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Risk Management in a General Context

The importance of risk management in the Melbourne Metro Tunnel project is due to the requirements of high performance and quality while resources are limited, as in many of the projects most contemporary firms take on. The Melbourne Metro Tunnel project is extensive and complex, with a large number of activities and stakeholders involved over a long period of time. Hence, the project also includes a large number of uncertainties. The concept of risk is a product of that uncertainty, and is defined as "a measure of the probability and consequence of not achieving a defined project goal" (Kerzner 2003, p.653). In order to secure project success, risk management should therefore be applied as a part project.

The risk management process consists of a number of stages as shown in Figure 1; establishing risk context, risk identification, risk analysis, risk evaluation and risk treatment. Finally, this results in a risk management plan, including risk treatment, risk monitoring and risk control that is to be followed up on continuously during the project delivery phase. This report will investigate and discuss these risk management procedures and stage by stage apply these on the Melbourne Metro Tunnel Project for the sake of exemplification.

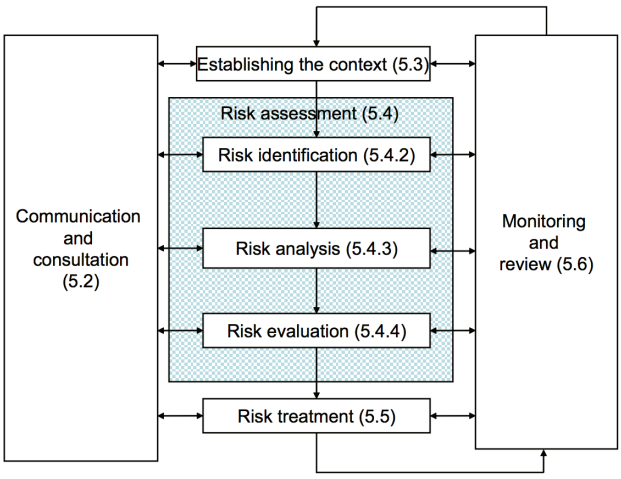


Figure 1: The risk management process (Standards Australia 2009, p.14)

Establishing Risk Context

When establishing the risk context, the purpose is to gather information that will provide knowledge about the project itself and the environment it operates in. This will be the basis of the risk management, hence, as in all project management, this first stage ought to be dedicated adequate resources in order to make an effective assessment in all later stages. The Melbourne Metro Tunnel project is primarily a high-public-impact-project, and hence this ought to be a high-focus-area of the investigation. Also, time, scope, technical properties, quality management and economy are important factors to investigate.

Project Brief

The Melbourne Metro Tunnel Project is a $10.9 investment which objective is to make the train traffic run more efficiently through Melbourne City (Melbourne Metro Rail Authority 2017, p.3). When the project is complete, there will be new twin rail tunnels and five new underground stations making space

for 39 000 more passengers in each peak period. The project was initiated 2016 and is expected to be finished by 2026 (Victoria's Big Build n.d.). The different project stages are shown in figure 2. The project is ordered by the Victorian Government and the party responsible for delivery is the Victorian Government body, Rail Projects Victoria (RPV).

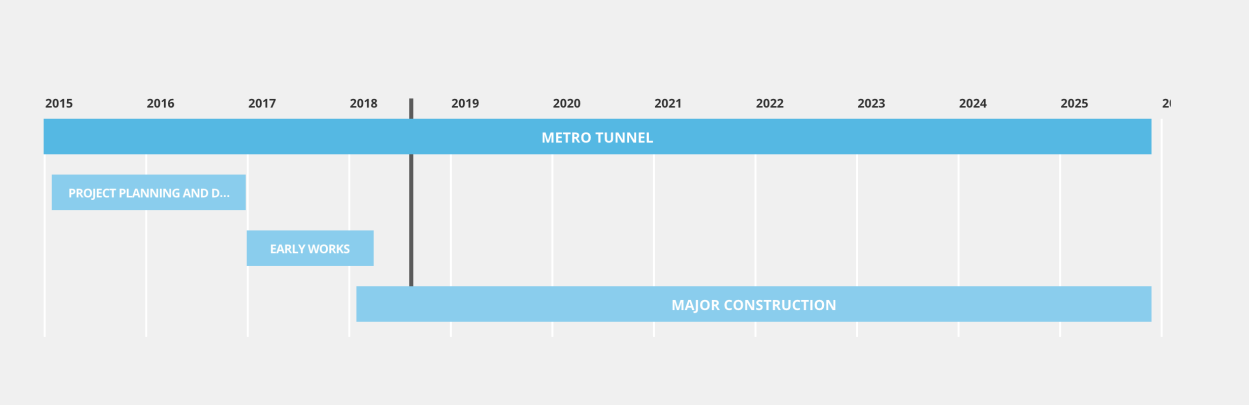


Figure 2: Project Timeline: (Victoria's Big Build n.d.)

Project Scope

In the metro tunnel project, 6 major categories of operations has been established which will lead to the overall delivery of the project. In all of these categories there will be a great number of underlying operations which in total will make out the complete scope of the project.

1. Preparing the construction site. This is done by relocating existing utility services on the construction site along with other similar operations.
2. Conducting tunnelling works and building mechanical and electrical systems for the train service.
3. Building rail infrastructure including decline structures, turn backs and local reconfiguration and realignment of existing lines.
4. Building rail systems (such as signalling systems), including design, installation works, rail systems integration and commissioning.
5. Building five underground stations including station fill-out and building mechanical and electrical systems along with preparing for maintenance services.
6. Conducting enhancements in the wider network including track modifications and upgrades to stations and signalling system.

(Metro Tunnel 2018)

Stakeholder Chart

Stakeholder	**Relation**	**Key Interest in Project**	**Project Phase**
Commuters	User	Safety and effectiveness in commuting, easy access and reliance in transport, aesthetics	During construction and after project finalization
Residential, surrounding properties and landowners	Affected	Non-disturbing construction process, non-disturbing performance (i.e. noise, smell, vibrations, crowdedness etc.), undisturbed utilities	During construction and after project finalization
The Victorian Government	Project owner	Effective legislation, high performance creating customer satisfaction. Responsible for state planning approvals	During all stages
Tax payers	Affected	Cost effectiveness	In payments
Construction firms and other project partners	Hired	Clear instructions, effective contracting process, good working conditions, effective synchronizing	During planning stage and construction

		between different construction firms, effective prizing, effective communication	
Local councils	Municipality	Responsible for local permits and approvals	During planning and construction stage
Train Franchisee	Managing the running system	Easily manageable system, effective commuter handling system that decrease crowds and lines, design and planning which support good working conditions.	After project finalization
Business owners inside and surrounding the new tunnel	Business relation	Design which supports good business, customer access, easy access for deliveries and maintenance.	After project finalization
Institutions (i.e. schools and health etc.)	Affected	Non-disturbing construction process, non-disturbing performance (i.e. noise, smell, vibrations, crowdedness etc.), undisturbed utilities	During construction and after project finalization
Media	Communication	Reporting details about project to the public	During all stages
Maintenance and cleaning firms	Hired	Easy access, plain surfaces, material easy to maintain.	After project finalization
Emergency Services	Hired	Secure areas and easy access in case of emergency or crime.	During construction and after project finalization

Table 1: Stakeholder Chart (Melbourne Metro Rail Authority 2017, p.10) (Melbourne Metro Rail Authority 2018, p.6)

Quality Control and Planning

A number of documents has been produced that will be used for managing quality throughout the project. In order to secure a successful outcome on environmental and stakeholder level, two frameworks have been established; the Metro Tunnel Environmental Management *Framework and the Community* and *Stakeholder Engagement Management Framework*.

The Melbourne Metro Tunnel project will contribute to the urban atmosphere of Melbourne where by an *Urban Design Strategy* has been established in order to make sure the finalized project will meet the existing guidelines of urban design. The *Business Support Guidelines for Construction* has been established in order to mend negative impacts implied on surrounding businesses due to ongoing and finalized project.

In order to secure an accurate execution of all internal activities a planning scheme has been established under which an *Early Works Plan* has been approved and commenced. Each contractor has also provided *Development Plans* extending the works relevant to them, which are for all later stages of the project. (Melbourne Metro Rail Project 2017, Appendix 2)

Project Economic Outcome

In the disclosure of nominal flows, displayed in Table 2, the Melbourne Metro Tunnel Project overall cost is displayed, including calculation of time value of money. This is based on the agreed contract between all of the project actors along with other necessary costs such as land acquisition, leasing costs to support the project and compensations for disturbances to the existing rail network caused by the project. Some of the costs will be covered by the state through capital contributions, and some costs will be covered by the future revenues generated from the project. (Melbourne Metro Rail Authority 2018, p.18)

Cost of contracted proposal (net present cost) as at 30 September 2017	Discount rate used to arrive at net present cost	Total cost of contracted proposal (nominal)	First full year payment (nominal)
$'million	%	$'million	$'million
5,240.4	5.70% and 5.19% for the State Contribution	9,580.7	187.0

Table 2: Disclosure of nominal Flows (Melbourne Metro Rail Authority 2018, p.17)

Risk Identification

Identification Method

The foundation to a successful risk assessment is a complete risk identification, and adoption to the right identification tools and techniques is a crucial part of achieving success in this (Rostami 2016). When choosing tools and techniques it is crucial to consider the established context.

Since the Melbourne Metro Tunnel is including activities on several different levels and in several different areas, the best way to make a complete risk identification process is to use different tools and techniques. This gives a broadness to the identification process and displays the different activities from several points of view which provides deep understanding. This increases the probability of acknowledging all relevant risks.

Personal experience or past organizational experience (Documentation review)
This has been identified as one of the most preferred tool to identify risks within an organisation, which is based on internal strengths and weaknesses (Rostami 2016). Key methodology is to review documents of the previous business plans, strategies, activities, contracts and other stored information. This uses internal resources, which often is resource effective and thereby a cheap but effective method.

Interview/focus group discussion/brainstorming
The Melbourne Metro Tunnel Project has high public effect. In order to gain understanding of this group of stakeholders there are possible gains to perform interviews on the interests and concerns. This is also a way of engaging people in the project in an early stage, which could be important for the project's general acceptance.

The method of interviewing can be made in group or as individual assessment. This is known to require a lot of resources in terms of time and organisational requirements (Rostami 2016). Furthermore, a second tool that can be used either separately or with the method of interviewing is Brainstorming, which is known as a more resource effective tool (Rostami 2016).

Examination of local or overseas experience
This is a sort of benchmarking. An effective way of identifying the unknown of the project is to learn from other similar projects that has been conducted. This method is resource effective and simple to evaluate. The possible struggle could be that responsible parties might not be willing to share sensible information about specific project, because of competitiveness and unwillingness to reveal information that could be harmful if spread.

Judgemental – Consensus, Speculative/Conjectural, Intuitive with experts;
According to Rostami (2016), a commonly preferred method is Expert Judgement. The report states that risk management experienced firms use the method because of: "affordability of resources required in

terms of time and budget; valuable results and outcomes; uncomplicated process to set up and quick to produce results". If the experts are available within the firm, this would facilitate the process. External experts might be expensive to access.

A useful tool in this process is the Delphi Process. As described by Hsu & Sandford (2007), "The technique is designed as a group communication process which aims to achieve a convergence of opinion on a specific real-world issue" furthermore "Delphi, in contrast to other data gathering and analysis techniques, employs multiple iterations designed to develop a consensus of opinion concerning a specific topic." The strength in this approach is that the iterative approach facilitates a continuous learning in a specific subject, allowing for alterations and improvements along the away as knowledge is accumulating.

Work Breakdown Structure Analysis
The work breakdown structure gives an overview of all activities in a project in relation, in relation to time and dependence. This makes it easier to address risks to every activity in specific. The work Breakdown structure can successfully be used in the previously mentioned methods, because it gives a good overview of the different stages and activities of the project.

Risk Identification

When identifying risk there are a number of sources to consider, Financial, Safety, Economic, Market, Political, Natural Events, Environmental, Social, Technological, Human Behaviour (Hou, 2018). The identified risks of the Melbourne Metro Tunnel Project are shown in Table 4.

Source	No	Risk Description
Financial (and insurance)	1	Risk in managing private sector financing (Melbourne Metro Rail Authority, 2018)
	2	Risk of change in base interest rate (Melbourne Metro Rail Authority, 2018)
	3	Refinancing losses (Melbourne Metro Rail Authority, 2018)
	4	Risk of increased tax (Melbourne Metro Rail Authority, 2018)
	5	Risk of change in insurance cost (Melbourne Metro Rail Authority, 2018)
Safety	6	Risk in workers safety during construction (e.g. high falls, cuts, burns, falling objects etc.)
	7	Risk in limited access for emergency services
	8	Risk in unsafe commuter environment after project delivery and people safety when finished (e.g. slippery floors, falls etc.)
	9	Risk in unsafe working environment for maintenance staff
Economic	10	Risk in land acquisition (Melbourne Metro Rail Authority, 2018)
	11	Risk of design changes during project affecting costs or time (Melbourne Metro Rail Authority, 2018)
	12	Risk that construction activities are delayed or delivered with increased cost
	13	Risk of damaging existing rail and commuter networks during construction activities and/or disturb its operations (Melbourne Metro Rail Authority, 2018)
	14	Risk that there might be defects in the construction which are identified after completion of construction (Melbourne Metro Rail Authority, 2018)
	15	Risk of delay from faulty, insufficient or wrong equipment on the work site (Melbourne Metro Rail Authority, 2018)
	16	Risk in poor communication between different contractors causing delay or increased costs

	17	Risk in implementation of ticketing system (Provision and performance) and interface with Franchisee (Melbourne Metro Rail Authority, 2018)
	18	Risk in tunnel and stations not meeting required performance (Melbourne Metro Rail Authority, 2018)
	19	Risk of increased lifecycle costs (Melbourne Metro Rail Authority, 2018)
	20	Risk of change in rail service levels (Melbourne Metro Rail Authority, 2018)
Market	21	Risk of a change in general commuter patterns
	22	Risk of new emerging technologies changing demand
	23	Risk of change in commercial opportunities affecting revenues from presumption (Melbourne Metro Rail Authority, 2018)
Political	24	Risk of change in legislation directly affecting the project in construction or maintenance phase (Melbourne Metro Rail Authority, 2018)
	25	Risk of change in legislation indirectly affecting the project in construction or maintenance phase ((Melbourne Metro Rail Authority, 2018)
Natural events	26	Risk of heavy rainfalls
	27	Risk of days with extreme temperatures
	28	Risk of natural disasters such as earth quakes
Environmental	29	Risk of unanticipated geotechnical properties or other conditions underground (Melbourne Metro Rail Authority, 2018)
	30	Risk of emissions and/or contamination (Melbourne Metro Rail Authority, 2018)
	31	Risk of disturbing the surrounding environment during construction (e.g. noise, smell, vibrations etc.)
	32	Risk of disturbing the surrounding environment after construction (e.g. noise, smell, vibrations etc.)
	33	Risk of impact from other projects in the area (Melbourne Metro Rail Authority, 2018)
Social	34	Risk of complains from public affecting the project (Melbourne Metro Rail Authority, 2018)
	35	Risk of historical (aboriginal) artefacts findings on site delaying the project (Melbourne Metro Rail Authority, 2018)
Technological	36	Risk of misalignment
	37	Risk of unsuccessful management interfaces with the Franchisee in track occupations, design development process and testing and commissioning
	38	Risk of poor utility synchronizing
Human behaviour	39	Risk of poor working moral amongst staff

Table 4: Risk Identification

Risk analysis

The risk analysis consists of two parts; the first identifying the likelihood of an identified risk and the second part will identify the consequence of the risk. The reason to make the analysis is to evaluate the significance of a risk based on qualified research made on each risk. The analysis is then displayed in a manner that allow a comparison of the risks, which in this study will be made through a rating system. What is important when constructing a rating system is to define what the different levels of risk signify. This is because managers view risks from different perspectives based on their experience and knowledge, and therefore they might rate this risk differently. Also, some personal features might affect the analysis process, as some people find it easier to accept risk, i.e. risk seekers, while other might be more risk adverse, leading them to give high ratings. This is why the risk analysis is difficult, especially when qualitative methods are used. (Kerzner 2003, p.670)

Risk Likelihood

The method of identifying the probability of an identified risk will be made using quantitative analyses when possible, otherwise the analysis will be made using qualitative analyses. In order to make a quantitative risk assessment in the Melbourne Metro Tunnel Project, there is need for simulations using historical data or information. This will then be used to make simulations based on statistical models. Collecting the required data or information can be made through historical outcome in previous representative projects, expert judgements, interviews or field investigations and research.

An example of this type of quantitative analysis is computer based simulation based on Monte Carlo. When using the Monte Carlo method, the simulation is based on a known distribution and variables generated from the historical data or information. This then generates simulated random sampling. The expected outcome of the risk is then decided from this simulation.

If there is no historical data available a qualitative assessment can be made. When there are risks concerning construction, computer based design tools can be used to make the estimation of risk. Solid Works is an example of this, which allows the user to simulate mechanics of materials in complex configurations. If no models can be made to analyse the risk, an expert judgement can be made.

When making the analysis, it is important to keep in mind that it often is extremely difficult to predict the future. When conducting simulation methods, the underlying data or information might be misguiding, which is threatening to produce a simulation output that will not be representative of reality. Therefor the simulations should be treated critically using qualitative assessments. Obviously, the qualitative methods can also be misleading when background information and experience are not adequate or if the environment in which the project is operating is changing. The conclusion is that assessing risk is a difficult procedure to make accurate, therefor this could become a resource dense activity in the risk management process.

The method used for identifying the likelihood of a certain risk will be to grade them on a scale from one to five according to Table 5:

Score	Likelihood descriptor	Description
1	Rare/ Highly unlikely	The event may occur only in exceptional circumstances
2	Unlikely	The event could occur at some time
3	Moderate/ Possible	The event should occur at some time
4	Likely	The event will probably occur in most circumstances
5	Almost certain/ Highly probable	The event is expected to occur in most circumstances

Table 5: Probability Grading Scale (Hou, 2018)

Risk Consequence

The consequence of the risks in the Melbourne Metro Tunnel project are identified using a qualitative assessment based on experience, knowledge and information about the specific risk in focus. Based on these assessments the consequence of the identified risk will be graded according to Table 6. The same discussion about qualitative analyses as in the part describing risk likelihood, applies here.

Score	Consequence	Description
1	Negligible/ Insignificant	Negligible impact upon objectives
2	Minor	Minor effects that are easily remedied
3	Moderate	Some objectives affected
4	Major	Some important objectives cannot be achieved

5	Severe/ Catastrophic	Most objectives cannot be achieved

Table 6: Consequence Grading Scale (Hou 2018)

Final Analysis

The final analysis is using the result from the identified likelihood The following table is a display of the result of the risk analysis. The colour coding is based on the Likelihood- Consequence Matrix seen in appendix 1. The purpose of the matrix is to categorize and compare the different risks from an emotionally neutral point of view. The way of categorizing the risk in different levels, with a specific colour, gives a clear overview for further assessment of the different risks.

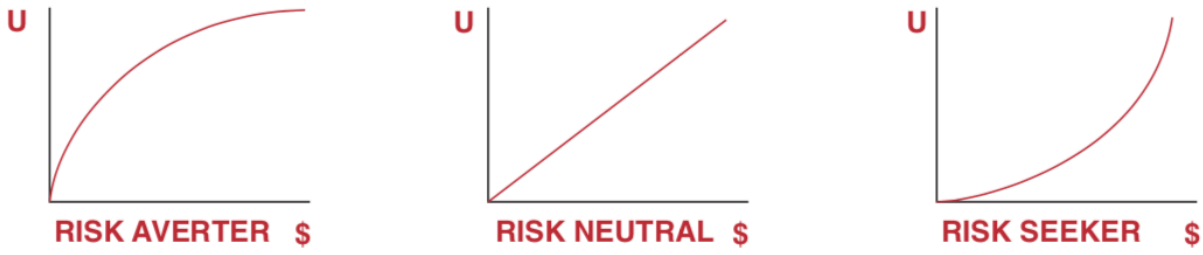
Source	**No**	**Risk Description**	**Likelihood Score**	**Consequence Score**	**Final Analysis**
Financial	1	Risk in managing private sector financing (Melbourne Metro Rail Authority, 2018)	2	3	6
	2	Risk of change in base interest rate (Melbourne Metro Rail Authority, 2018)	2	1	2
	3	Refinancing losses (Melbourne Metro Rail Authority, 2018)	1	2	2
	4	Risk of increased tax (Melbourne Metro Rail Authority, 2018)	1	2	2
	5	Risk of change in insurance cost (Melbourne Metro Rail Authority, 2018)	2	3	6
Safety	6	Risk in workers safety during construction (e.g. high falls, cuts, burns, falling objects etc.)	4	3	12
	7	Risk in limited access for emergency services	3	5	15
	8	Risk in unsafe commuter environment after project delivery and people safety when finished (e.g. slippery floors, falls etc.)	3	4	12
	9	Risk in unsafe working environment for maintenance staff	4	3	12
Economic	10	Risk in land acquisition (Melbourne Metro Rail Authority, 2018)	1	4	4
	11	Risk of design changes during project affecting costs or time (Melbourne Metro Rail Authority, 2018)	5	5	25
	12	Risk that construction activities are delayed or delivered with increased cost	4	4	16
	13	Risk of damaging existing rail and commuter networks during construction activities and/or disturb its operations (Melbourne Metro Rail Authority, 2018)	3	3	9
	14	Risk that there might be defects in the construction which are identified after completion of construction (Melbourne Metro Rail Authority, 2018)	3	4	12
	15	Risk of delay from faulty, insufficient or wrong equipment on the work site (Melbourne Metro Rail Authority, 2018)	4	3	12
	16	Risk in poor communication between different contractors causing delay or increased costs	3	3	9
	17	Risk in implementation of ticketing system (Provision and performance) and interface with Franchisee (Melbourne Metro Rail Authority, 2018)	2	3	6
	18	Risk in tunnel and stations not meeting required performance (Melbourne Metro Rail Authority, 2018)	3	5	15
	19	Risk of increased lifecycle costs (Melbourne Metro Rail Authority, 2018)	3	3	9
	20	Risk of change in rail service levels (Melbourne Metro Rail Authority, 2018)	1	2	2

Market	21	Risk of a change in general commuter patterns	1	1	1
	22	Risk of new emerging technologies changing demand	1	1	1
	23	Risk of change in commercial opportunities affecting revenues from presumption (Melbourne Metro Rail Authority, 2018)	3	1	3
Political	24	Risk of change in legislation directly affecting the project in construction or maintenance phase (Melbourne Metro Rail Authority, 2018)	2	4	8
	25	Risk of change in legislation indirectly affecting the project in construction or maintenance phase (Melbourne Metro Rail Authority, 2018)	2	3	6
Natural events	26	Risk of heavy rainfalls	2	3	6
	27	Risk of days with extreme temperatures	2	3	6
	28	Risk of natural disasters such as earth quakes	1	4	4
Environmental	29	Risk of unanticipated geotechnical properties or other conditions underground (Melbourne Metro Rail Authority, 2018)	3	4	12
	30	Risk of emissions and/or contamination (Melbourne Metro Rail Authority, 2018)	3	2	6
	31	Risk of disturbing the surrounding environment during construction (e.g. noise, smell, vibrations etc.)	4	3	12
	32	Risk of disturbing the surrounding environment after construction (e.g. noise, smell, vibrations etc.)	3	2	6
	33	Risk of impact from other projects in the area (Melbourne Metro Rail Authority, 2018)	3	2	6
Social	34	Risk of complains from public affecting the project (Melbourne Metro Rail Authority, 2018)	2	1	2
	35	Risk of historical (aboriginal) artefacts findings on site delaying the project (Melbourne Metro Rail Authority, 2018)	2	2	4
Technological	36	Risk of misalignment	3	3	9
	37	Risk of unsuccessful management interfaces with the Franchisee in track occupations, design development process and testing and commissioning	3	3	9
	38	Risk of poor utility synchronizing	2	3	6
Human behaviour	39	Risk of poor working moral amongst staff	2	2	4

Table 7: Risk Assessment

4. Risk evaluation

The risk evaluation is based on the risk assessment and decides how a project is supposed to act on each specific risk. In order to generate a plan for treatment and monitoring in a later stage, there is need for a risk strategy level to be established. In a general context some projects operate under high risk and do so knowingly in order to increase the chance of high return. This concept is displayed in Figure 2. A government owned project like the Melbourne Metro Tunnel Project should do the opposite, i.e. operate under a low risk level. This means that the project should carefully evaluate identified risks in order to secure a successful project. The reason behind doing the risk evaluation is because it is unlikely enough available resources to treat all the identified risks, which is why there is need to prioritise them to focus resources on certain risks.



The shape of a given decision-maker's curve is derived from comparing response to alternative decision acts.

Figure 2: Risk preference and the utility function (Kerzner 2003, p.655)

The criteria on which the risk evaluation is based are, according to Hou 2018; "Specified Consequences, The Likelihood of specified events or outcomes, the cumulative effect of multiple events and the range of uncertainty for the risk levels at some specified level of confidence". This means, the evaluation is conducted on a qualitative basis, for each activity identifying the value and risk of the activity in a bigger context.

Given the categorizing from the risk analysis the different risks of the Melbourne Metro Tunnel Project are prioritized. According to the established risk strategy, it is decided how the project will act on each risk, i.e. a risk priority is established as seen in Table 8. The priority scale is:

P1. Risk is not tolerable and needs treatment
P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
P3. Risk is low priority and no treatment except for monitoring
P4. No treatment

No	Risk Description	Likelihood Score	Consequence Score	Final Analysis	Priority
11	Risk of design changes during project affecting costs or time (Melbourne Metro Rail Authority, 2018)	5	5	25	P1. Risk is not tolerable and needs treatment
12	Risk that construction activities are delayed or delivered with increased cost	4	4	16	P1. Risk is not tolerable and needs treatment
7	Risk in limited access for emergency services	3	5	15	P1. Risk is not tolerable and needs treatment
18	Risk in tunnel and stations not meeting required performance (Melbourne Metro Rail Authority, 2018)	3	5	15	P1. Risk is not tolerable and needs treatment
9	Risk in unsafe working environment for maintenance staff	4	3	12	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
6	Risk in workers safety during construction (e.g. high falls, cuts, burns, falling objects etc.)	4	3	12	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
8	Risk in unsafe commuter environment after project delivery and people safety when finished (e.g. slippery floors, falls etc.)	3	4	12	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive

14	Risk that there might be defects in the construction which are identified after completion of construction (Melbourne Metro Rail Authority, 2018)	3	4	12	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
15	Risk of delay from faulty, insufficient or wrong equipment on the work site (Melbourne Metro Rail Authority, 2018)	4	3	12	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
29	Risk of unanticipated geotechnical properties or other conditions underground (Melbourne Metro Rail Authority, 2018)	3	4	12	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
31	Risk of disturbing the surrounding environment during construction (e.g. noise, smell, vibrations etc.)	4	3	12	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
13	Risk of damaging existing rail and commuter networks during construction activities and/or disturb its operations (Melbourne Metro Rail Authority, 2018)	3	3	9	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
16	Risk in poor communication between different contractors causing delay or increased costs	3	3	9	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
19	Risk of increased lifecycle costs (Melbourne Metro Rail Authority, 2018)	3	3	9	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
36	Risk of misalignment	3	3	9	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
37	Risk of unsuccessful management interfaces with the Franchisee in track occupations, design development process and testing and commissioning	3	3	9	P2. Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive
24	Risk of change in legislation directly affecting the project in construction or maintenance phase (Melbourne Metro Rail Authority, 2018)	2	4	8	P3. Risk is low priority and no treatment except for monitoring
1	Risk in managing private sector financing (Melbourne Metro Rail Authority, 2018)	2	3	6	P3. Risk is low priority and no treatment except for monitoring
5	Risk of change in insurance cost (Melbourne Metro Rail Authority, 2018)	2	3	6	P3. Risk is low priority and no treatment except for monitoring
17	Risk in implementation of ticketing system (Provision and performance) and interface with Franchisee (Melbourne Metro Rail Authority, 2018)	2	3	6	P3. Risk is low priority and no treatment except for monitoring
25	Risk of change in legislation indirectly affecting the project in construction or maintenance phase ((Melbourne Metro Rail Authority, 2018)	2	3	6	P3. Risk is low priority and no treatment except for monitoring
26	Risk of heavy rainfalls	2	3	6	P3. Risk is low priority and no treatment except for monitoring
27	Risk of days with extreme temperatures	2	3	6	P3. Risk is low priority and no treatment except for monitoring
30	Risk of emissions and/or contamination (Melbourne Metro Rail Authority, 2018)	3	2	6	P3. Risk is low priority and no treatment except for monitoring
32	Risk of disturbing the surrounding environment after construction (e.g. noise, smell, vibrations etc.)	3	2	6	P3. Risk is low priority and no treatment except for monitoring
33	Risk of impact from other projects in the area (Melbourne Metro Rail Authority, 2018)	3	2	6	P3. Risk is low priority and no treatment except for monitoring
38	Risk of poor utility synchronizing	2	3	6	P3. Risk is low priority and no treatment except for monitoring
10	Risk in land acquisition (Melbourne Metro Rail Authority, 2018)	1	4	4	P3. Risk is low priority and no treatment except for monitoring

28	Risk of natural disasters such as earth quakes	1	4	4	P3. Risk is low priority and no treatment except for monitoring
35	Risk of historical (aboriginal) artefacts findings on site delaying the project (Melbourne Metro Rail Authority, 2018)	2	2	4	P4. No treatment
39	Risk of poor working moral amongst staff	2	2	4	P4. No treatment
23	Risk of change in commercial opportunities affecting revenues from presumption (Melbourne Metro Rail Authority, 2018)	3	1	3	P4. No treatment
2	Risk of change in base interest rate (Melbourne Metro Rail Authority, 2018)	2	1	2	P4. No treatment
3	Refinancing losses (Melbourne Metro Rail Authority, 2018)	1	2	2	P4. No treatment
4	Risk of increased tax (Melbourne Metro Rail Authority, 2018)	1	2	2	P4. No treatment
20	Risk of change in rail service levels (Melbourne Metro Rail Authority, 2018)	1	2	2	P4. No treatment
34	Risk of complains from public affecting the project (Melbourne Metro Rail Authority, 2018)	2	1	2	P4. No treatment
21	Risk of a change in general commuter patterns	1	1	1	P4. No treatment
22	Risk of new emerging technologies changing demand	1	1	1	P4. No treatment

Table 8: Risk Evaluation

5. Risk treatment

The process of risk treatment is when resources are allocated to the different risks in order to prevent them or mend the consequences in case of impct. There are different ways of treating risks based on the priority, required action and resources available. According to the Australian standard AS/NZS ISO 31000-2009 (Standards Australia 2009, p.19) some prime treatments are:

T1. Risk avoidance
T2. Accepting risk in order to pursue an opportunity
T3. Removing the risk from the source
T4. Challenge the likelihood of the risk
T5. Challenge the consequence of the risk
T6. Sharing or completely shift the risk on to another party, risk transfer
T7. Retaining risk based on an informed decision

When selecting risk treatments to the risks in the Melbourne Metro Tunnel project considerations should be assigned to the balance of cost of treatment in relation to cost of risk in an economical, legal, commercial, environmental and social context. The stakeholders should also be included in this process, as their interests are important to the project's success.

No	Risk Description	Priority	Treatment
11	Risk of design changes during project affecting costs or time (Melbourne Metro Rail Authority, 2018)	Risk is not tolerable and needs treatment	T3. Establishing a Design Management Plan
12	Risk that construction activities are delayed or delivered with increased cost	Risk is not tolerable and needs treatment	T6. Contracting
7	Risk in limited access for emergency services	Risk is not tolerable and needs treatment	T3. Design and Work Standards

18	Risk in tunnel and stations not meeting required performance (Melbourne Metro Rail Authority, 2018)	Risk is not tolerable and needs treatment	T3. Establishing a Design Management Plan
9	Risk in unsafe working environment for maintenance staff	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T3. & T6. Establishing a Design Management Plan and Contracting
6	Risk in workers safety during construction (e.g. high falls, cuts, burns, falling objects etc.)	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T3. & T6. Construction site design and Work Standards. Insurance.
8	Risk in unsafe commuter environment after project delivery and people safety when finished (e.g. slippery floors, falls etc.)	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T3. Establishing a Design Management Plan
14	Risk that there might be defects in the construction which are identified after completion of construction (Melbourne Metro Rail Authority, 2018)	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T6. Contracting BOOT, BOT, PPP
15	Risk of delay from faulty, insufficient or wrong equipment on the work site (Melbourne Metro Rail Authority, 2018)	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T6. BOOT, BOT, PPP Contracting
29	Risk of unanticipated geotechnical properties or other conditions underground (Melbourne Metro Rail Authority, 2018)	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T7. Tunnelling management
31	Risk of disturbing the surrounding environment during construction (e.g. noise, smell, vibrations etc.)	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T3. Community and Stakeholder Engagement Management Framework
13	Risk of damaging existing rail and commuter networks during construction activities and/or disturb its operations (Melbourne Metro Rail Authority, 2018)	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T7. Insurance and BOOT, BOT, PPP Contracting
16	Risk in poor communication between different contractors causing delay or increased costs	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T3. Establishing a contractor communication plan
19	Risk of increased lifecycle costs (Melbourne Metro Rail Authority, 2018)	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T3. & T5. Establishing a Design Management Plan
36	Risk of misalignment	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T3. & T7. Establishing a Design Management Plan. BOOT, BOT, PPP Contracting
37	Risk of unsuccessful management interfaces with the Franchisee in track occupations, design development process and testing and commissioning	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T3. & T6. In the Design Management plan, handle the cooperation with the Franchisee
	Risk No: 1, 2, 3, 4, 5, 10, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 32, 33, 34, 35, 38, 39	Risk is low priority and no treatment except for monitoring or no treatment	T2.

Table 9: Risk Treatment

Risk Treatment Plan

As the process of deciding the actions of risk treatment are finalized there is also need for a risk treatment plan in order to implement these actions. The process of settling a plan should be in consent with the relevant stakeholders and be in line with the project's established risk management strategy. According to the Australian standard AS/NZS ISO 31000-2009 (Standards Australia 2009, p.20) the plan should include:

- The reason why the specific treatment was chosen

- Those accountable for the decision of treatment and those who are responsible for executing the treatment
- The alternative treatments to the one chosen
- Required resources for the risk treatment
- Constrains and performance measurement of the risk treatment
- How to monitor and report the risk and risk treatment
- Time schedule and deadlines

The Risk Treatment Plan and Monitoring will be designed as shown in Table 10. The table will describe the plan, from a practical view, hence will only six of the identified risks be included, but in reality all identified risks should be included in the plan.

Monitoring and Control Plan

No	Risk Description	Activity risk is related to	Risk Impact on Project	Likelihood Score	Consequence Score	Final Analysis	Priority	Treatment	Responsible	Required resources for the risk treatment	Cost [AUD]	Time Schedule/deadline	Monitoring Method	Indicators for Monitoring
11	Risk of design changes during project affecting costs or time (Melbourne Metro Rail Authority, 2018)	Early Work and Major Construction	Higher costs, delay, decrease of property, market loss	5	5	25	Risk is not tolerable and needs treatment	T3. Establishing a Design Management Plan	Design management along with relevant stakeholder	Staff, material, communication channels	Cost A	21/06/2015-30/08/2025	Communication about working progress with contractors and stakeholders	Activity time and cost
12	Risk that construction activities are delayed or delivered with increased cost	Early Work and Major Construction	Higher costs, delay, decrease of property, market loss	4	4	16	Risk is not tolerable and needs treatment	T6. Contracting	Tender process and contractors	Tender process material	Cost B	21/06/2015 – 30/08/2025	Communication about working progress with contractors and stakeholders	Activity time and cost
7	Risk in limited access for emergency services	All activities on construction site	Damage caused to people or property	3	5	15	Risk is not tolerable and needs treatment	T3. Design and Work Standards	Design management and construction site responsible	Staff knowledge in the issue, administrative material	Cost C	21/06/2015-	Daily on site follow up according to standars	Number of identified hazards
18	Risk in tunnel and stations not meeting required performance (Melbourne Metro Rail Authority, 2018)	All project activities	Increased costs and possible safety faults	3	5	15	Risk is not tolerable and needs treatment	T3. Establishing a Design Management Plan	Design management along with relevant stakeholder	Staff, material, communication channels	Cost D	21/06/2015 – 30/08/2025	Weekkly on-site follow-up with relevant stakeholder	Quality evaluation grade
9	Risk in unsafe working environment for maintenance staff	Maintenance stage	Damage caused to people or property	4	3	12	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T3. & T6. Establishing a Design Management Plan and Contracting	Design management along with relevant stakeholder	Staff, material, communication channels	Cost E	30/08/2025-	Daily on site follow-up according to standars	Number of identified hazards
6	Risk in workers safety during construction (e.g. high falls, cuts, burns, falling objects etc.)	All activities on construction site	Damage caused to people or property	4	3	12	Risk is moderate priority, and require treatment if the treatment is not exceedingly expensive	T3. & T6. Construction site design and Work Standards. Insurance.	Construction site responsible and contractors	Staff, material, communication channels	Cost F	2017/09/01-30/08/2025	Daily on site follow-up according to standars	Number of identified hazards

Table 10: Risk Management Plan and Monitoring; Design

Summary and Discussion

As the full risk assessment is completed, there is still need to continue the work throughout the project. The Melbourne Metro tunnel project is expanding over several years, during which the environment will change and the project will develop. New knowledge and information will be discovered, changing the conditions, possibilities and constrains of the different activities, which will all affect the project outcome. This is why there is need for a constant update of the risk assessment made initially. This should be done in an interval relevant to the project.

Conclusively all steps of the risk management is made to make a high quality estimation about the unknown of the future. There are a number of different tools and methods to apply, and it is important to choose the ones that are making the best use for the specific project. Construction projects in specific has a famous tendency to exceed the time and money budget, affecting stakeholders and project owner. In a project management context risk management gaining more and more focus. Due to the technical development, there are new emerging tools and methods that can be applied to make a more qualitative analysis about the uncertainties of the future. These technologies are simulation tools, big data, communication platforms etc. The increased pressure on firms to create competitiveness through resource effectiveness and quality is a reason why risk management is becoming more important during recent years.

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Appendix 1: Likelihood- Consequence Matrix

Likelihood - Consequence Matrix

Likelihood \ Consequence	Negligible 1	Minor 2	Moderate 3	Major 4	Severe 5
Rare 1	Low	Low	Medium	Medium	High
Unlikely 2	Low	Low	Medium	Medium	High
Moderate 3	Low	Medium	High	High	High
Likely 4	Medium	Medium	High	High	Very High
Almost Certain 5	Medium	High	High	Very High	Very High