčany section).[1]

Parameter	Value
Operation	Passenger trains dedicated lines
Track arrangement	quadruple track line
Operational speed	200 – 320 km/h
Track design speed	350 km/h
Electrification	AC 25 kV 50 Hz (existing system DC 3 kV)
Signalling	ETCS/ERTMS L2
New high-speed line length	29 km
New conventional link length	16 km
New civil structures	3 tunnels, 18 rail bridges, 21 road bridges
New terminals	1 terminal
Infrastructure cost investment	CZK 27,400mil (GBP 930mil) in price level 2018 with 10% conting.

Table 1: HSR CZ (Praha (Běchovice) to Poříčany Section) Project Technical Facts. [2]

[1] Michal Babič (Mott MacDonald). *HIGH SPEED RAILWAY PROGRAMME IN THE CZECH REPUBLIC (HSR CZ) - Programme overview*. Unpublished confidential document; 2021.

[2] Mott MacDonald. *High Speed Railway in The Czech Republic Praha-Běchovice – Poříčany section (Bid Introduction).* Unpublished confidential document; 2020.

Methodology

The research and study of the methodology of infrastructure project management will be done following the guidelines of the PMBOK Guide.

Firstly, the theoretical chapter describes the planning phase, which is the first stage of a project. It also gives an extended definition of infrastructure projects and their special features, as well as provides the framework for managing them.
Choosing an effective team to work with is essential for the project's success. Therefore, the project manager and the project team are the engines of the process and orchestrate projects from the beginning to the end.
Stakeholders are those involved in the project in some way. Managing the project stakeholders is aimed at deciding the necessary roles that will take part in the organization, as well as their level of authority.
The planning stage continues with the project schedule. There are several methods to organize the necessary tasks and predict the length of the process in the most accurate way. Budgeting is a key part of the project plan, including the CAPEX and OPEX item calculation, as well as the life cycle cost calculation. Risk management includes an analysis that affects the feasibility of the project, and the level of risk tolerance determines the acceptance of the project.
Finally, when all these planning elements are gathered, the project definition is complete. The tendering process begins and the funding decisions are made. Public-Private Partnership (PPP) is a usual way of financing infrastructure projects.
Later, the most important task is managing and controlling the processes once the project has started, adapting to changes and threats while trying to stick to the initial plan.

Secondly, the practical part is aimed at studying and examining the HSR Project in the Czech Republic, with the help of the company Mott MacDonald. The guidelines to plan an infrastructure project are described in the real project, from the planning phase to the team management during the construction process. As a huge infrastructure project, managing it is a laborious process.

Motivation

Infrastructure project management is a great combination of the engineering and business management worlds. This study provides an insight into this field and helps to acquire valuable knowledge for a future job in the sector.

Working with a real company like Mott MacDonald contributes to acquiring a real sense of how big consultancies operate and the way in which they develop their projects. This consultancy is known for its sustainability and its social and environmental commitment. One of their main purposes is to consider social outcomes in all their projects, therefore improving society and providing this thesis with a social vision.

Lastly, among the initial goals was to bring together the Czech and Spanish cultures and learn how companies from both countries work, along with their differences and similarities. This also motivated the choice of a Czech Director of the thesis. The enrichment of studying at a foreign university is greater, not only by speaking and working in English but also by overcoming the social and performing differences between both cultures.

Conclusion

Infrastructure projects are those that contribute to the correct functioning of a country by the development and maintenance of services, facilities, and systems. Project management is aimed at achieving the project objectives within time and cost, facing risks, changes, and uncertainty. They have some features which make them really hard to manage, such as their risk, long duration, or multidisciplinary nature. Therefore, the general processes become laborious and they need great detail and precision. An effective project team with an appropriate project manager is key to the project's success.

Furthermore, cooperating with Mott MacDonald has been a great challenge, especially learning how large infrastructure projects are prepared and implemented with the participation of major international companies. Working with an international company and a director who is a professional in the field has contributed to the acquisition of a real sense of how big consultancies operate and the way in which they develop their projects while providing insight into the project management world. The enrichment of studying in a foreign university has been greater, not only by speaking and working in English but

also by overcoming the social and performing differences between the Czech and Spanish cultures.

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A. INFRASTRUCTURE PROJECTS MANAGEMENT

According to the Project Management Institute, "A project is a temporary endeavor undertaken to create a unique product, service, or result." (PMBOK, 2013).
Every project should always have a unique result, with its own characteristics and circumstances. Additionally, projects have a clear goal with defined starting and finishing dates. They entail the work of professionals from different fields in order to meet cost, resource, scheduling, and planning requirements.

Project managing is the application of knowledge to plan, coordinate and control people and resources. Its main goal is to achieve the project objectives within time and cost, facing risks, changes, and uncertainty. The PMBOK® Guide describes the methodology for the development of project management.

In this first section, infrastructure projects will be examined in-depth, as well as their management. The elements for the performing of the project and its procedure will also be described and analyzed.

1. Infrastructure projects

Infrastructure projects are those that contribute to the correct functioning of a country by the development and maintenance of services, facilities, and systems. The main designer is an engineer, who prepares a complete design before construction contracts are agreed upon. These include a wide range of projects from different sectors of the industry, and they contribute to the economic and social growth of the area where they are implemented. Their main goal is to take part in the development of regions by combining the work of the private and public sectors. They usually last extended periods, requiring large, multi-professional, and often international implementation teams.

The approval processes are very demanding and require high-quality risk analysis, advanced financial models, and extended contractual documentation. As a rule, they are accompanied by specific requirements in the areas of management of quality, environmental protection, material and energy sustainability, hygiene, safety at work, and

social responsibility. Therefore, they are very professionally demanding and not flexible. But at the same time, they rely on sufficient resources for advanced methods of their provision and management.

Nowadays, technological innovations make the planning and implementation processes easier. The great development of computer hardware and software, such as the CADD technology is useful in the design, engineering, and construction phases. The coordination and planning of activities are also influenced by technological evolution.

2. Types of infrastructure projects

There are several ways to classify infrastructure projects depending on their features. Firstly, taking a look at their size, they can be divided into small and large infrastructure projects. In this division, size is not only related to costs but also to range or reach.

Large projects need an extensive budget, organization, and duration, involving complex planning and expertise. When implementing megaprojects in a specific area, they contribute to its growth. Usually, these projects cost up to billions of CZK and they are based on complex multi-source funding concepts.

The main difference between small and large infrastructure projects is not only their budget but also their impact and duration. On one hand, big projects require higher financing and are also riskier, affecting a bigger sector of the population and making it harder to predict their outcome. Therefore, they can be more controversial than the small ones, resulting in delays and complications of timelines. On the other hand, once they are finished, their impact is also greater than smaller projects. The benefits they bring can be very positive, economically, and socially wise. They are transformative and can improve people's lives in many ways.

Secondly, depending on the field they are developed in, projects can be classified into eight different categories:

- Road and street infrastructure: the objective of this kind of project is not only to build new transiting routes but also to fix and repair the already-existing ones.

- Bridges: these infrastructure projects involve building and maintaining bridges, including the massive ones with daily heavy traffic on highways, which makes them even more complicated.

- Airports and airspace: the projects in this category oversee the construction and modernization of airplanes and airports. This is an essential part of a country's transportation system.

- Public transport: a well-made connection of the city is a crucial part of its infrastructure. The public transport network includes bus, metro, or tram lines among others. The main goal of these projects is to build and improve these connections keeping up with the expansion and new requirements of every city.

- Power and energy: this type of project entail the generation and transmission of energy. Electrical infrastructure includes power plants as well as electrical lines.

- Telecommunications: technology allows today's world to be interconnected, so telecommunication infrastructure is essential.

- Water infrastructure: drinkable water must be accessible to everyone. That's why these projects focus on managing the hydrological resource to achieve effective water transportation.

- Waste management: this category includes waste from garbage to hazardous waste. The correct storing, treatment and elimination of waste allow cities to be clean and safe. They avoid the spread of illnesses and viruses and protect citizens by storing toxic waste in a safe place.

3. Project management

Garold D. Oberlender defines project management as: "The art and science of coordinating people, equipment, materials, money, and schedules to complete a specified project on time and within approved cost" in his book *Project management for engineering and construction (2000).* Just like any other planning process, the purpose of project management is to foresee as many threats as possible and find the best way to face them. It accepts the fact that uncertainty and risk are an inevitable part of a project, but they can be overcome by adequate planning.

According to the PMBOK® Guide, Project management processes are grouped into five categories known as Project Management Process Groups:

1. Initiating Process Group: Activities aimed at obtaining authorization or specifying the definition of a new project or a new phase of an existing one.

2. Planning Process Group: Processes that establish the scope of the project, explain its objectives, and define the steps required to reach the project's goals.

3. Executing Process Group: Those tasks performed to complete the work following the guidelines described in the project management plan.

4. Monitoring and Controlling Process Group: Processes that track, review, and regulate the performance of the project. The progress is also tracked in these processes by identifying necessary changes and updates to the plan.

5. Closing Process Group: Those activities performed to finalize all ongoing processes from all Process Groups to formally close the project or phase.

These five groups shape the whole project management process. Although they are clearly defined as separated and sequential stages, in real life they overlap and depend on each other in different ways depending on each project.

As Figure 1 represents, the Monitoring and Controlling Processes Group encompasses the other four groups. Logically, the Initiating and Closing Processes Groups are the first and last in the interactions, respectively. The Planning Processes allow the beginning of the Executing Processes within the performance of the project.

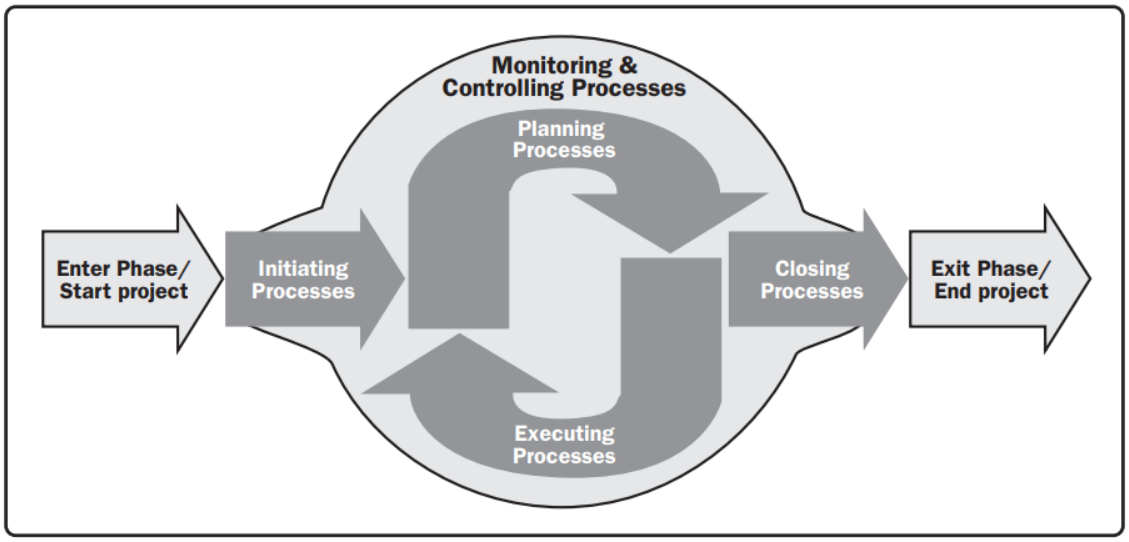

Figure 1: Project Management Process Groups Interactions. Source: PMBOK Guide, 2013.

All of these groups are present in every project, but the complexity and duration of the processes it's very different depending on their characteristics. Projects can have four different outcomes: a product, a service, an improvement for an existing product or service, or a result, such as an outcome or document.

4. Specifics of infrastructure projects PM

In the previous section, a general overview of project management was described. But the purpose of this thesis is to focus on infrastructure projects and their specific management. They have some features which make them really hard to manage, such as their risk, long duration, or multidisciplinary nature. Therefore, the general processes become laborious and they need great detail and precision.

To overcome the problem of the high risk involved in these projects, deep analysis and an accurate plan are developed in the risk management phase of the project, which will be explained later in the text. Also, the long duration of infrastructure projects is solved

with a detailed schedule in the planning stage. As mentioned above, well-structured planning of large infrastructure projects is crucial for their success. To ease this process, there are different methods to plan the sequence of phases and steps. The most common diagrams are Gannt, CPM, PERT, or Flowchart.

A project manager is one of the most influential parts of the project, especially when it comes to coordinating the wide range of professional disciplines involved in infrastructure projects. The variety and number of stakeholders are large, resulting in laborious management.

5. PMBOK as a PM methodology

The book *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)* is the official manual for managing projects. It explains the general instructions as well as standardized rules, procedures, concepts, and tasks to deal with every kind of project. Additionally, it describes the project life cycle in detail and provides essential guidelines for the project management career. In short, it presents the established methodology for succeeding at project managing.

The guide is published by the Project Management Institute (PMI) and has been updated and renewed over time. It was first published in 1996 and there are many subsequent editions. The most recent one is the seventh edition which was published in 2021. PMI is an organization composed of experts from different fields and has a certification program to obtain the PMP (Project Management Professional) credential. The purpose of the guide is to standardize the managing process to be recognized internationally, as well as to serve as a tool for project managers.

As explained previously, the project operations are divided into five distinct categories: initiating, planning, executing, monitoring and controlling, and closing. According to the book, each of these processes have three stages: inputs, tools and techniques, and outputs. These describe the initiation, process, and outcome of every part of the management procedure. It also divides the areas of management expertise into project integration, scope, schedule, cost, quality, resource, communications, risk, procurement, and stakeholder management. In total, forty-nine processes are explained in detail.

This theoretical part of the thesis is based on the PMBOK, from where most of the information has been gathered.

6. Project stakeholders

The stakeholders of the project include people and organizations that are involved in it. They can either impact or be impacted by the project and therefore they have responsibilities towards it. The project stakeholder management is aimed at identifying them, clarifying their obligations and expectations, as well as ensuring their engagement and satisfaction with the project.

The first step in managing stakeholders is to determine the necessary roles that must take part in the project, as well as their authority levels and their relationships with the rest of the organization. This includes internal and external parties, and they are identified by the project manager. Decisions regarding stakeholders are influenced by factors such as the organizational structure, the size, and scope of the projects, or governmental regulations.

Some general roles that usually are present in every type of project are shown in Figure 2. Taking a look at the center-top circle, the sponsor is the promotor of the project, providing funds and support from the initialization to the end of the whole process. The project team will be described in section C. On the right, outside of the project team, customers and users are those who will use the final result of the project. They can be either internal or external to the organization. Also, functional managers are professionals involved in the administrative part of the project. On the left, other stakeholders include other organizations who are interested in the output or the financial part of the project or contribute to its input.

After the identification and classification of the stakeholder have been done, the process of registration begins. The registration process consists in detailing and making official the previous analysis. Moreover, this description is reviewed and updated throughout the life cycle of the project.

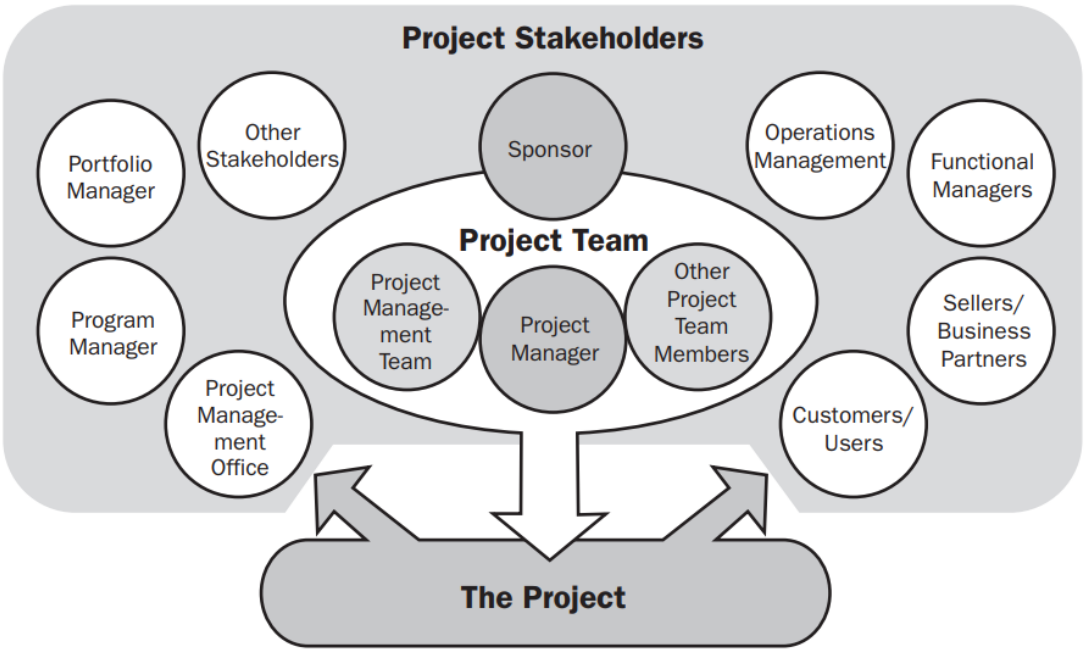

Figure 2: Relationships between stakeholders and the project. Source: PMBOK Guide, 2013.

Secondly, the management plan includes the relationships between the stakeholders, their interests, and expectations. Additionally, the plan describes the strategies to keep them engaged and satisfy their needs while maintaining the project boundaries. This is essential for the project's success. If they are aware of the objectives, changes, and threats of the project, they will be active supporters and they will help the manager guide the process and make decisions.

When issues and changes occur during the process of the project, change logs are used to document them. The project manager must inform every stakeholder about these changes, as well as their impact on the project. Also, they should address changes by finding consensus, negotiating, and solving conflicts. Through stakeholders' feedback, suggestions, and reports, the stakeholders' management plan is constantly reviewed and updated.

B. PLANNING PHASE OF THE INFRASTRUCTURE PROJECTS

Developing an accurate and realistic project plan is essential for its success. The plan must take every sector of the process into account, and foresee as many dangers and problems as possible while being flexible for the changes that might occur.

The most important parts of the plan are the technical planning, budgeting, tendering, and the final implementation of the defined plan. Also, the project life cycle will be explained in an effort to understand the planning phase within the whole process of project management and provide a holistic view of the project.

Uncertainty is the key factor in the planning process, as it is impossible to have every event under control. However, effective planning can mitigate the impact of unforeseen circumstances and provide the necessary guidelines for the productive management of the project.

7. Project Life Cycle

The project life cycle refers to the stages that the project goes through from the beginning to the end of its duration. The length, importance, and goals of each phase are determined by the project's needs and specifications. The achievement of specific goals or results marks the end of a phase. Although stages are usually ordered sequentially, there are some cases where they have to overlap each other.

For smaller and simpler projects, the six general phases of the project life cycle are represented in Figure 3.

However, for large infrastructure projects it's usual that these six phases are extended to a larger number, as a general example in Figure 4 shows.

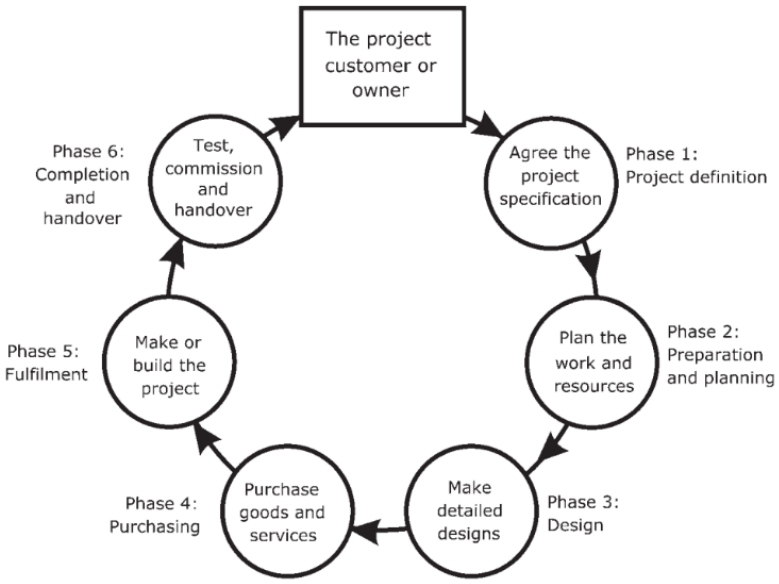

Figure 3: General phases of the project life cycle for small projects. Source: Lock, D. (2007). Project Management (9th ed.). Gower Publishing.

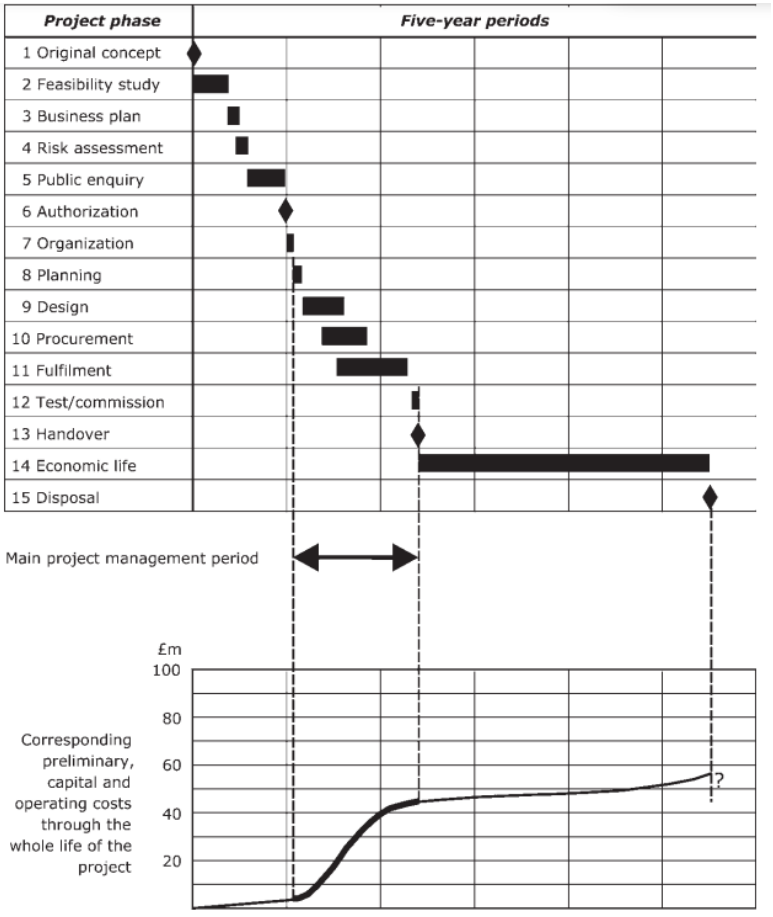

Figure 4: Example of a detailed project life history for large projects. Source: Lock, D. (2007). Project Management (9th ed.). Gower Publishing.

The four first stages of the project comprise the formative period, as they set the basis for the development of the project. It's the time between the moment when the initial idea is born and when the specifics of the project are established and agreed upon. The feasibility study determines the viability of the project, and the assessment should have a positive outcome. By the end of phase four, the business plan, schedule, and budget should be defined.

Some projects have a huge social or environmental impact, and they are usually delayed as the population and public inquiry are very critical of their outcome. This is why the fifth phase might take longer and delay the start of the project.

Phase number six is the authorization of the project, which should be the most immediate one, as all parts agree with the definition of the project, the legal requirements are solved, and the capital is available to begin the process.
The start-up period is represented by phases seven and eight when the organization is set and the project managers begin to mobilize their team.

From phase nine to eleven, the design, acquisition of supplies, and construction of the project are done, and they finish with the final outcome of the project. To make sure the result works as expected and the safety requirements are met, the twelfth phase represents the carrying out of the necessary tests. Only then can the project be put into operational use and be handed over to the customer, in phase thirteen.
The two last phases represent the useful life of the outcome of the project when it's economically profitable, and the end of its life as it becomes obsolete or is eliminated.

Finally, the plotted curve at the bottom of Figure 4 is the economic and operating costs of each stage. It's divided into three periods with similar expenses: the preparation stage, the design and construction stage, and the operation stage. Logically, the most accentuated slope comprehends the design and construction phases, from the beginning of the work to the end of the project. The period before the authorization does not require such capital, compared to the second period. Finally, during the life of the outcome of the project, the costs continue growing at slower rate for a long period.

8. Technical Planning (design)

The design project manager is responsible for reviewing the request for proposal (RFP) delivered by the sponsor and making a real engineering project out of it. This first step must be done at an early stage of the process of planning, to avoid too many adjustments once the project has started. The proposal might have assumptions or ideas that are unfeasible, and it is the design project manager's job to identify, clarify and make the necessary changes to deliver the final proposal. They also coordinate the work plan and the communication between different parties of the team.

The design engineering team is composed of professionals who are responsible for identifying potential problems, defining the technical work, and making a realistic project proposal. Depending on the magnitude of the project, the number of members of the design team must be more or less extensive, and the level of expertise higher or more basic. This way, each part of the team has its own responsibilities within the technical planning and must give a detailed description of its corresponding part. These specifications could include drawings, designs, or other types of documentation that complete the necessary information. Also, the design project manager coordinates the team and must make sure resources are available when needed.

The design work plan includes the schedule and budget of the design process. Firstly, the detail sheet for the design proposal details the work of every part of the team. Then, the design budget is integrated within the design schedule, which includes the expected duration of each part, the description of work, and the materials used. The design budget is measured by work hours instead of dollars, and these hours of work include tasks such as making the calculation or computer designing. For this part, CADD work is essential, as well as the establishment of rules and a proper framework. Some methods that help the organization of the design phase are the CPM method for more complex projects or bar charts for smaller projects.

Measuring the progress of the design phase is often complicated, as it's a creative process. It might seem like no advances have been made, but several iterations might be necessary to see the final result. Therefore, measuring the process by finished designs might not be the best option. This is the reason why an agreement between the sponsor and the design team must be made before starting the process.

9. Budgeting

The budgeting phase is a key part of the project plan, and it depends on two variables: estimated planning and risk management. Therefore, the budget is the highest price the organization is willing to pay for the project realization. It includes not only the capital expenditures (CAPEX) item calculation but also the operating expenses (OPEX) item calculation and the life cycle cost calculation. The budget is the basis for developing the financial model required at all levels of project preparation and implementation. The financial model breaks down all costs and income over time, including other cost items such as design costs, project management costs, tenders, capital, financial, and risk costs. The financial model is the basis for evaluating the effectiveness and sustainability of the project and consequently for its cost management.

Just like every part of the process, each sector of the team is responsible for the estimated budget of its part of the project. The owner's organization begins with an overall project budget and desired scope. Every professional must prepare their budget estimation according to the described guidelines made in the owner's approved initial budget. However, the final budget plan is reached after a process of continuous readjustment, and some changes might be required to find a suitable solution for every party involved. This is why every plan must be flexible, to adapt to the needs of the different sectors. At the same time, the level of accuracy of the estimations should be the highest possible, marked by a plus and minus percentage.

Infrastructure projects have two types of estimates, compared to industrial projects which are more complex and harder to estimate. The first type is budget or approximate estimates, which are prepared by the owner during the feasibility study. The second type is the final or detailed estimates, which represent the amount of money every party will receive and pay and are prepared by the construction contractor.

The analysis to determine the economic feasibility of the project begins once the owner's estimates have been established. The estimated costs are based on prior experience or similar projects that have been done before. Concretely, infrastructure projects rely on the *Means Cost Guide*. This document is useful for different types of costs and estimations. When reviewing previous projects, it's important to adjust to the current circumstances of the actual project in order to obtain precise information. Some useful methods of

making this adjustment are using formulas with maximum and minimum costs to obtain an average price, or using the annual index of construction costs published by the *Engineering News Record (ENR).*

Economic feasibility can be determined in two ways depending on the owner. On one hand, if the owner is in the private sector, feasibility is determined by the return on the initial investment. This number can be calculated by capital recovery, payback period, or rate of return. The formulas used to take into account the present and future value of the money, as well as the interest rates. On the other hand, if it's a public owner, this determination is done by a benefit/cost ratio. The minimum value of the ratio for the project to be feasible is one, which means benefits and costs are the same. Additionally, public government projects are not just driven by the economic returns, but also by the social benefits these projects could have.

The two basic parts of the final budget of infrastructure projects are the design budget and the contractor's bid. As explained in the previous section, the design organization has a difficult job when providing estimates. Costs are calculated by hours of designing, with multipliers to salary costs to compensate for the design process and contingencies. Extra costs, such as a higher level of expertise, travel expenses, and extra supplies depending on the size of the project are compensated by the owner, as well as an extra fee agreed by the organization beforehand. The largest amount of the project's cost is spent during the construction phase. Before this phase starts, the price is agreed upon by the contractor and the owner. Building contractors provide a detailed explanation of the labor, materials, duration, and costs of the construction process, usually following the *Construction Specification Institute's (CSI)* masterformat. This format provides an organized and widely recognized description of the work. However, the final cost is not exactly known until the end of the construction period. To compensate for the difference between the estimated price and the final cost, both parties might agree on a maximum price before the construction process. If this maximum quantity is exceeded, the distribution of the difference in costs is done by different percentages to compensate for the error range. All these detailed distributions and agreements are explained in the signed construction contract.

An example of the building construction project bid summary is shown in Figure 5.

Item	Division	Material	Labor	Subcontract	Total
1	General requirement	$ 16,435.00	$ 36,355.00	$ 4,882.00	$ 57.672.00
2	Sie-work	15,070.00	20,123.00	146,186.00	181,389.00
3	Concrete	97,176.00	51,524.00	0.00	148,700.00
4	Masonry	0.00	0.00	212,724.00	212,724.00
5	Metals	212,724.00	59,321.00	0.00	272,045.00
6	Woods and plastics	38,753.00	10,496.00	4,908.00	54,157.00
7	Thermal and moisture	0.00	0.00	138,072.00	138,072.00
8	Doors and windows	36,821.00	32,115.00	0.00	68,936.00
9	Finishes	172,587.00	187,922.00	0.00	360,509.00
10	Specialties	15,748.00	11,104.00	9,525.00	36,377.00
11	Equipment	0.00	0.00	45,729.00	45,729.00
12	Furnishings	0.00	0.00	0.00	0.00
13	Special construction	0.00	0.00	0.00	0.00
14	Conveying systems	0.00	0.00	0.00	0.00
15	Mechanical	0.00	0.00	641,673.00	641,673.00
16	Electrical	0.00	0.00	354,661.00	354,661.00
	Total direct costs	$605,314.00	$408,960.00	$1,558,360.00	$2,572,644.00
	Material tax (5%)	30,266.00			2,602,910.00
	Labor tax (18%)		73,613.00		2,676,523.00
	Contingency (2%)			53,530.00	2,730,053.00
	Bonds/Insurance			34,091.00	2,764,144.00
	Profit (10%)			276,414.00	3,040,558.00
					Bid price = $3,040,558.00

Figure 5: Example of a Building Construction Project Bid Summary Using the CSI Organization of Work (Project Management for Engineering and Construction, 2000).

10. Finance model

The finance model is aimed at assessing the economic feasibility of the project. Continuing with the budgeting analysis, this part of the document will describe the project feasibility analysis in detail.

A feasible project can be done reasonably and has the potential for success. An infrastructure project needs studies from many different areas to be feasible, as it involves economic, social, environmental, as well as a wide variety of additional risks. Also, the initial investment is usually higher than any other project, but it's compensated with higher expected profit too. The owner normally receives earnings at the end of the project, while the contractors might receive progress payments while the project is in process. This is the reason why the owner must make sure the project is feasible and be committed to it.

The financial appraisal is done using two methods: the simple payback method and the use of discounted cash flow techniques. In both techniques, the expected result is aimed at balancing the expenses (cash outflows) with the revenues (cash inflows). The first method is the most common one, and it consists in analyzing the investment and forecast earnings over time until they have the same value and the project earnings pay for its cumulative expenses. This way, the amount of time that it will take the future cash inflows to recover the initial cost it's calculated. Contrastingly, the discounted cash flow is more accurate but less simple. It also calculates the length of time it will take for the initial investment to be recovered, but it discounts the cash inflows to their present value. This means the time value of money is taken into account applying the cost of capital.
Based on uncertainty, these methods are just predictions and should be estimated in the best possible way. The sensitivity and Monte Carlo analysis are two studies used to make sure these estimations are reliable.

Planning and studying the financial part of the project is important, but who has the money to pay for it? Infrastructure projects can also be divided into public and private, depending on their funding. Public projects are owned by the government, and they usually choose those projects that entail the least expenses while offering positive social outcomes. Private projects are those owned by private businesses, and profit optimization is the main goal.

Government is the biggest investor when it comes to infrastructure projects. But due to the great scale of these projects, more than one option of funding is usually necessary. Therefore, multi-source funding is the most common approach. These sources could be from the same type or different types of institutions. Public-private partnership (PPP) is a common model used to finance infrastructure projects. The government represents the public part, at a national or local level. On the contrary, the private part is represented by businesses or any private actor. In some cases, governments try to make this partnership more appealing for the private party by reducing their total tax liability or providing them with other economic benefits.

11. Tendering

Project tendering is the process of inviting bids for a project. The purpose of this process is to obtain the best price and conditions for the construction work while clarifying the obligations and needs of every party involved in the contract.

Project tendering is composed of three stages: tender preparation, tender period, and tender evaluation. The first stage gathers the activities required to prepare the tender documentation and begin the selection process after the project plan and definition has been completed, so the goals and needs of the project are clear. The tender documents are sent to the tenderers and they will answer by specifying the price for supplying the required goods or services to meet the bid offer.

In the second phase, the call for tenders is made. The commercial offer is developed and the tender offer period is finished.

During the tender evaluation, the offers are evaluated. Tenderers are chosen based on their experience and competence, as well as the price offer and the clarity of content. After, the negotiation process begins. The terms and conditions are agreed upon by both parties, and a formal contract is signed.

Tendering processes vary from public to private projects. In public projects, the government is the one that invites tenders from every expertise to design and finance the process. Contrastingly, in private projects, the used term is "bidding" instead of "tendering". The private organization ensures that bids are made on the project.

12. Public-Private Partnership (PPP)

A large number of infrastructure projects in the world are implemented in cooperation with the private sector. The private sector invests and maintains the infrastructure on the basis of a contract with the public sector. Furthermore, there are two options: the infrastructure is provided to the public sector to provide a public service (the public sector is the operator) or the private sector itself operates the infrastructure and provides the public service directly to the public. In the first case, the public sector pays a fee to the private sector for the availability of infrastructure (availability fee), in the second case, the private sector collects public service charges from the public, and the difference in

the balance sheet is paid by the public sector (demand fee). In the case of profitable projects, on the other hand, the private sector pays a concession fee to the public sector.

Not all PPP projects are beneficial for the public sector. Therefore, the public sector in the feasibility study phase verifies the benefits of cooperation with the private sector by comparing two options: the traditional (so-called public comparator) and the cooperation with the public sector. The decisive factor is the comparison of the resulting NPV (Net Present Value) or IRR (Internal Rate of Return) of both variants. NPV or IRR are calculated for the entire life cycle of the project, i.e. for example for 25 - 30 years of operation (that's why we're talking about lifecycle contracts). If it turns out the advantage of a private road, then it is not the construction part of the project but the project as a whole that is tendered.

C. PROJECT MANAGEMENT

A project is in a continual state of change as it develops from the beginning to the end. Every organization has its own style when it comes to project performance. This is highly influenced by factors such as their organizational structure, company policies, or environment. However, some general elements are common to every enterprise.

Generally, managing infrastructure projects is very professionally demanding. As a rule, the public sector does not have enough experts to provide at the necessary level. Therefore, it often cooperates with private project organizations, as explained previously in Public-Private Partnership. However, it is necessary that these private organizations provide the demanded level. The selection of the project organization precedes the selection of the general contractor for the construction phase, which is then usually managed by the project team.

In the following last section of the theoretical part, the mentioned project organization will be defined in detail. The project governance describes the framework to carry out the project. The first and most important role is the project manager, who leads the rest of the team. The team and manager work together to accomplish the project goals within the imposed limitations. The process of leading includes a well-planned schedule and a managing procedure that will be explained.

13. Project manager

The project manager is the professional that leads the project team, strategically coordinating and organizing the work for the successful performance of the project. His role is key in the organization of the project.

A project manager must combine different personal and technical skills to succeed in his job. They will work and coordinate many different people from a wide variety of fields, so they must have team building and motivation abilities to work well with everyone. Just like any other leader, they should always keep in mind each worker’s abilities and make the most of them. They must be fast and effective when solving problems and making decisions, as well as manage to work well under pressure. A project manager must also be organized and never miss the final goal of the whole process: completing the project successfully.

The team formed by professionals is the most important driver of the project. A positive and decisive attitude is crucial for a healthy working environment. As the coordinator of every part, the project manager should look at every problem as a challenge with a solution instead of as a threat. Also, they are the ones that will have all the information related to the project. This is why it's very important for them to know what to do with it and how to communicate it. Every person involved should be informed about the progress of the project or about changes that might occur. Not only is communication between the managers and the rest of the team important, but also a good connection between all parties. As people from different working fields will be working together, their interaction and sharing of information must also be effective.

However, although project managers have major responsibilities, their decision-making is often limited by the organization. Therefore, the project manager must also be willing to accept the regulations, approaches, and rules of the company. They have the biggest responsibility with little authority, which makes the job even more complicated. Generally, the success of the project is directly related to the successful performance of the project manager and the other way around. The pressure can get to a point where the personal cost involved in their job is sometimes greater than their earnings.

14. Project team

The project team is composed of the previously described role of the project manager plus the rest of the professionals who carry out the project. The size of the team varies according to the magnitude of the project. Also, the necessary roles are very different depending on the field and type of the project. The common factor regardless of the project's characteristics is the project manager, although their level of authority depends on the organization. They are the coordinators, but team managers rely on their teams to succeed in their work. However, some roles are usually present in project teams.

First of all, the **management staff**. This group includes members who are in charge of the whole process of planning the project.

Secondly, the **project staff** is composed of the design and construction teams. These teams include different experts who perform the necessary activities to get the final result

of the project. There can also be supporting experts who perform particular skills that could be needed in the project.

Also, there are the **customer representatives**. They ensure that the desired outcomes are always present, coordinating the process with the final result asked by the customer.

Finally, **external companies** include suppliers and business partner members. These members enter the team to deliver the necessary components or services for the project. Business partners can also provide support or specialized expertise.

Teams can be dedicated or part-time depending on the amount of necessary time spent on the project. In the first type, the team members are assigned full-time jobs and they report directly to the project manager. Contrastingly, the latter way of working only demands additional work, as some members or even the project manager might be working on several projects at the same time. Both compositions are compatible with virtual work, as nowadays is possible to work in many different locations as the same team. This methodology relies on technology for its implementation, with tools like videoconferences or online working spaces.

15. Time schedule

The process of defining a realistic schedule is a laborious one. As shown in Figure 6, it includes seven steps that need to be completed before starting the project. Each of them depends on the previous one and their correct definition affects the next one. Once the final schedule is defined and delivered, the project is ready to begin. A more detailed description of each step will be provided.

"Plan Schedule Management is the process of establishing the policies, procedures, and documentation for planning, developing, managing, executing, and controlling the project schedule. The key benefit of this process is that it provides guidance and direction on how the project schedule will be managed throughout the project." (PMBOK® Guide – Fifth Edition, 2013). It is the first step and it establishes the initial basis for the final schedule.

The second part is defining activities, by describing each specific process that is necessary for completing the project and its attributes. By doing this, there is a detailed and organized description of the estimated actions and timing to control the work.

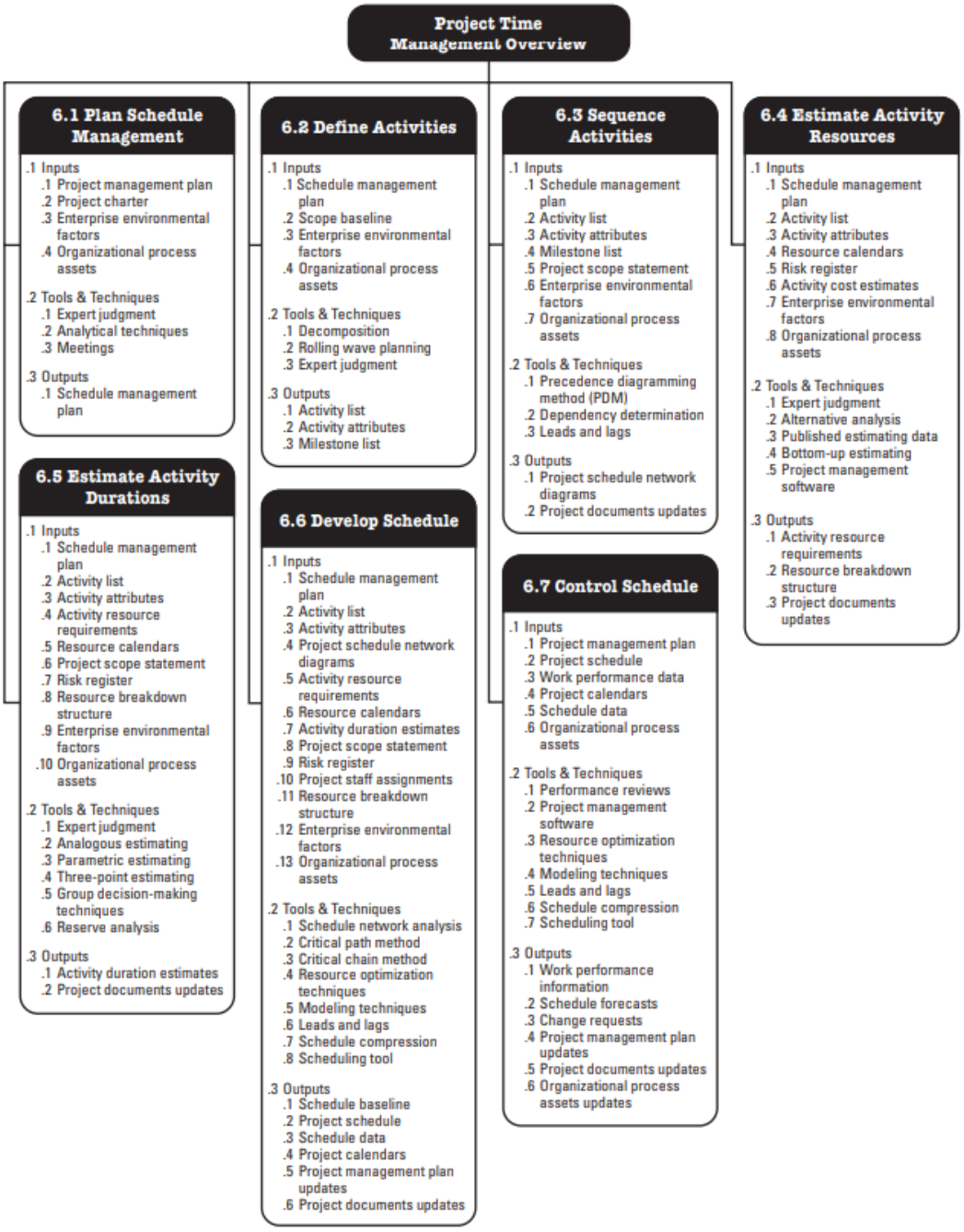

Figure 6: Project Time Management overview. Source: PMBOK Guide, 2013.

Once the list of activities has been made, the sequence in which they will be performed must be defined. The most common method is the PDM (Precedence Diagramming Method) which separates every step of the process into an independent node, which is connected to one or more nodes logically according to the project schedule. The whole diagram is represented graphically by the AON method (Activity-On-Node), which gives a visual summary of the project. There are four possible relationships between the activities depending on the requirements for the beginning and end of each process: Finish-to-start (FS), in which an activity can't begin until the previous one has been finished; Finish-to-finish (FF), in which an activity can't finish until the previous one has been finished; Start-to-start (SS), in which an activity can't begin until the previous one has started too; and Start-to-finish (SF), in which an activity can't finish until the previous one has been finished too. A visual representation is made in Figure 7.

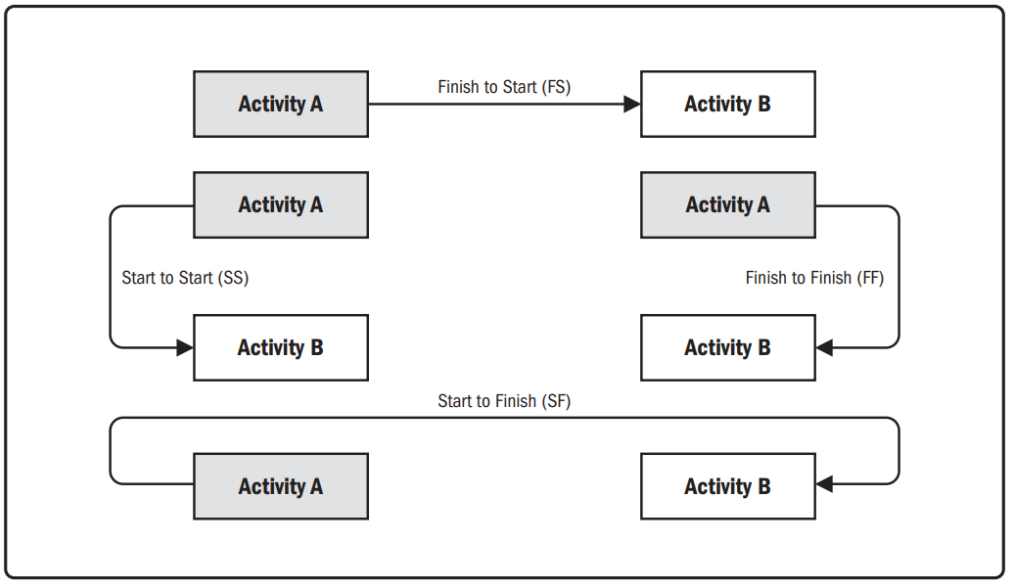

Figure 7: PDM relationships between activities. Source: PMBOK Guide, 2013.

When the project schedule network diagram is done, as Figure 8 illustrates, there is a clear and visual representation of the methodology of the whole project. Now it's time to estimate the necessary resources for each activity.

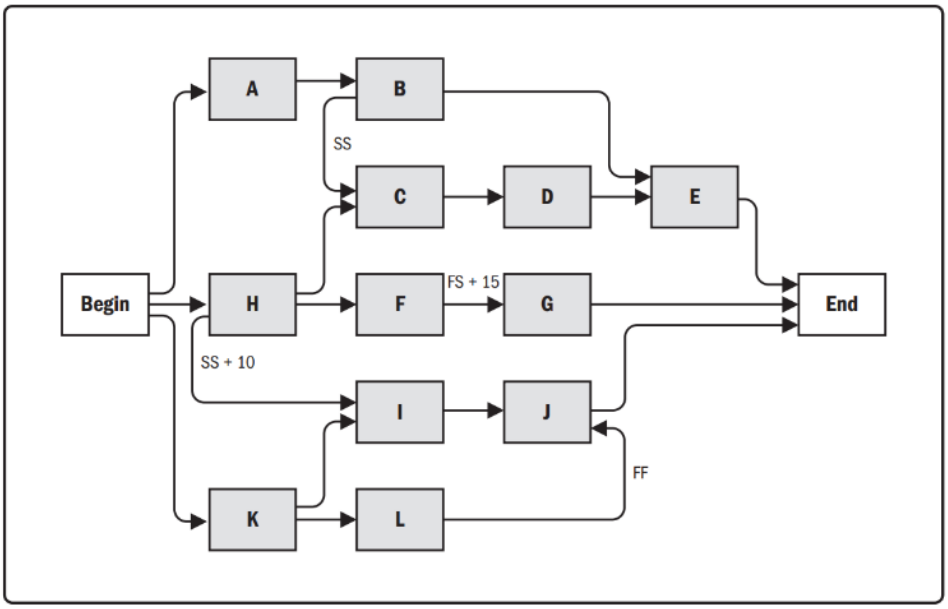

Figure 8: Example of a Project Schedule Network Diagram. Source: PMBOK Guide, 2013.

The necessary resources include human work, materials, or tools, as well as their amount and characteristics. This determination eases the process of estimating the cost and duration of the project.

As uncertainty is an unavoidable part of project management, knowing the exact periods is impossible. This is the reason why three estimates are used in PERT (Program Evaluation and Review Technique) to find the most accurate duration. The first one is the most likely duration, based on a realistic analysis of the activity. Then, there is the optimistic duration as the best-case scenario possible. Finally, the pessimistic duration is the worst-case scenario for the activity. With these three estimates, the expected duration of every process can be defined more realistically.

Developing the schedule is done by reviewing and updating it. Once the estimated duration is defined, the description is given to the people involved in every activity to review and make sure there are no time or resource conflicts. In this part of the process, the flexibility of the project is also determined, with methods like the Critical Path Method (CPM). It is used to calculate the shortest possible project duration, as well as the amount of time every activity could be delayed or extended without affecting the project's final duration. Another schedule method is the Critical Chain Method (CCM), which uses

duration buffers to manage uncertainty. There are other techniques used to optimize resources or simulate different possible scenarios, to be as accurate as possible, and to adapt to every situation that might arise.

The schedule baseline is a schedule model that has been approved with all the former information, and it can only be modified by a formal procedure. There are several ways to present it: bar charts, milestone charts, project schedule network diagrams...
Finally, when the schedule baseline is delivered, the control schedule begins. Through this process, the progress of the process is followed and changes or updates are made. A constant review of the actual work is necessary to provide an accurate schedule forecast and account for any request to change the plan.

Even though project scheduling is an essential and laborious part of project management, it is just the base for managing and controlling the process in the real world. These processes will be described and explained in the next section.

16. Risk management

Having risk and danger under control is impossible, but their forecast can be done effectively to reduce their negative impacts. Risk management includes the processes that identify, analyze and control the project's threats and opportunities. This stage is crucial for ensuring positive outcomes and the survival of the project, but it's important to keep in mind that it's based on uncertainty. The risk analysis affects the project's feasibility, and the level of risk tolerance determines the acceptance of the project.
Risk is an uncertain incident that impacts the project and could have an effect on any of its features. Its causes can be either internal or external to the project, as well as its conditions.

A decisive part of large infrastructure projects is the calculation of risk costs. The cost of an individual risk is a multiple of its probability and the cost of its consequences. Usually, the total cost of risks of infrastructure-type projects is about 20% of investment costs, which is not a small amount. Therefore, they cannot be neglected. A neglected and little-treated risk of infrastructure projects is the situation that at some stage of preparation and implementation they will be stopped and thus all the costs incurred so far will be wasted.

Another common risk is the extension of the length of project implementation, which represents a large cost loss to which the public sector does not like to subscribe.
The first step in the calculation of risk costs is to identify the possible threats. The methods used include brainstorming, checklists, SWOT analysis, or examining similar previous projects. Once they have been determined, the next step is to study and classify them. The risk analysis can be qualitative if it is purely descriptive, or quantitative if the outcomes are exactly measured.

Qualitative cause and effect analysis use methods like fault trees and fishbones, Failure mode and effect analysis (FMEA), and risk classification matrices.
Moreover, quantitative analysis methods aim at assigning numerical values to the listed risks. The most common procedure involved is Failure mode effect criticality analysis (FMECA).

After the evaluation of risks, they have to be registered in order to decide what strategy is going to be implemented to deal with them. The decision depends on the nature of the risk itself, its characteristics, and its potential effects. Contingency will be assigned based on the chosen method. There are six possible methods used to deal with risks:

1. Avoiding the risk, by giving up the causes or just canceling the start of the project.
2. Preventing or mitigating the risk impact, by taking precautions and organizing the whole team to take preventive measures.
3. Accepting the risk, when its effects are not extremely consequential and can be solved by rearranging.
4. Sharing the risk, when it’s high enough to divide responsibilities and reduce its impact.
5. Limiting the risk, by approving each step of the project at a time and controlling each of its effects before moving to the next one.
6. Transferring the risk, by passing it on to a different party. Insurance companies are crucial here, as the project organization pays a fee to cover the risk.

17. Management and controlling

Managing and controlling the project is a process of constant change and adjustment. This phase includes those processes required to track and review the progress and performance of the project. The main purpose is to identify the areas of the project in which changes to the plan are required, find the best strategy to implement them, and start the approved changes.

The project performance is measured and analyzed regularly to identify variances from the project management plan. This continuous review of the work provides the project team insight into the current situation of the project and identifies any areas requiring additional updates. Consequently, the assessment can result in recommended and approved updates to the project management plan. This way, the plan will probably have more than one version, and the whole team must be informed of the changes and the updated versions of the project planning.

The final purpose of the managing and controlling stage is the project‘s success, which is defined in the book *Project management: A systems approach to planning, scheduling, and controlling (10th ed.)* as: "Today, the definition of project success has been modified to include completion:

- Within the allocated period
- Within the budgeted cost
- At the proper performance or specification level
- With the acceptance by the customer/user
- With minimum or mutually agreed upon scope changes
- Without disturbing the main workflow of the organization
- Without changing the corporate culture".

Control systems are those aimed at tracking work and measuring the progress of the project compared to the work plan. The variables of every control study are the reporting period (N), the amount of work (X), the level of quality (Q), and the predicted cost (C).

Evaluating a process in constant change requires effective methods and a flexible plan, which can be adapted to necessary changes to meet the project's objectives. They should be easy to carry out, interpret, and aimed at improving the work.

There are six methods for measuring progress during construction on infrastructure projects: Units Completed, Incremental Milestone, StartFinish, Supervisor Opinion, Cost Ratio, and Weighted Units. The system is selected depending on the nature and complexity of the project and the desired level of control by the project manager.

PRACTICAL CHAPTER

PRACTICAL CHAPTER

Once the theoretical chapter is done and the guidelines to plan an infrastructure project have been explained, it is time to put all the learnings into practice. Moreover, the project management methodology will be presented by the analysis of a real project.

The chosen project is the High-Speed Railway in the Czech Republic (HSR CZ), which links the three main cities in the country: Prague, Brno, and Ostrava, as well as major cities in bordering countries: Dresden, Munich, Vienna, Bratislava, and Katowice. The strategic location of the Czech country in the middle of the continent is what makes it necessary for the European railway network to be upgraded in this area.

The client is the Czech Railway Infrastructure Administration (SZDC), Správa železniční dopravní cesty in Czech. The entire process began in 2013 and it is estimated to finish in 2050. However, the focus of the practical chapter will be the analysis of the section Praha-Běchovice to Poříčany for the purpose of this thesis. The company Mott MacDonald is taking part in the joint venture led by Sudop Praha and with Egis Rail France as another partner.

In collaboration with Mott Macdonald, who provided the necessary documents for the study of the project, the research will be more realistic and easier to conduct. Not only will the project be presented and analyzed, but some main points will also be discussed, such as the project's organization and management, the division of tasks between stakeholders, the project timeline, phasing, and tasking, finishing with the summary and conclusion of the thesis.

1. Basic information about the project investor

The High-Speed Railway in the Czech Republic (HSR CZ) is a public infrastructure project. Therefore, the Government is the investor in this case. The sector of the planning funding is the State Fund for Infrastructure Projects of the Czech Republic (SFDI, Státní Fond Dopravní Infrastruktury in Czech). The Fund was established in 2000 and they are in charge of the construction and conservation of the road infrastructure in the country. This organization gets the capital to fund these projects from transportation taxes and fees. SFDI is also responsible for the construction funding of the project, along with the

European Union Funds and the European Investment Bank (EIB) according to the Czech National Investment Plan.

The infrastructure cost investment is CZK 27,400mil (GBP 930mil[3], EUR 1 billion), and the payment conditions of the design are the following: 30 % after technical conception, 30 % after draft delivery of Preliminary design, and 40 % after final delivery for Planning permit application.

A top-level working group was established to ensure the correct sharing of information about the project and the effective communication between the stakeholders and it's directed by the Minister of Transport, Mr. Dan Ťok. This working group is formed by representatives of the Ministry of Transport, Ministry of Environment, Ministry for Regional Development, Ministry of Industry and Trade, Ministry of Finance, Ministry of Agriculture, State Transport Infrastructure Fund, SŽDC, Association of Regions of the Czech Republic, Economic Committee of the Chamber of the Parliament and Association for Infrastructure Development. Additionally, the Czech infrastructure manager SŽDC established a special committee that is in charge of the further preparation of the project, focused on the commission of the feasibility studies.

Finally, the client is the national railway infrastructure manager in the Czech Republic, called Správa Železnic (SŽ) in Czech, which is a state organization.

2. About Mott MacDonald (PM and technical advisor company).

Mott MacDonald describes itself as a global engineering, management, and development consultancy. Although it is headquartered in the United Kingdom, they have been working in the Czech Republic for more than twenty years and they have been part of some of the biggest infrastructure projects in the country.

The consultancy is one of the largest companies owned by employees in the world. It has been operating since 1989, created by the partnership between Mott, Hay, and Anderson with Sir M MacDonald & Partners. Both companies were engineering consultancies, but the latter was specialized in water management while the first was a transportation one.

[3] Amount according to price level 2018 with 10% contingency.

After the merger, the company started to acquire international consultancies from a wide variety of fields, expanding their working sectors. In 2008 they earned the *New Civil Engineer*'s recognition as the *International Consultant of the Year*[4].

Today, they operate in 140 countries with 180 principal offices on every continent[5] and they have worked on a great number of famous projects across the globe.

As it is stated on their own web page, "Our purpose is to improve society by considering social outcomes in all we do, relentlessly focusing on excellence and digital innovation, transforming our clients' businesses, our communities, and employee opportunities." (Mott MacDonald, 2022).

These are some of the most interesting projects they are actually involved in:

- The transformation of a closed gold mine into a renewable energy hub in Australia, that will be completed in 2024.
- Solving the water shortage in England, optimizing water use, and finding more sources of supply in an environmentally-friendly way.

3. Presentation of the project

Prague is well-known for having one of the most effective transportation networks in the world. However, the high-speed lines in the country are undeveloped despite its strategic location in the European continent. Aware of this problem, the Czech Government approved a program in 2017 to develop fast rail connections in the country.

One of the biggest projects taking part in this program is the High Speed Railway Programme in the Czech Republic (HSR CZ), which mainly focused on the construction of high-speed lines for the transportation of passengers. It is a great example of a large infrastructure project, with a construction period that will last 25 years starting in 2025.

At the moment, the project is in the phase of Environmental Impact Assessment (EIA) approval and Feasibility Study.

As the scope of the described project is too extensive to study in detail, this chapter is intended to analyze the section from Praha (Běchovice) to Poříčany, as Figure 9 shows.

[4] "Mott MacDonald "stunning year" earns it NCE/ACE International Firm Award". *New Civil Engineer*. 20 March 2009. Retrieved 3 July 2022.

[5] Mott MacDonald. *Regions - Mott MacDonald*. Retrieved 3 July 2022, from https://www.mottmac.com/careers/regions

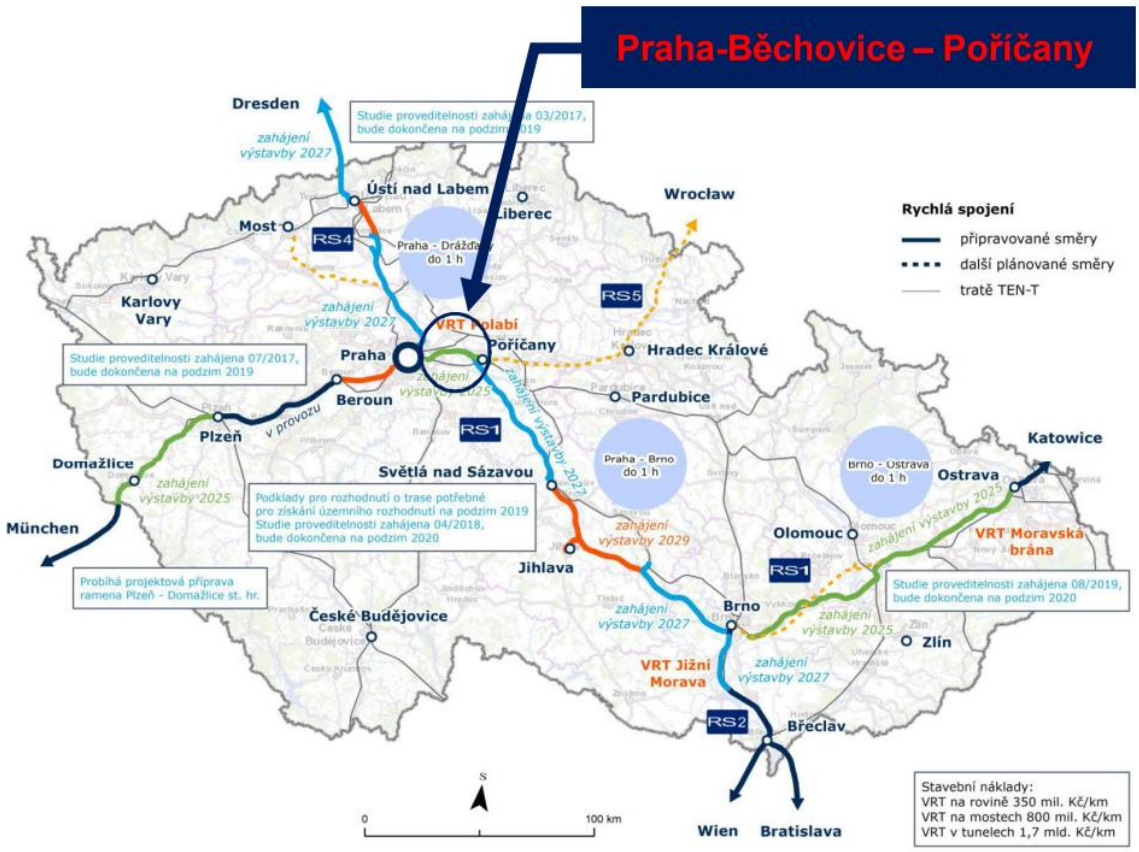

Figure 9: Map of the HSR in the Czech Republic (Praha (Běchovice) to Poříčany section).[6]

This section of the project aims to solve the capacity issue in the already-existing line between Prague and the east of the Czech Republic. The problem is that the line that connects Praha-Běchovice with the Poříčany station is an electrified triple-track line that has been exploited above its capacity levels in the past years. As the railway route goes through populated and sensitive forest areas, the two main goals of the project are to free the line in order to make it safer and enduring and at the same time shorten travel times. The most effective way to do so is by transforming the line into a quadruple track one, as well as adding faster adjacent lines between the two stops.

The operational scheme of the whole line is schemed in Figure 10, while Figure 11 represents the general track plan for the new line.

[6] Michal Babič (Mott MacDonald). *HIGH SPEED RAILWAY PROGRAMME IN THE CZECH REPUBLIC (HSR CZ) - Programme overview*. Unpublished confidential document; 2021.

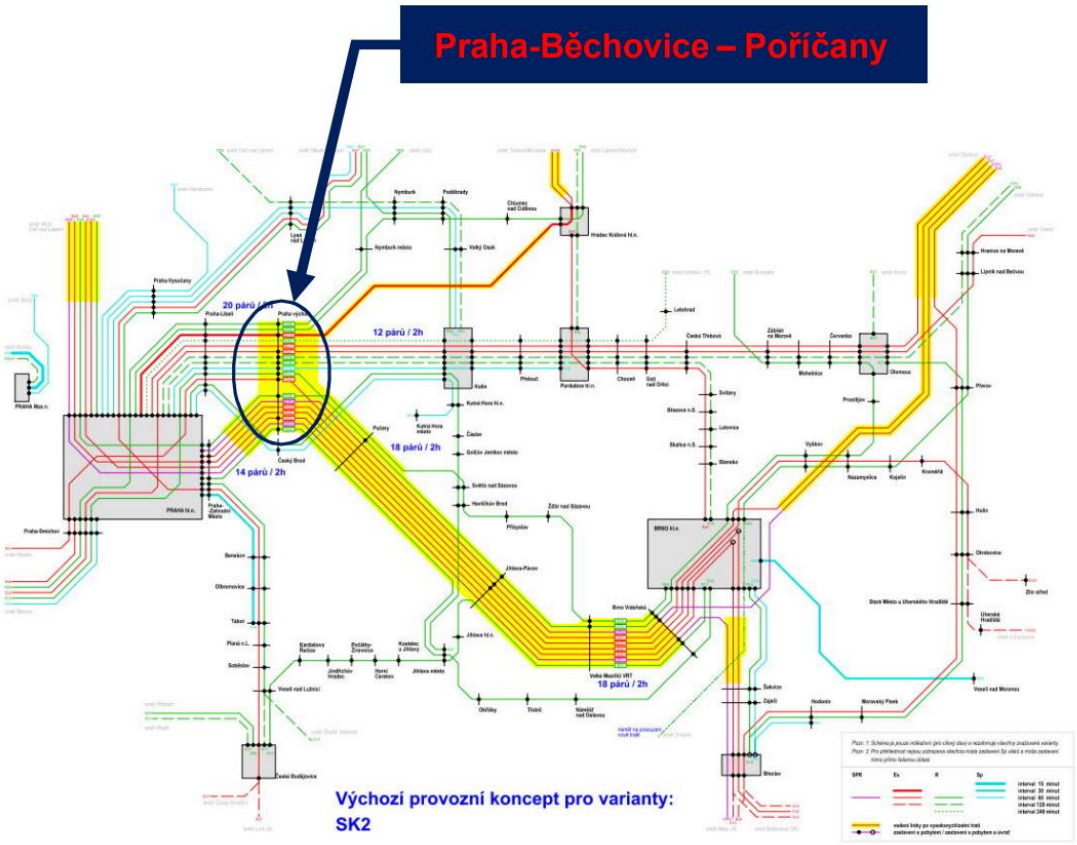

Figure 10: Operational Scheme of the HSR.[7]

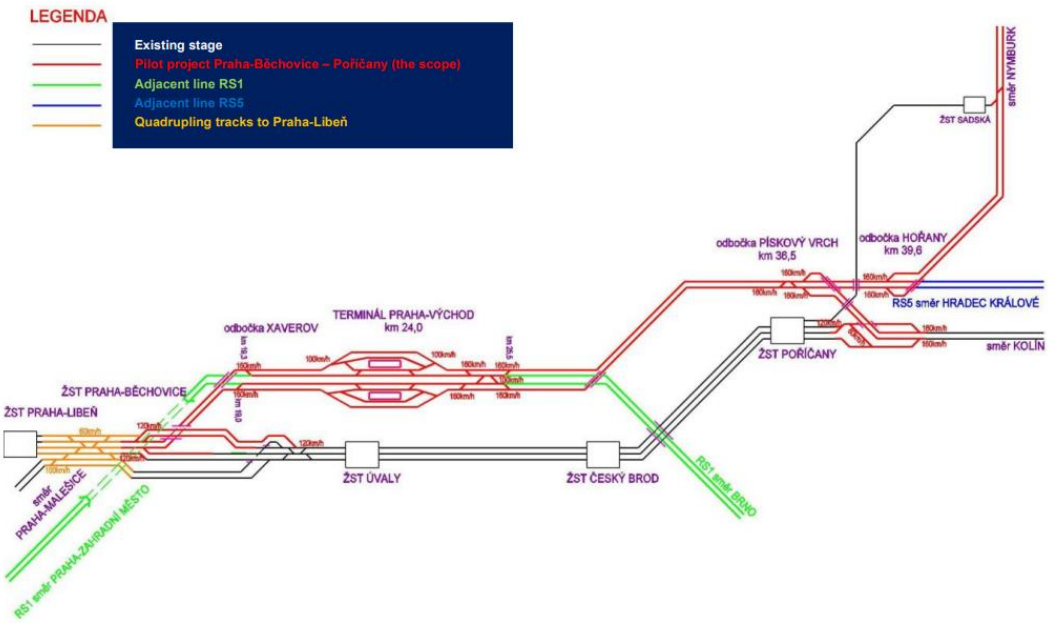

Figure 11: General Track Plan from Praha (Běchovice) to Poříčany.[7]

[7] Michal Babič (Mott MacDonald). *Praha-Běchovice – Poříčany section, Preliminary design info*. Unpublished confidential document; 2021.

Additionally, Table 1 lists some technical facts from the infrastructure of the project. The main advantage of the "quadruplication" of the lines is that they are able to stand heavy traffic on busy routes. This way, high-speed trains can co-exist with older and slower trains.

Parameter	Value
Operation	Passenger trains dedicated lines
Track arrangement	quadruple track line
Operational speed	200 – 320 km/h
Track design speed	350 km/h
Electrification	AC 25 kV 50 Hz (existing system DC 3 kV)
Signalling	ETCS/ERTMS L2
New high-speed line length	29 km
New conventional link length	16 km
New civil structures	3 tunnels, 18 rail bridges, 21 road bridges
New terminals	1 terminal
Infrastructure cost investment	CZK 27,400mil (GBP 930mil) in price level 2018 with 10% conting.

Table 1: HSR CZ (Praha (Běchovice) to Poříčany Section) Project Technical Facts.[8]

As the track plan shows in Figure 11, there are two double-track lines:

- The South connection of Prague central station via station Praha-Zahradní Město and a new alignment through Praha Běchovice, round the protected forest to concurrence with highway D11, and then heading southeast towards Brno as high-speed line RS1.
- The North connection of Prague central station via station Praha-Libeň and existing line to Praha Běchovice, where it turns to the new alignment alongside highway D11 and nearby station Poříčany connects the existing conventional lines towards Kolín and Nymburk, with provision for the future high-speed line RS5 towards Hradec Králové and Wroclaw, Poland.

[8] Mott MacDonald. *High Speed Railway in The Czech Republic Praha-Běchovice – Poříčany section (Bid Introduction).* Unpublished confidential document; 2020.

4. Objectives of the diploma thesis in relation to the given project

The analysis of the chosen project represents the implementation of the previously described theoretical chapter in real life. From the planning phase to the team management during the construction process, the explained ideas can be found in this actual project.

The HSR CZ Project is a perfect example of a large infrastructure project management. Although the project consists of the planning and real construction of the described section of the railway, the main purpose of the diploma thesis is the analysis of the whole process of the project management. This process includes tasks such as the description of the system of project management, the competency scheme of project stakeholders, the project phasing and tasking, the project time plan, or the division of the work among individual project participants.

Mott MacDonald is a global engineering, management, and development consultancy that leads a great number of interesting projects all over the world. They provided the necessary materials for this study, including confidential documents like the anti-bribery risk assessment. The company also contributed to the realistic point of view of the practical chapter and helped to understand and assimilate the research in project management. Even so, not everything was used in this work as it exceeded the purpose of the thesis.

Working with a real international company during the Erasmus year has contributed to the acquisition of a real sense of how big consultancies operate and the way in which they develop their projects while providing insight into the project management world. The enrichment of studying in a foreign university has been greater, not only by speaking and working in English but also by overcoming the social and performing differences between the Czech and Spanish cultures.

5. Project management

All deliverables (documents, models, and drawings) will be developed in ProjectWise. The principal software packages will be Civil 3D, AutoCAD 3D, Microstation V8i, and RailTrack. MS Office will be used for written deliverables – client requirements. MIDAS and Idea RS for structure analysis. Executive, Correspondence, Protocols, and Background Data will be saved on SharePoint.

The legal part of the project foresees some laws, assessments, and regulations. The Civil Code is the legal consideration than needs to be taken into account. There is also a "Strategic Environmental Assessment" (SEA) that is mandatory for the approval of the project, as is foreseen in EU legislation. The Environmental Impact Assessment (EIA) has to be carried out at the same time as the planning process. Finally, the high-speed railway lines must be constructed according to Regulation (EU) No. 1315/2013, Art. 11.2(a).

The organization of the management team from Mott MacDonald is displayed in Figure 12. Although most positions are not assigned to specific people, the goal is to show the team structure. On top of the chart, the client team from SŽ is shown in orange. The HSR Department Head is Martin Švehlik and the Project Manager is Marek Pinkava. The client reports directly to the Joint Venture Board, composed of three Project Directors from the three partners that will be presented in the next section. The Leadership Team from Mott MacDonald is led by the Project Manager. Additionally, the Interdisciplinary Coordinator, the Design Manager, and the Requirement Manager work at the same level, reporting to the Project Manager. The Pursuit Director of the project is Radko Bucek and the Pursuit Manager is Michal Babič.

Underneath the leading team, the management is divided into five groups:

- Technical Disciplines
- Three Lots according to the three stops of the line
- Speciality Expertise from the U.K Team
- Stakeholders and Environment Team
- Digital Platform

Finally, one last team is responsible for operations, cost estimate, construction planning, and risk assessment.

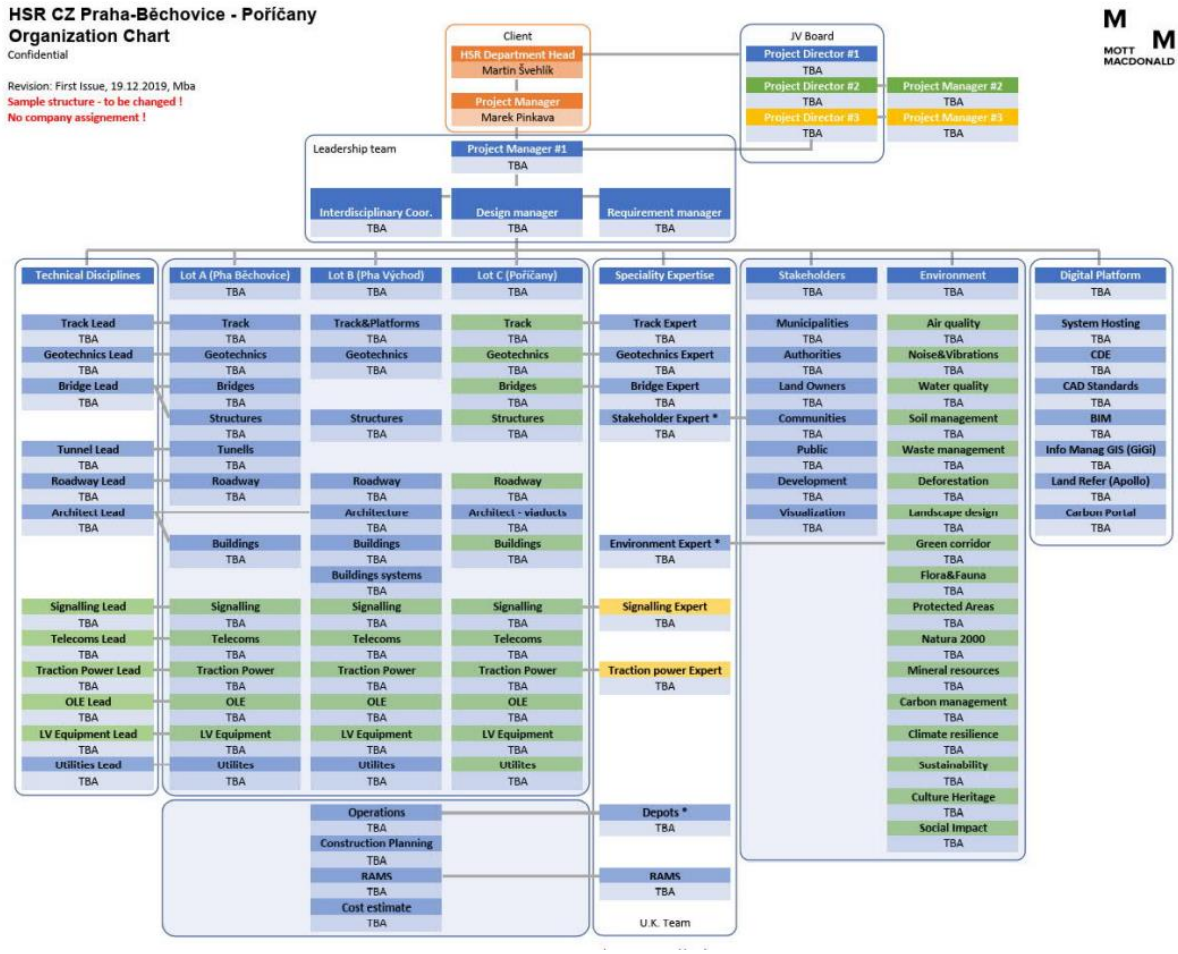

Figure 12: Mott MacDonald's Organization Chart for HSR CZ Project (Praha (Běchovice) to Poříčany section).[8]

6. Project stakeholders

"A stakeholder is an individual, group, or organization who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project. Stakeholders may be actively involved in the project or have interests that may be positively or negatively affected by the performance or completion of the project. Different stakeholders may have competing expectations that might create conflicts within the project. Stakeholders may also exert influence over the project, its deliverables, and the project team in order to achieve a set of outcomes that satisfy strategic business objectives or other needs." (PMBOK Guide, 2013).

After launching the tender for the documentation for the zoning decision and the documentation for the Environmental Impact Assessment (EIA) of the HSR CZ Project, the Czech Rail Infrastructure manager (Správa železnic, SŽ) selected the winning association based on qualitative indicators and the lowest price for documentation. The joint venture responsible for the project is composed of a Czech-French-British association: Sudop Praha is the first partner and administrator, Egis Rail (France) is the second partner, Mott MacDonald CZ is the third partner, and Mott MacDonald Limited (U.K.) is the fourth partner. Meanwhile, the Project Manager is Jan Nový and the Project Principal is Michal Babič (of the Mott MacDonald part only). The explained organization of the joint venture is shown graphically in Figure 13.

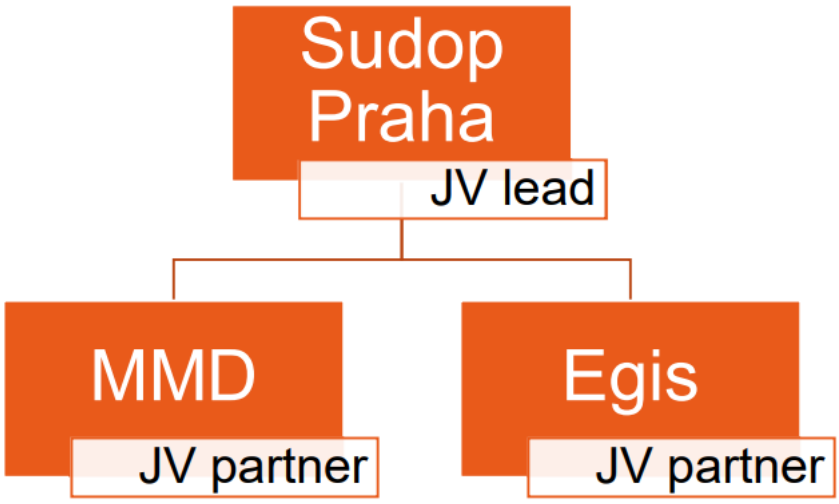

Figure 13: Joint venture hierarchy.[8]

Egis Rail is part of the Egis Group. The controlling shareholder (75%) in the Group is Caisse des Dépôts, a French public entity under the control of the French Parliament. The remaining 25% is held by Partner Managers (Iosis Partenaires) and by employees through the "FCPE" shareholding fund. The Chairman and CEO of the company is Nicolas Jachiet.

The second stakeholder is the Government, which is the investor and operator as explained previously. The sector of the planning funding is the State Fund for Infrastructure Projects of the Czech Republic (SFDI, Státní Fond Dopravní Infrastruktury in Czech). The necessary insurances for the project are Public and Products Liability (PPL), Commercial General Liability (CGL), and Third Party Liability (TPL).

GEFOS a.s. is the land surveying company responsible for the geodetic bearing of the Praha-Běchovice – Poříčany line.[9]

Recently, there has been a new cooperation agreement between Správa železnic and SNCF Réseau for the next 8 years. Representatives of the French national state-owned railway company will work with Czech experts on consulting decisions for the next stages of the HSR preparation.[10]

Finally, the rest of stakeholders such as the financial and legal advisor, the designers of the following stages of the project, the general contractor of construction, the suppliers of the construction part and traffic management technologies, or the companies providing maintenance and repairs are still on the tendering process, therefore the final bidder has not been decided yet.

[9] *SŽDC launched design tender for the first high-speed line.* Railway PRO. (2020, January 9). Retrieved July 3, 2022, from https://www.railwaypro.com/wp/szdc-launched-design-tender-for-the-first-high-speed-line/

[10] *Správa železnic has made significant progress in HSR preparation in past year*. (2021, December 12). Správa železnic - Press release [Online].

7. Project phasing and tasking

The general terms of the project life cycle were explained in section number seven of the Theoretical chapter. However, the high-speed railway project is a laborious and extensive one. Its phases are detailed and some might take more than ten years. According to the High Speed Railway System Implementation Handbook, the stages of the specific railway project process are organized in Figure 14:

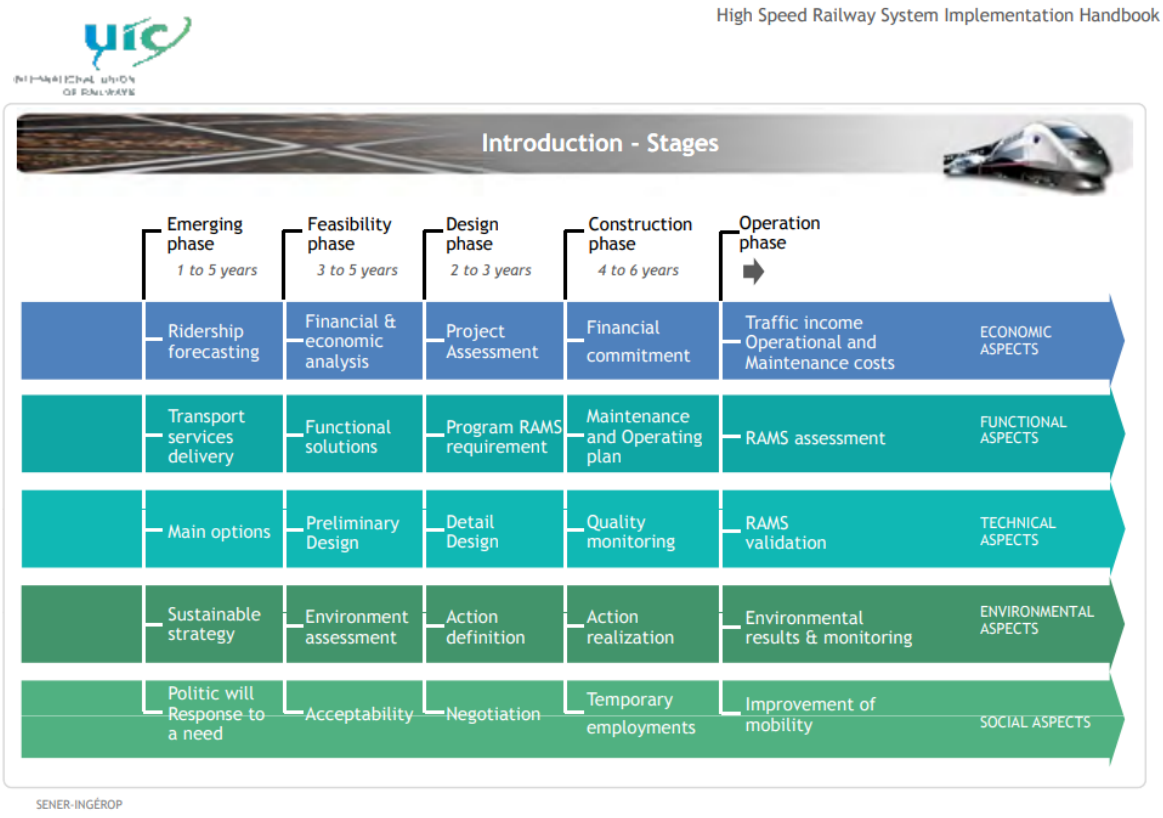

Figure 14: Project implementation phases and activities. Source: UIC handbook "High-Speed Railway System Implementation Handbook".

The five successive phases are arranged chronologically, and each of them has economic, functional, technical, environmental, and social aspects to take into account.

1. Emerging phase: The decision to implement a high-speed line in a country might come from a demand rise, from a political decision, or the preference for rail transportation. Once the project has emerged, some initial predictions must be made. The goals of the project should be clear, as well as estimated costs and

passenger flows. Studies on timetables, capacity, and operational aspects should be completed before the next phase.

2. Feasibility phase: The second phase includes the necessary analysis and assessments to ensure the viability of the project. The first one is the feasibility study, by which the costs are compared with the final outcome to decide if the project is feasible or not. Not only does it consider economic costs like planning or construction, but also social and environmental costs. This study must be fully completed, analyzing technical aspects, time, and operational savings, to give a real understanding of the project's future.

   The environmental management plan includes the environmental assessment, that examines the impact of the project and possible ways to moderate it.

   The financial and economic analysis determine if the project is profitable, so the large initial investment from the government is returned.

   Gathering all these studies, the multicriteria analysis is aimed at selecting the best option for the development of the project.

   Finally, the preliminary design is essential for determining the route, technical aspects, and power supply. If everything is correct, the procurement phase is prepared and the project is ready to begin.

3. Design phase: A plan for maintenance and operation must be developed, taking into account the infrastructure needs of the project. The detailed design is the solution to technical, architectural, and landscaping problems, with the specific final route, material, and labor needs. By the end of this phase, the project continues with the tendering procedure.

4. Construction phase: The basis for the construction planning is an elaborate schedule. It should foresee realistic periods for the construction work steps and foresee as many unexpected events as possible.

   Once the planning stage and the tendering process conclude, the construction stage starts. It's crucial that this process is cautiously supervised and documented. Also, it's important to follow the plan carefully and try to minimize deviations from the initial plan.

When the construction stage is finished, the final outcome must be tested and the safety and legal restrictions should be met.

5. Operation phase: The last phase of the project includes activities that ensure appropriate reliability and the correct functioning once the line has started to operate. Additionally, it is important to investigate and review the whole process of the project as well as the final result. This gives an overview of the project, analyzing mistakes or things to improve, in order to take them into account for future projects.

Specifically, the project scope of the the Poříčany section was part of the preliminary design in the Feasibility phase and consisted of three main tasks:

- The preliminary design for the new high-speed railway and related structures and measures.
- The environmental impact assessment and the feasibility study.
- The planning permit application, including state bodies, self-governance, and public inquiry.

8. Project timeline

The analyzed design of the Poříčany section of the full HSR Project has already been finished and followed the schedule shown in Table 2. The work commencement started in January 2021 and lasted five months, followed by the technical conception period between June and October of the same year. The concept delivery was done in February 2022, and the final release finished the process in March.

Months	Work commencement	Technical conception	Concept delivery	Final release
01/2021				
02/2021				
03/2021				
04/2021				
05/2021				
06/2021				
07/2021				
08/2021				
09/2021				
10/2021				
11/2021				
12/2021				
01/2022				
02/2022				
03/2022				

Table 2: Timeline of the Poříčany section design from the Project HSR CZ

Source: Author.

Despite the closed process of the first described section, the ongoing HSR Project has a longer timeline, as displayed in Table 3. The processes shown in this table are the organized tasks described in the previous section "Project phasing and tasking".

The route and project studies began in 2013 and lasted till 2017 when the Government approved the Program. After that, the feasibility studies were carried out for four years. In 2021, three pilot sections were designed, including the Praha (Běchovice) to Poříčany

section described before. The other two sections are expected to be finished by 2023 when the detailed design will begin. The construction period is forecasted to last between 2025 and 2050. It will be divided into two periods: firstly, construction according to the FIDIC contracts, in French 'Fédération Internationale des Ingénieurs – Conseils' (The International Federation of Consulting Engineers) till 2030, when the first sections are expected to open. Finally, the Programme Implementation Completion (PIC) process will be carried out between 2030 and 2050.

Timeline	HSR Studies	Government approval	Feasibility studies	Preliminary design	Detailed design	Construction	PIC
2013							
2014							
2015							
2016							
2017							
2018							
2019							
2020							
2021							
2022							
2023							
2024							
2025							
2026							
2027							
2028							
2029							
2030							
Till 2050							

Table 3: Full project HSR Timeline. Source: Author.

9. Division of tasks among individual project stakeholders

According to Mott MacDonald's confidential documents, the necessary tasks to complete the Poříčany section design were divided between the members of the association. The division of work between Mott MacDonald CZ and UK was done the following way:

1. Mott MacDonald CZ has been responsible for tracks, roadways, bridges, tunnels, and buildings design for HSL Praha-Běchovice – Terminal Praha Východ (quadruple track, 9 km in length, terminal excluded) and for connection to the conventional network at Praha-Běchovice station (4 km in length).

2. Mott MacDonald Limited (U.K.) was in charge of the technical advisory from experts with experience in HSL design in disciplines: tracks, bridges, and geotechnics. Their role was to support the team during the design conception phase and make high-level technical reviews of designed solutions.

10. Overview of current situation and follow-up tasks of the project.

In 2021, three sections of the new line have been designed according to the official documents regarding zoning laws. These are the Krušnohorský tunel (Ore Mountains Tunnel), the VRT Jižní Morava (HSR South Moravia) between Modřice and Šakvice and the VRT Polabí (HSR Elbe Flatlands) between Prague and Poříčany. The main purpose has been to connect the Czech Republic with Western Europe.

Another important step forward has been the decision by the European Commission to include the future new lines in the TEN-T Core Network.

In 2022, the project is in the pre-project phase. The environmental impact assessment and feasibility studies are being done and approved. The completion of the zoning proceedings is expected by Správa Železnic in 2023.

Afterward, the following steps include:

- The selection of a designer and preparation of documentation for the construction and technology of the project. Eight new sections are intended to be designed next year.

- The elaboration of a new detailed construction budget, which will be the basis for comparing suppliers' quotations and for project cost management.

- Followed by a selection procedure concerning the general contractor of the construction and technology subcontractors. The tender documentation is usually prepared based on project documentation by a specialized consultant. By next year, documentation for 300 new kilometers should be ready.
- The project will be supervised by the technical supervision of the construction and the investor's steering committee.
- A demanding phase is the trial operation and approval of the building
- According to the contract and budget plan, the construction will be covered by state funds.
- The construction insurance during construction work will be provided by the contractor.

The public contracts of the project will be the first ‘Design & Build’ type. "Design and build is a term describing a procurement route in which the main contractor is appointed to design and construct the works, as opposed to a traditional contract, where the client appoints consultants to design the development, and then a contractor is appointed to construct the works." (Designing Buildings, 2022).

As stated in the time schedule, the construction works are expected to begin in 2025 and will last till 2030. But the project won't be complete and implemented until 2050.

11. Summary and conclusion

The high-speed rail in the Czech Republic is undeveloped compared to the rest of Europe. This is why in 2014 the Czech Government approved a program aimed at modernizing the railway network, called the High-Speed Railway in the Czech Republic (HSR CZ). Like Jan Ilík[11] assured in the 13th International Conference Modern Electrified Transport (MET'2017) that "The lack of capacity on the most important parts of the conventional network is thus representing one of the most critical issues for the railway sector and its development and is becoming critical for its further growth and its further intermodal competitiveness.

In addition, the ambition to construct an HSR system in the Czech Republic appears urgent regarding to the need of (i) reorganization of the railway network. This decision takes into account both, the internal requirements of the Czech Republic and the development of the infrastructure abroad and, at the same time, (ii) The objective is to optimize the transport flows in the coming decades, as well as to remedy some of the major deformations, which can be seen on the current network."

Therefore, the urge and motivation to carry out the project are contended by the necessity of a renewed high speed railway. Additionally, the HSR project will contribute to the socio-economic development of the named regions and it will serve 5.5 million people, which is almost half the Czech population.

On the whole, high-speed rail is a high-cost solution but it brings many positive outcomes. As the US High Speed Rail Association on their website "Faster, more efficient mobility, enormous energy savings, reduced environmental damage — a train system solves many problems:

• Offers a convenient, comfortable way to travel without hassles or delays
• Congestion Relief — delivers new mobility while relieving congestion on highways and runways
• Drastically reduces oil addiction and lowers our risk from the coming peak oil crisis
• Freedom from oil — Powered by clean electricity from renewable energy sources: wind, solar, geothermal, ocean/tidal...
• Safe, affordable, green transportation for everyone
• Saves lives, due to fewer road accidents

[11] Ministry of Transport, Department of Railway and Waterborne Transport, Czech Republic.

• Provides efficient mobility that moves people and goods without delay and waste
• Creates millions of green jobs Europe-wide building the new rail infrastructure and manufacturing the rail cars".

Even though infrastructure projects usually differ in uncountable features, the management basics are common to all of them. As a result, the guidelines described in the theoretical chapter are present in the practical part. The chosen project is the representation of the project management methodology of an infrastructure project.

Firstly, the theoretical chapter is the summary of the research that has been carried out. It describes the planning phase, which is the first stage of a project. It also provides the guidelines for managing an infrastructure project. Choosing an effective team to work with is essential for the project's success. Therefore, the project manager and the project team are the engines of the process and orchestrate projects from the beginning to the end. Stakeholders are those involved in the project in some way. Managing the project stakeholders is aimed at deciding the necessary roles that will take part in the organization, as well as their level of authority.
The planning stage continues with the project schedule. There are several methods to organize the necessary tasks and predict the length of the process in the most accurate way. Budgeting is a key part of the project plan, including the CAPEX and OPEX item calculation, as well as the life cycle cost calculation. Risk management includes an analysis that affects the project‘s feasibility, and the level of risk tolerance determines the acceptance of the project.
Finally, when all these planning elements are gathered, the project definition is complete. The tendering process begins and the funding decisions are made. Public-Private Partnership (PPP) is a usual way of financing infrastructure projects.
Later, the most important task is managing and controlling the processes once the project has started, adapting to changes and threats while trying to stick to the initial plan.

Secondly, the practical part is aimed at studying and examining the HSR Project in the Czech Republic, with the help of the company Mott MacDonald. The guidelines to plan an infrastructure project are described in the real project, from the planning phase to the team management during the construction process. As a huge infrastructure project, managing it is a laborious process.

Furthermore, cooperating with Mott Macdonald has been a great challenge, especially learning how large infrastructure projects are prepared and implemented with the participation of major international companies. The official unpublished documents provided by them have been crucial for the completion of the task.

Infrastructure project management is a great combination of the engineering and business management worlds. This study helps to acquire valuable knowledge for a future job in the sector. Also, working with an international company and a director who is a professional in the field has contributed to the acquisition of a real sense of how big consultancies operate and the way in which they develop their projects while providing insight into the project management world. The enrichment of studying in a foreign university has been greater, not only by speaking and working in English but also by overcoming the social and performing differences between the Czech and Spanish cultures.

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ANNEX I: ALLIGNMENT WITH SUSTAINABLE DEVELOPMENT GOALS.

The Sustainable Goals from the United Nations gather the world's main problems to be solved by society and they are the objectives every country should consider when making decisions.
Mott MacDonald is a specialist in designing and delivering projects to maximise their contribution to achieving all seventeen of this Goals. Some of their biggest achievements have been becoming carbon neutral in 2020 or joining the World Economic Forum's Alliance of CEO Climate Leaders, becoming one of the seventy companies calling on world leaders to make greater efforts in the race to net-zero. They also take part in the Coalition for Climate Resilient Investment and support the Powering Past Coal Alliance.

This project is mainly aligned with four Goals, although it could be related to some other. First of all, goal number 9 is about industry, innovation, and infrastructure. This thesis contributes to building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. By learning how to manage large infrastructure projects, this goal's targets are more easily reachable. For instance, target 9.1 is to "Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all." (United Nations, 2022)

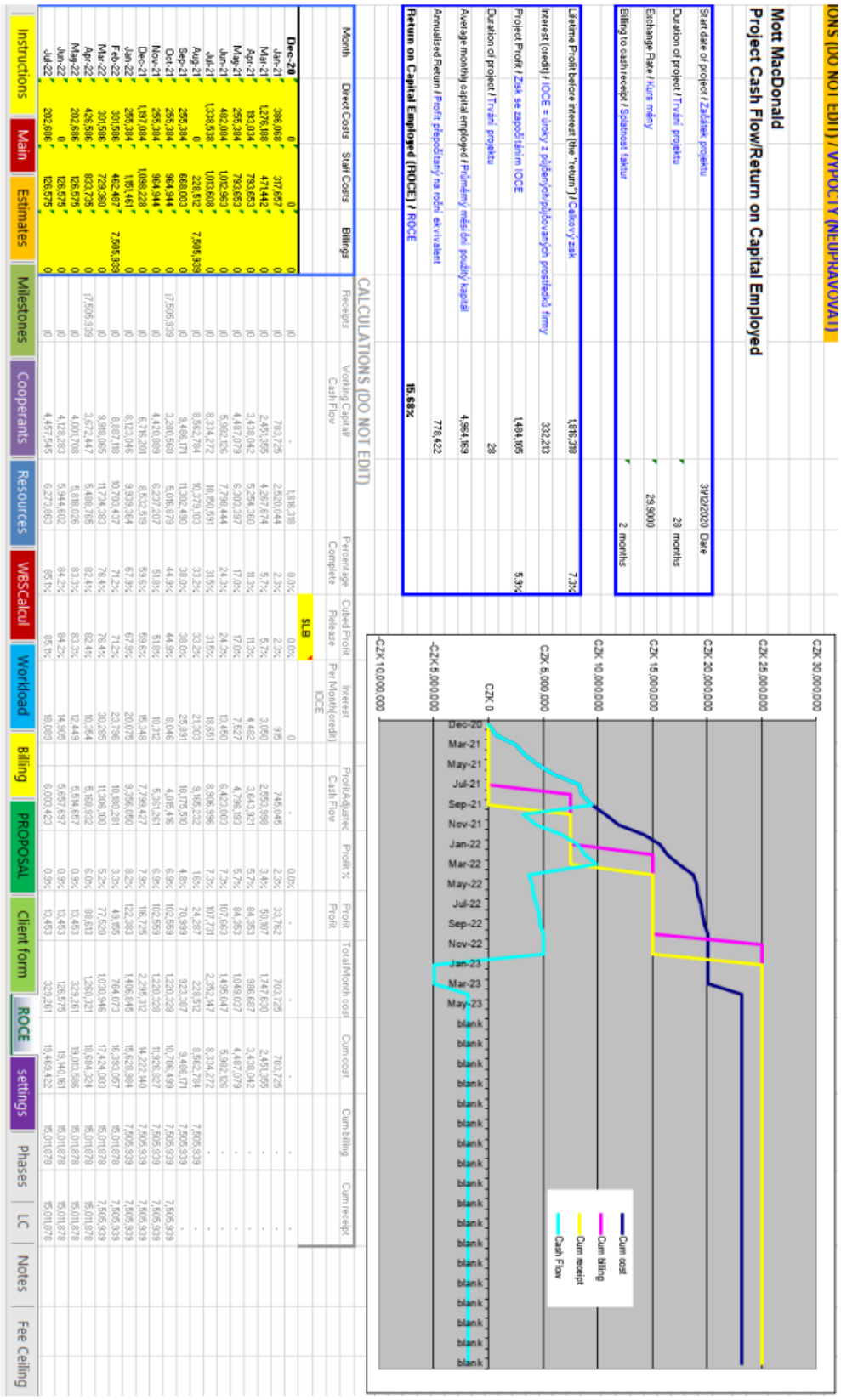
The second goal is number 8: Decent work and economic growth. Large projects contribute to the promotion of sustained, inclusive, and sustainable economic growth, full and productive employment, and adequate work for all. This kind of projects involve many different professionals, helping against unemployment by providing decent work for everyone. Consequently, enterprises that participate in them benefit from this job creation and are able to grow more easily. Infrastructure projects also entail economic benefits for the cities they are built in and for the public sector.

The third contribution is to goal number 10: Reduced inequalities. Reduce inequality within and among countries. Finding the most affordable and sustainable way of carrying out this kind of projects, helps to build better infrastructures in undeveloped countries and

help in their growth. This way, the project contributes to the fight against discrimination and it's a step towards a greater equality.

Finally, the last contribution is to goal number 11: Sustainable cities and communities. Make cities and human settlements inclusive, safe, resilient, and sustainable. By improving infrastructures in cities, the population's quality of life is improved. For example, the United Nations stated that "Only half of the world's urban population have convenient access to public transport" (2019). By constructing adequate public transport network, or improving the existing ones, this number could be reduced, and it could be assured that every person has access to the public transport system.

ANNEX II


IONS (DO NOT EDIT) / VYPOCTY (NEUPRAVOVAT)
Mott MacDonald
Project Cash Flow/Return on Capital Employed
Start date of project / Začátek projektu
3/02/2020 Date
Duration of project / Trvání projektu
28 months
Exchange Rate / Kurs měny
29.9000
Billing to cash receipt / Splatnost faktur
2 months
Lifetime Profit before interest (the "return") / Celkový zisk
1,816,318
7.3%
Interest (credit) / IOCE = úroky z půjčených/půjčovaných prostředků firmy
332,213
Project Profit / Zisk se započítáním IOCE
1,484,105
5.9%
Duration of project / Trvání projektu
28
Average monthly capital employed / Průměrný měsíční použitý kapitál
4,964,169
Annualised Return / Profit přepočítaný na roční ekvivalent
778,422
Return on Capital Employed (ROCE) / ROCE
15.68%
CZK 30,000,000
CZK 25,000,000
CZK 20,000,000
CZK 15,000,000
CZK 10,000,000
CZK 5,000,000
CZK 0
-CZK 5,000,000
-CZK 10,000,000
Dec-20
Mar-21
May-21
Jul-21
Sep-21
Nov-21
Jan-22
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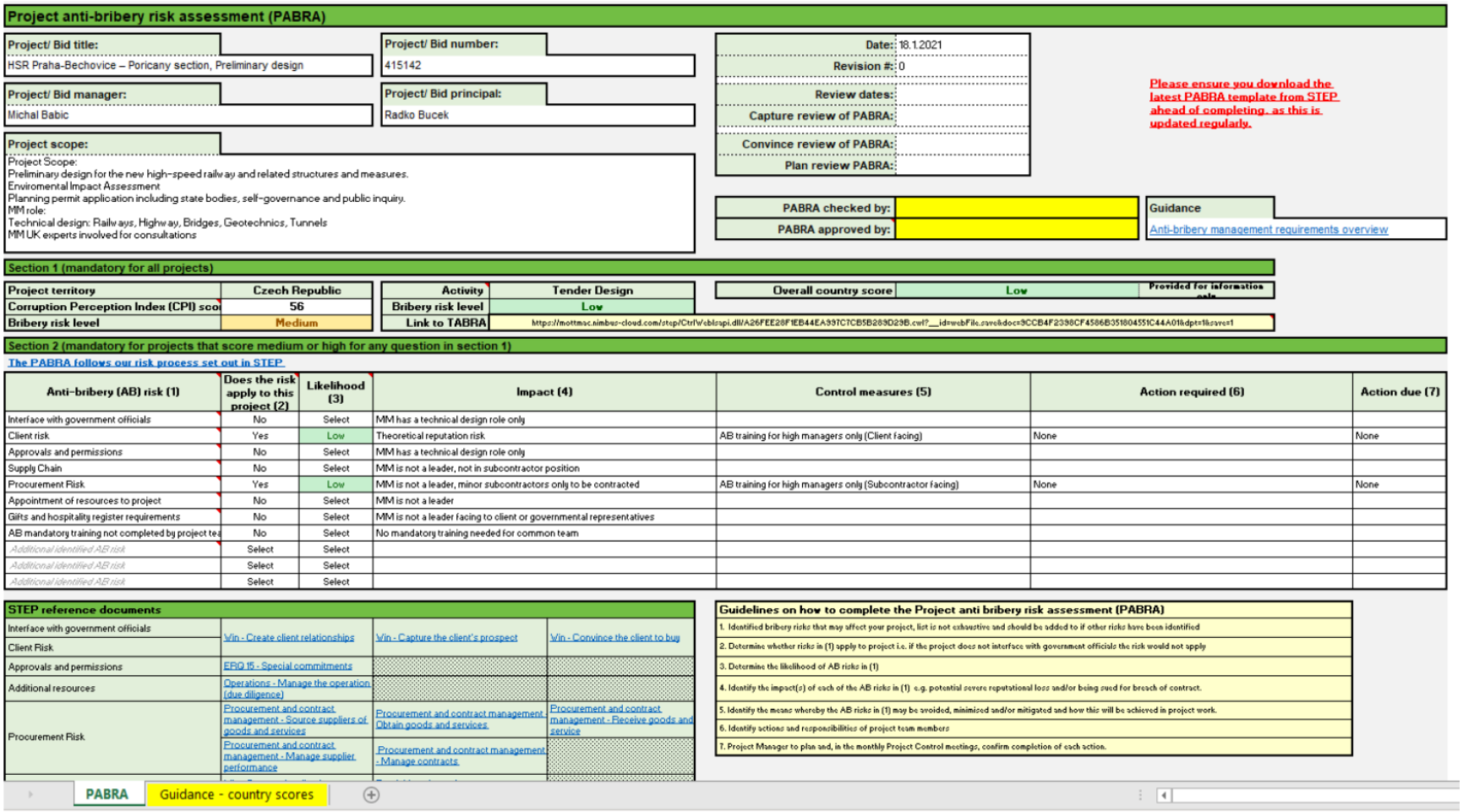
May-22
Jul-22
Sep-22
Nov-22
Jan-23
Mar-23
May-23
Cum cost
Cum billing
Cum receipt
Cash Flow
CALCULATIONS (DO NOT EDIT)
Month
Direct Costs
Staff Costs
Billings
Receipts
Working Capital/ Cash Flow
Percentage Complete
Cubed Profit Release
Interest Per Month(credit) IOCE
Profit/Adjusted Cash Flow
Profit %
Profit
Total Month cost
Cum cost
Cum billing
Cum receipt
SLB
Dec-20 0 0 0 0 0 0.0% 0 0 0.0% - - - - -
Jan-21 386,068 317,857 0 0 1,816,318 0.0% 0 746,045 2.3% 33,762 703,725 703,725 - -
Mar-21 1,276,188 471,442 0 0 703,725 2.3% 916 2,553,898 3.4% 50,107 1,747,630 2,451,355 - -
Apr-21 893,034 793,853 0 0 2,451,355 5.7% 3,050 3,643,921 5.7% 84,353 986,687 3,438,042 - -
May-21 256,384 793,853 0 0 3,438,042 11.3% 4,482 4,796,893 5.7% 84,353 1,049,037 4,487,079 - -
Jun-21 482,084 1,012,963 0 0 4,487,079 17.0% 7,827 6,423,003 5.7% 84,353 1,495,047 5,982,126 - -
Jul-21 1,338,538 1,093,609 0 0 5,982,126 24.3% 10,451 8,906,996 7.3% 107,653 2,362,147 8,334,272 - -
Aug-21 0 228,512 7,506,939 0 8,334,272 31.5% 13,651 21,303 1.6% 24,267 226,512 8,562,784 7,506,939 -
Sep-21 255,384 668,000 0 0 8,562,784 33.2% 25,991 10,075,560 4.8% 70,989 323,387 8,886,171 7,506,939 -
Oct-21 255,384 964,944 0 0 9,486,171 38.0% 44,9% 8,046 6.9% 102,569 1,220,328 10,706,499 7,506,939 -
Nov-21 255,384 964,944 0 0 3,200,660 5,016,679 44.9% 4,015,416 6.9% 102,569 1,220,328 11,926,827 7,506,939 -
Dec-21 1,897,084 1,098,228 0 0 4,420,889 6,237,207 51.8% 10,312 5,351,261 6.9% 102,569 2,295,312 14,222,140 7,506,939 -
Jan-22 255,384 1,151,461 0 0 6,716,201 8,532,519 59.6% 15,348 7,739,427 7.9% 116,726 2,295,312 14,222,140 7,506,939 -
Feb-22 301,586 462,487 7,506,939 0 8,123,046 9,933,364 67.3% 20,075 9,356,050 8.2% 122,383 1,406,845 15,628,984 7,506,939 -
Mar-22 301,586 723,360 0 0 8,887,119 10,703,437 71.2% 23,798 10,880,281 3.2% 49,455 764,073 16,393,057 15,011,878 7,506,939
Apr-22 426,586 833,735 0 0 3,916,085 11,734,383 76.4% 30,285 11,306,100 5.2% 77,520 1,030,946 17,424,003 15,011,878 7,506,939
May-22 202,686 126,679 0 0 3,672,447 5,488,755 82.4% 10,354 5,168,932 6.0% 88,613 1,260,321 18,684,324 15,011,878 15,011,878
Jun-22 0 126,679 0 0 4,001,708 5,816,026 83.3% 12,449 5,514,857 0.9% 13,453 329,261 19,013,586 15,011,878 15,011,878
Jul-22 202,686 126,679 0 0 4,128,283 5,944,602 84.2% 14,905 5,657,697 0.9% 13,453 126,679 19,140,161 15,011,878 15,011,878
4,457,545 6,273,863 85.1% 18,089 6,003,423 0.9% 13,453 323,261 19,463,422 15,011,878 15,011,878
Instructions
Main
Estimates
Milestones
Cooperants
Resources
WBSCalcul
Workload
Billing
PROPOSAL
Client form
ROCE
settings
Phases
LC
Notes
Fee Ceiling

ANNEX III



Project anti-bribery risk assessment (PABRA)

Project/ Bid title:	HSR Praha-Bechovice – Poricany section, Preliminary design
Project/ Bid number:	415142
Project/ Bid manager:	Michal Babic
Project/ Bid principal:	Radko Bucek

Project scope:

Project Scope:
Preliminary design for the new high-speed railway and related structures and measures.
Enviromental Impact Assessment
Planning permit application including state bodies, self-governance and public inquiry.
MM role:
Technical design: Railways, Highway, Bridges, Geotechnics, Tunnels
MM UK experts involved for consultations

Date:	18.1.2021
Revision #:	0
Review dates:	
Capture review of PABRA:	
Convince review of PABRA:	
Plan review PABRA:	

Please ensure you download the latest PABRA template from STEP ahead of completing, as this is updated regularly.

PABRA checked by:	
PABRA approved by:	

Guidance

Anti-bribery management requirements overview

Section 1 (mandatory for all projects)

Project territory	**Czech Republic**	**Activity**	**Tender Design**	**Overall country score**	**Low**
Corruption Perception Index (CPI) sco	56	**Bribery risk level**	**Low**		**Provided for information only**
Bribery risk level	**Medium**	**Link to TABRA**	https://mottmac.nimbus-cloud.com/step/CtrlWebApi.dll/A26FEE28F1EB44EA997C7CB5B289D29B.cwf?__idnwebFile.cweb.doc=3CCB4F2398CF4586B351804551C44A01&dpt=1&cover=1		

Section 2 (mandatory for projects that score medium or high for any question in section 1)

The PABRA follows our risk process set out in STEP

Anti-bribery (AB) risk (1)	Does the risk apply to this project (2)	Likelihood (3)	Impact (4)	Control measures (5)	Action required (6)	Action due (7)
Interface with government officials	No	Select	MM has a technical design role only			
Client risk	Yes	Low	Theoretical reputation risk	AB training for high managers only (Client facing)	None	None
Approvals and permissions	No	Select	MM has a technical design role only			
Supply Chain	No	Select	MM is not a leader, not in subcontractor position			
Procurement Risk	Yes	Low	MM is not a leader, minor subcontractors only to be contracted	AB training for high managers only (Subcontractor facing)	None	None
Appointment of resources to project	No	Select	MM is not a leader			
Gifts and hospitality register requirements	No	Select	MM is not a leader facing to client or governmental representatives			
AB mandatory training not completed by project tea	No	Select	No mandatory training needed for common team			
Additional identified AB risk	Select	Select				
Additional identified AB risk	Select	Select				
Additional identified AB risk	Select	Select				

STEP reference documents			
Interface with government officials	Win - Create client relationships	Win - Capture the client's prospect	Win - Convince the client to buy
Client Risk			
Approvals and permissions	ERQ 15 - Special commitments		
Additional resources	Operations - Manage the operation (due diligence)		
Procurement Risk	Procurement and contract management - Source suppliers of goods and services	Procurement and contract management - Obtain goods and services	Procurement and contract management - Receive goods and service
	Procurement and contract management - Manage supplier performance	Procurement and contract management - Manage contracts	

Guidelines on how to complete the Project anti bribery risk assessment (PABRA)
1. Identified bribery risks that may affect your project, list is not exhaustive and should be added to if other risks have been identified
2. Determine whether risks in (1) apply to project i.e. if the project does not interface with government officials the risk would not apply
3. Determine the likelihood of AB risks in (1)
4. Identify the impact(s) of each of the AB risks in (1) e.g. potential severe reputational loss and/or being sued for breach of contract.
5. Identify the means whereby the AB risks in (1) may be avoided, minimised and/or mitigated and how this will be achieved in project work.
6. Identify actions and responsibilities of project team members
7. Project Manager to plan and, in the monthly Project Control meetings, confirm completion of each action.

PABRA | Guidance - country scores

ANNEX IV

MOTT MACDONALD

TABRA Czech

Territory Anti-Bribery Risk Assessment (TABRA)

Territory: Czech Republic

Territory Manager: Radko Bucek

Date: 30/10/2019
Rev: 1

ABRA approved By: Radko Bucek

Territory bribery risk:
Low. As we work (95%) for only three major Public clients in Czech Republic (Highway agency, Railway agency, Prague municipality) that are constantly under scrutiny of media, politicians and public and all tenders and contracts are publicly available, the room for bribery is very low. I am not aware of a single case of bribery in recent years and also I did not face a single request, or hint that bribe is expected.

Section 1 (mandatory for all territories)

Territory	Czech Republic
CPI score	59
Bribery risk level	Medium

Section 2 (mandatory for territories that score medium or high for any question in section 1)

Anti Bribery (AB) Risk (1)	Does the risk apply to this terr	Likelihood (3)	Impact (4)	Control measures (5)	Action required (6)	Action Due (7)
Interface with government officials	Only publicly at official events	non	non - only marketing	not necessary	non	non
Client risk	Low (see above)	low	theoretical reputation risk	AB training only few top managers in MM CZ talk to clients	non	non
Approvals and permissions	Processes and deadlines given by law - non	non	non			
Supply Chain	Low	low	low	contracts signed by two execs/mandatory minitenders	non	non
Procurement Risk	medium	low	medium	Exiger, MM contract templates, two signatories	non	non
Appointment of resources to territory	no - only 3 clients, long-term relationship	non	non	non	non	non
Gifts and hospitality register requirements	non	low	low	updated gift register, regularly audited	non	non
AB mandatory training not completed by team	low	low	low	100 % e-learning ethics courses	non	non
Additional identified AB risk						
Additional identified AB risk						
Additional identified AB risk						

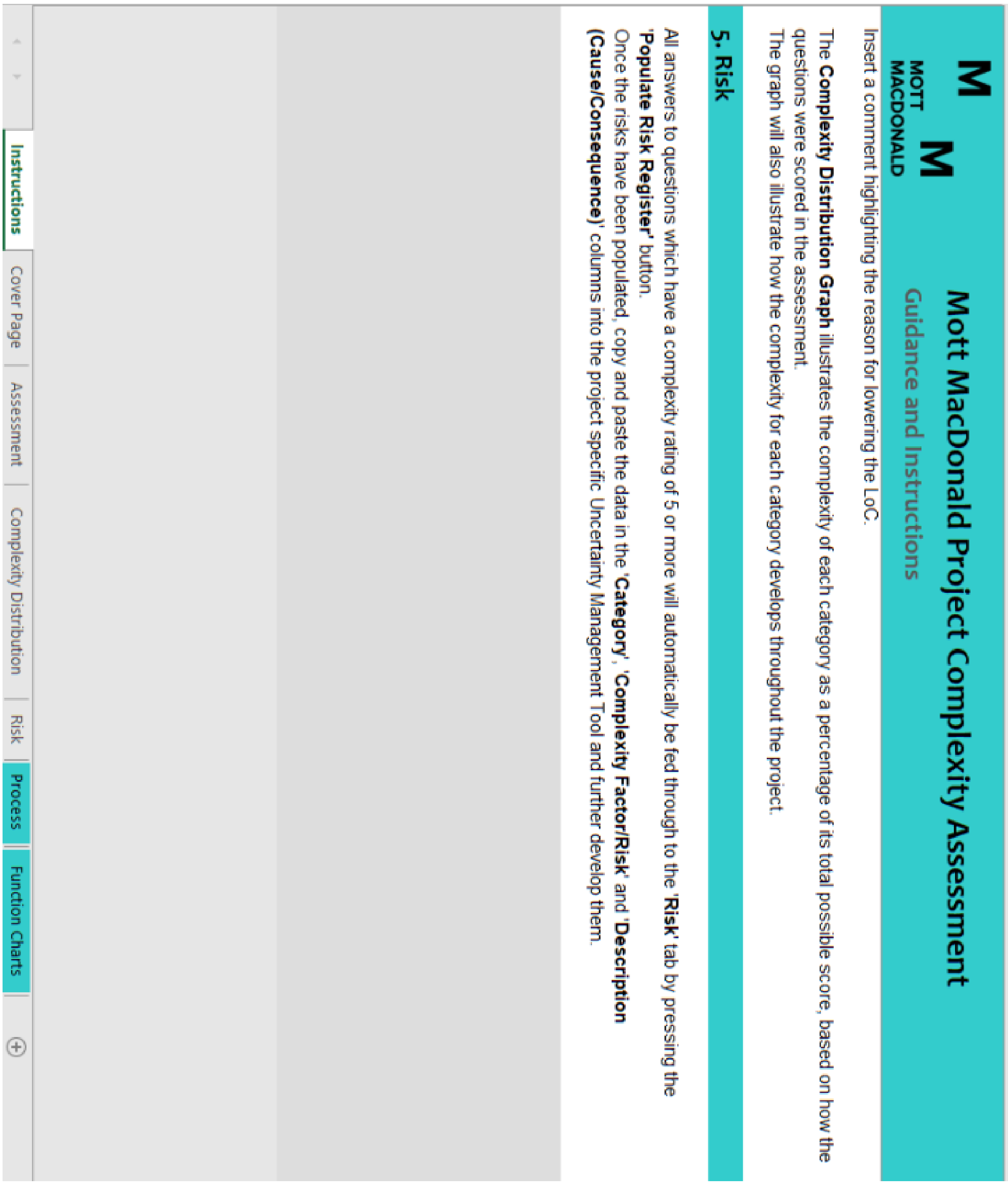
STEP reference documents			
Interface with government officials	Win I Create client relationships	Win I Capture the client's prospect	Win I Convince the client to buy
Client Risk	Win I Create client relationships	Win I Capture the client's prospect	Win I Convince the client to buy
Approvals and permissions	EBQ 15 I Special Commitments		
Additional resources	EBQ 6 I Due Diligence		

Guidelines on how to complete the Anti bribery Risk Assessment (ABRA)

1 Identified bribery risks that may affect your territory, list is not exhaustive and should be added to if other risks have been identified

2 Determine whether risks in (1) apply to territory i.e. if the territory does not interface with government officials the risk would not apply

ANNEX V



Mott MacDonald Project Complexity Assessment
Guidance and Instructions
MOTT MACDONALD
Insert a comment highlighting the reason for lowering the LoC.
The Complexity Distribution Graph illustrates the complexity of each category as a percentage of its total possible score, based on how the questions were scored in the assessment.
The graph will also illustrate how the complexity for each category develops throughout the project.
5. Risk
All answers to questions which have a complexity rating of 5 or more will automatically be fed through to the 'Risk' tab by pressing the 'Populate Risk Register' button.
Once the risks have been populated, copy and paste the data in the 'Category', 'Complexity Factor/Risk' and 'Description (Cause/Consequence)' columns into the project specific Uncertainty Management Tool and further develop them.
Instructions
Cover Page
Assessment
Complexity Distribution
Risk
Process
Function Charts

Project Complexity Assessment

Win Stage - Plan The Bid (Mandatory)

CHECK QUESTIONNAIRE

Q	Complexity Factor	Description	Rating	Selection	Win Stage Plan The Bid (Mandatory)	Comments
1	Fee basis	Fixed fee (lump sum)	10	●		
		Target cost with pain gain	10	○		
		Timescale with cap (reimbursable time and materials, not-to-exceed)	8	○		
		Fixed fee with well-defined program or timescale with difficult reimbursement penalties	7	○		
		Timescale no cap (reimbursable time and materials)	1	○		
2	Payment terms	Very onerous. More than 20% of milestone payments are dependent on client or 3rd Party approvals Pay when paid arrangements A combination of difficulties such as: Delayed payments & Performance bonds	10	○		
		Onerous – with a single but major difficulty, such as deferred payment or retention.	7	○		
		Manageable – requires attention to ensure prompt payment, e.g. due to complex client billing process.	5	○		
		Straightforward – simple to invoice or a process we are already familiar with and operate good payment cycle.	1	●		
3	Contract Terms	Very Onerous e.g: Uninsured Risks Unpredictable dispute resolution process anticipated (Weak rule of applicable law, no arbitration clause in an undeveloped jurisdiction / legal system) Uncapped liquidated damages Provision for Evergreen performance bond	10	○		
		Onerous e.g: Cap On Liability is greater than10 times the fee Fitness for purpose obligation	8	○		

Instructions | Cover Page | Assessment | Complexity Distribution | Risk | Process | Function Charts

Project Complexity Distribution

	Risk Categories	Complexity Score	Complexity Distribution	Level of Control	Can the level of control be dropped? (Yes or No)	New Level of Control	Comment
Win Stage - Plan The Bid (Mandatory)	Scope/Delivery	26	28.9%	LoC200	Yes	LoC100	New HSR system, but known client; Client given technical manual
	Schedule (time)	7	70.0%	LoC400	Yes	LoC300	Review during project start, effectively manageable with client; client is open for negotiations usually
	Commercial/Contractual	48	40.0%	LoC200	No	LoC200	Fixed conditions based on SZDC template
	Resource	7	35.0%	LoC200	Yes	LoC100	In time resource planning by experienced PM
	Interface	14	28.0%	LoC200	No	LoC200	

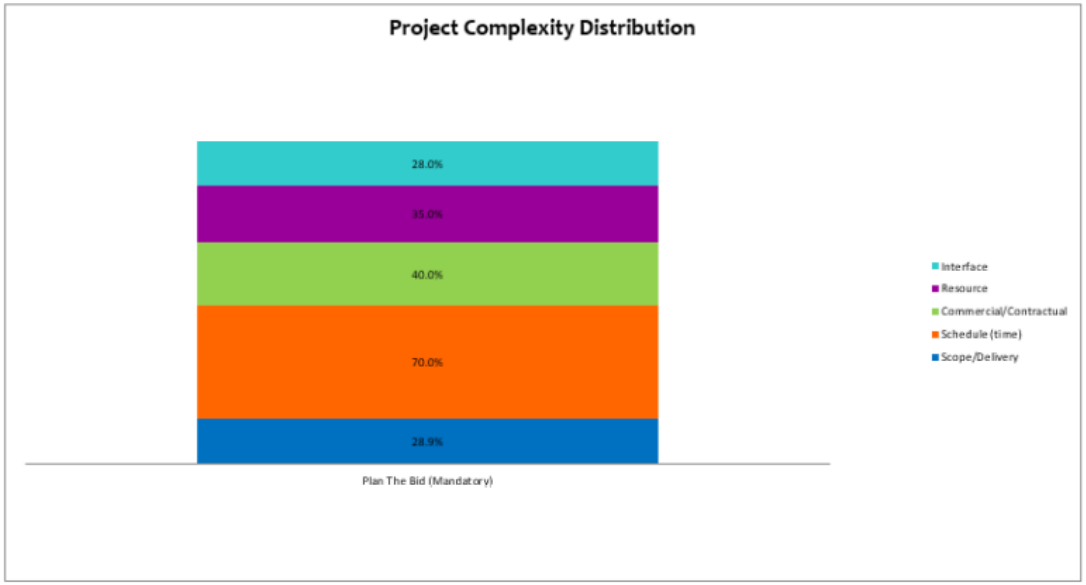
	Complexity Score	Overall Level of Control	Relevant Function Chart	Minimum PM competency level	Recommended PM competency level	Recommended PP competency level
Win Stage - Plan The Bid (Mandatory)	102	LoC200	B	2	3	4

Scoring Boundaries

LoC100	LoC200	LoC300	LoC400
0-19	20-40	41-53	54-90
0-2	3-4	5-6	7-10
0-25	26-54	55-70	71-120
0-4	5-9	10-12	13-20
0-10	11-22	23-29	30-50

Overall Complexity Score

<61	61-130	131-170	>170



Instructions | Cover Page | Assessment | Complexity Distribution | Risk | Process | Function Charts

Project Complexity Risk Output

POPULATE RISKS

Category	Complexity Factor	Description	Complexity Score
Commercial/Contractual	Fee basis	Fixed fee (lump sum)	10
Commercial/Contractual	Fee size	Between £1m and £10m (or GBP equivalent)	7
Commercial/Contractual	Average Rate of Spend (Gross Revenue)	Between £100k/month and £500k/month (or GBP equivalent)	5
Interface	Other MM inputs	More than one Unit	5
Resource	No of staff (under MM management control)	20 to 50	5
Commercial/Contractual	Team structure	JV – MM as junior partner	8
Scope/Delivery	Technical risk, with respect to MM scope	Single novel systems/methods/technology	7
Commercial/Contractual	Client Type	Public Sector – good payment cycle	5
Schedule (time)	Schedule	Challenging schedule with late delivery penalty	7
Scope/Delivery	Client maturity	Understands its business but with limited competence in the service provided by MM.	7
Commercial/Contractual	Country Ethics / Sanctions	Corruption Perceptions Index rating of 50-74	5

Enhanced Project Controls Process

1. Determine Level of Control

Using the Project Complexity Assessment, determine the Level of Control required.
Observe the Complexity Distribution to investigate any risk categories requiring a greater consideration.

Low Complexity →			High Complexity
LoC100	LoC200	LoC300	LoC400

2. Refer to relevant Function Chart

Relate the Level of Control to the corresponding Function Chart to determine the extent of Project Control input.
Use the Function Chart as a guide as to how to set up your project team.
If a project is LoC300, in some cases, it may be beneficial to seek advice from internal project management specialists. They will be able to support team set up, bespoke systems or provide more general expertise.
If a project is LoC400, it is mandatory that project management professionals are contacted for advice.

3. Select a suitable Project Manager

Project Principals and Project Managers should all be assessed using **Tracker**.
Overall 'application' competency levels are correlated to Level of Control using the below matrix.
Competencies are broken down into the same five risk categories as the Level of Control.
Project Principal's must be at least 1 competency level higher than the Project Manager i.e. a Level 3 Project Principal can only mentor Level 1 or 2 Project Managers

Required Level of Control

Application Competence	100	200	300	400
1				
2				
3				
4				
5				

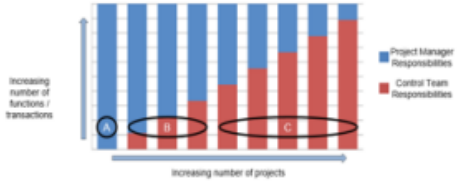
	Light Green	Competency of Project Manager is greater than required and is not the best use of resource if more complex projects are available.
	Green	Recommended level of Project Manager Competence
	Amber	Permissible level of competence provided the selected Project Principal has experience of successful delivery of projects of this complexity (or greater) and is able to guide and mentor the Project Manager.
	Red	Inadequate level of competence - significant risk of project failure

Function Charts

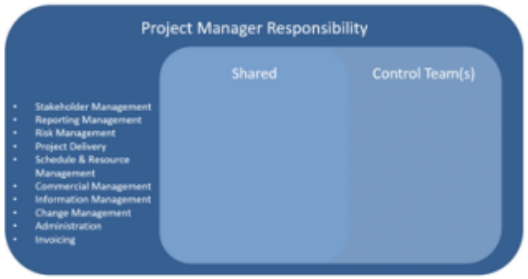
Relate the Level of Control to the corresponding Function Chart to determine the extent of Project Control input needed. This should support the discussion around team formation and required resource between the project leaders.

Level of Control	Relevant Function Chart
100	A
200	B
Portfolio 100 & 200	C
300	D
400	E
Portfolio 300 & 400	E

When there is a portfolio of LoC100 and 200 projects, refer to the bar graph. With an increasing number of projects to manage, more functions should be shared or assigned to the Project Control Team, indicated by the increase in the red bars. In this incidence, Function Chart C should be considered.



Function Chart A

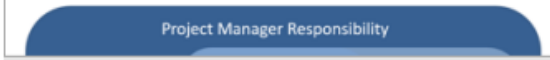


Function Chart B

Function Chart C

Function Chart D

Function Chart E



ANNEX VI

Mott MacDonald Uncertainty Management Tool

Instructions

Version Number: 1.2

This tool has been developed to improve the efficiency and quality of recording and measuring risk. Its purpose is to house the project specific risks and opportunities in a standardised manner, quantify their proposed impact or benefit, and determine an appropriate level of risk contingency.

All cells that require an input from the user are coloured yellow.

1) Complete the information fields on the **Cover Page** tab.
2) **Copy the initial risks generated from the Complexity Model and paste them as values (using paste options) in cell C9 of the Risks tab i.e. right click -> "Paste Options" -> "Values".**
   The risks generated from the Complexity Model should be used as a prompt therefore, review the generated risks and remove/amend to suit.
3) Add project specific Risks/Opportunities to the **Risks** or **Opportunities** registers as appropriate and **expand and elaborate** on each.
4) Ensure all Risks/Opportunities have a unique reference number.
5) Quantify the 'Anticipated Cost' by denoting a 'Minimum Cost', 'Most Likely Cost' and 'Maximum Cost' per Risk/Opportunity. **All three values must be entered.**
6) Assess the impact that the Risk would have on the 'Schedule' (VH, H, M, L, VL) based on the matrix in the **Scoring Matrix** tab.
7) Indicate the 'Likelihood' (VH, H, M, L, VL) of the Risk/Opportunity occurring 'Pre Mitigation'/'Pre Enhancement'.
8) Describe the 'Proposed Mitigation'/'Actions to Optimise Opportunity'.
9) Indicate the 'Likelihood' (VH, H, M, L, VL) of the Risk/Opportunity occurring 'Post Mitigation'/'Post Enhancement'.
10) Complete the further four columns indicating individuals responsible, 'Status of Implementation' and comments.
11) Complete the **Opportunities** tab by following steps 3, 4, 5, 7, 8, 9 and 10.
12) To arrange the Risks/Opportunities in order of 'Max Cost' click on the red button on the relevant tab.

    Alternatively, order the columns using the filters to review the Risks/Opportunities.
13) In the **Financials** tab, click on the button 'Generate Financial Analysis' and observe the statistical analysis.

    It presents the statistical distribution and corresponding cost of Risks and profit improvement of Opportunities.

    Percentiles show a value that indicates the percentage chance of the value or less occurring.

    e.g. the Risk 70th percentile is 25,000. This indicates that 70% of the time, the cost incurred from risks will be 25,000 or less.

    e.g. the Opportunities 60th Percentile is 0 and the 70th Percentile is 11,000. This indicates that 60% of the time, 0 profit improvement will be gained; there is a 10% chance that between 0-11,000 would be gained; and 30% of the time, more than 11,000 would be gained. Therefore, it would be high risk to consider any profit improvement in the Risk Contingency.

    A pie chart then presents the largest areas of Risks and Opportunities.
14) Select a statistic for the 'Calculated Contingency' of Risk and compare that to a 'Calculated Contingency' of Opportunity to help determine a suitable project Risk Contingency.

    As a default, the value of contingency is set as the **Median**. Other percentiles can be selected by using the drop down menu.

    Agreed Contingency should the discussed with the Project Principal.
15) Record the Agreed Contingency in the 'Record of Allowance' section.

Instructions | Scoring Matrix | Cover Page | Risks | Opportunities | Financials

Mott MacDonald Uncertainty Management Tool

Scoring Matrix

Version Number: 1.2

Risk Criteria

					Likelihood				
				Description	Very Low	Low	Medium	High	Very High
				Guidance	Extremely unlikely to happen	Unlikely to happen	Low but not impossible	Fairly likely to happen	More likely to occur than not
				Probability	1-5%	5-15%	15-35%	35-50%	>50%
	Scenarios	Description	Cost (% of fee)	Schedule Impact (% of Project Duration)	Scale	1	2	3	4	5
Impacts	Critical Impact on achievement of objectives and overall performance. Huge impact on costs and / or reputation. Unrecoverable	Very High	>10%	>25%	5	5	10	15	20	25
	Major Impact on costs and / or objectives. Serious impact on output and / or quality and reputation. Long term to recover, expensive to recover	High	5-10%	10-25%	4	4	8	12	16	20
	Reduces viability, significant waste of time and resources, impact on operational efficiency, output and /or quality. Medium term effect / to recover which may be expensive to recover	Medium	2.5 - 5%	5-10%	3	3	6	9	12	15
	Minor loss, delay, inconvenience or interruption. Short term effect / to recover. Will cost a small amount of money to remedy	Low	1 - 2.5%	2.5-5%	2	2	4	6	8	10
	Minimal loss, delay, inconvenience or interruption. Can be easily and quickly remedied	Very Low	<1%	1 - 2.5%	1	1	2	3	4	5

Opportunity Criteria

					Likelihood				
				Description	Very Low	Low	Medium	High	Very High
				Guidance	Very remote probability that the event would occur	Event unlikely to occur	Event may occur only in exceptional circumstance	Fairly likely to happen	More likely to occur than not
				Probability	1-5%	5-15%	15-35%	35-50%	>50%
					1	2	3	4	5
				Description	Profit Improvement i.e. additional profit generated (% of fee)				
Profit Improvement									
				Very High	>10%	5	10	15	20	25
				High	5-10%	4	8	12	16	20
				Medium	2.5 - 5%	3	6	9	12	15
				Low	1 - 2.5%	2	4	6	8	10
				Very Low	<1%	1	2	3	4	5

Mott MacDonald Uncertainty Management Tool

Risk Inputs

Arrange in order of 'Max Cost'

ABC Spelling

Version

Copy the initial risks generated from the Complexity Model. **Paste risks as values (using paste options) into cell C9 i.e. right click -> "Paste Options" -> "Values".** Review the generated risks and remove/amend to suit. Add project specific risks and assess their cost, impact and likelihood.

				Values must be entered for each scenario			As defined in the Scoring Matrix							
				Anticipated Cost			Assessed Impact		Likelihood of Risk Occurring					
Unique Ref Number	Category	Complexity Factor/ Risk	Description (Cause/Consequence)	Min Cost	Most Likely Cost	Max Cost	Cost Impact	Schedule Impact	Pre Mitigation	Proposed Mitigation	Post Mitigation	Owner	Action by	Status Implem
10	Scope/Delivery	Client maturity	Understands its business but with limited competence in the service provided by MM.		-	20,000	Low			Limited knowledge due to fuirst HS job within country mitigated by internal pier reviews from UK experienced staffs to mentor our resourced/JV/client.				
11	Commercial/Contractual	Country Ethics / Sanctions	Corruption Perceptions Index rating of 50-74 CZ: 59			-	Very Low	Very Low	Very Low	Working with tested partners with high standards, Exiger.	Very Low	Bid Manager	PM	

Mott MacDonald Uncertainty Management Tool

Opportunity Inputs

Arrange in order of 'Max'

ABC Spelling

Version Number:

				Values must be entered for each scenario			As defined in the Scoring Matrix						
				Anticipated Project Profit Improvement			Assessed Impact	Likelihood of Opportunity Occurring					
Unique Ref Numb	Category	Opportunity Title	Description (Cause/Consequence)	Min	Most Likely	Max	Cost Impact	Pre Enhancement	Actions to Optimise Opportunity	Post Enhancement	Owner	Action by	Status of Implementation
2	Scope/Delivery	additional work	Additional work is rising during design stage. There is strong experience, that there could be space for additional work, that will be necessary for client but out of range of contracted scope		100,000	500,000	Very High	Low	Regular contact with Client , listen to clients demands and offering our solution. Definition of added value by extra work and convince the client to accommodate the changes as variations.	Medium	PM	PM	open
1	Scope/Delivery	profit	we are authors of previous design stages	-	5,000	20,000	Low	Low	Utilising advantage of having all relevant data from the past	Medium	PP	PM	open

Instructions | Scoring Matrix | Cover Page | Risks | **Opportunities** | Financials

Mott MacDonald Uncertainty Management Tool

Financial Outputs

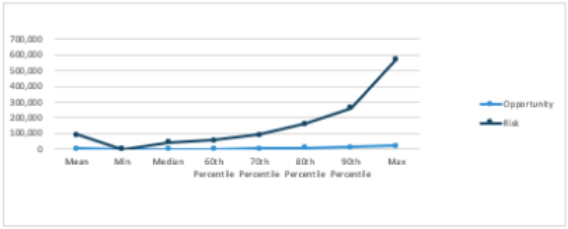
Generate Financial Analysis

Version Number: 1.2

Financial Risk Uncertainty

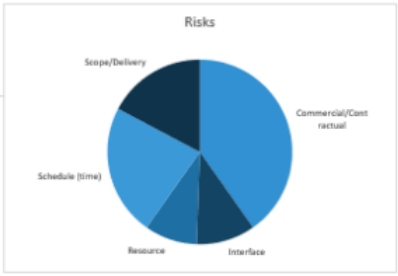
To recalculate click on the button 'Generate Financial Analysis'

	Opportunity	Risk
Mean	2,974	90,681
Min	0	0
Median	0	41,394
60th Percentil	0	54,827
70th Percentil	3,546	90,164
80th Percentil	7,454	160,975
90th Percentil	11,218	263,151
Max	19,804	572,120



High Cost Risks and Opportunities

	Opportunity	Risk
Commercial/ Contractual		35
Interface		9
Resource		8
Schedule (time)		20
Scope/Delivery	21	15



Calculated Contingency

Select the statistic to base your contingency on. This value is the calculated value rounded to the nearest 100

Risk Contingency		% of Gross Revenue	% of Gross Revenue excluding sub-contractors	% of Net Revenue
Median	41,400	3%	3%	4%

Opportunity Contingency		% of Gross Revenue	% of Gross Revenue excluding sub-contractors	% of Net Revenue
Median	-	0%	0%	0%

Opportunity Contingency should be quantified as potential future profit to Mott MacDonald. Opportunity Contingency should not be compared to Risk Contingency if the Opportunities recorded are based on total future fees as Risk is directly considering profit loss.

Record of Allowance

Please fill this in when the contingency allowance is changed

Date	Agreed Contingency	% of Gross Revenue	% of Gross Revenue excluding	% of Net Revenue	Comments
17/01/2020	95,000	7%	8%	10%	

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