



**Cambridge**  
**International**

**Professional Research Thesis**

**Titled**

**THE IMPORTANCE OF RISK MANAGEMENT IN METRO  
PROJECT CONSTRUCTION Case Study Cairo Metro Line  
3- Ph3**

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**2024**



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# **TO MY FATHER**

## **SUMMARY**

With the rapid development of metro construction all over the world, construction safety accidents occur frequently due to the lack of effective safety risk controls. Continuously improving the level of safety risk pre-control has become a significant factor in the safety managements of metro construction. This thesis presents the risk management induced in Mega Metro projects and presents the plan for Risk management plan applied Cairo Metro Line 3- Phase 3 as a case study.

Mega projects necessitate greater resources, time, and focus for effective risk management. While the application of risk management does not ensure project success, it can significantly diminish the probability of project failures. Thus, risk management is crucial as it has the potential to enhance the return on investment for these projects.

Risk is an uncertain event or condition that, if it occurs, has a positive or a negative impact on one or more project objectives, such as time, cost, scope or quality. Risk management includes the process concerned with the conducting the risk identification, analysis, responses and management planning and control on a project.

In this thesis we are going to consider Phase 3 of Cairo Metro Line 3 as a case study to demonstrate the importance of risk management in such Mega Projects.

## **Introduction:**

In the industry of Mega Metro projects construction, risk management has emerged as a significant area of focus. Construction of Metro projects is characterized as very complex projects because of huge number of uncertainties. It is essential that risk management is effectively implemented during the initial phases of projects; failure to do so may lead project managers to encounter increased complexity and challenges in addressing risks that arise.

Mega projects necessitate greater resources, time, and focus for effective risk management. While the application of risk management does not ensure project success, it can significantly diminish the probability of project failures. Thus, risk management is crucial as it has the potential to enhance the return on investment for these projects.

Risk is an uncertain event or condition that, if it occurs, has a positive or a negative impact on one or more project objectives, such as time, cost, scope or quality. Risk management includes the process concerned with the conducting the risk identification, analysis, responses and management planning and control on a project. Types of Risk in Construction Projects include Technical Risk, Financial Risks, Site Condition Risks and Human Capital Risks.

## The study Problem:

Major projects include many overlapping, visible and unforeseen activities, which require special care to reduce the size of risks and achieve the project implementation within the objectives in light of what was planned for.

The third phase of the third metro line is considered one of these Mega Construction Projects that the National Authority for Tunnels (NAT) put forward for implementation in 2014 to complete the route of the third metro line. The National Authority for Tunnels (NAT) has launched an invitation to bid for a design and construct contract of the Phase 3 of Cairo Metro Line No.3. , on 2014, as follow;

- Phase 3A: from ATTABA to KIT KAT.
- Phase 3B: from KIT KAT to ROD EL FARAG CORRIDOR.
- Phase 3C: from KIT KAT to CAIRO UNIVERSITY.

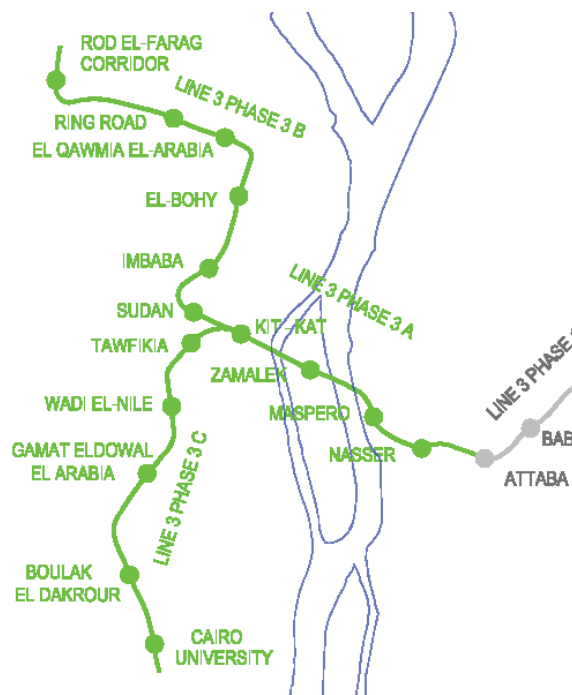


Figure 1 Boundaries of Line 3 Phase 3

## **Definitions/Abbreviations/ Acronyms**

The following terms are specifically defined for use in this plan.

- The Organization: Means The National Authority for Tunnels (NAT), the Client for the contract being tendered.
- VCGP: means the Contractor, Vinci Construction Grands Projects.
- The JV: means The Egyptian – French JV for Civil Works.
- Groups of works: means the 6 Groups of Works called for a tender by the Organization for the overall construction of the line 3 phase 3, as defined in the tenders' documents set out by the Organization.
- Group 2 (G2): the Contractor of the construction of the project responsible about civil, arrangement, electrical, plumbing and firefighting works.

## **The importance of studying:**

The Risk Management Plan used covers all fields of activity within the project. It is about controlling uncertainty in a structured, formalized and pro-active manner throughout the life of the Project.

It is a dynamic process anticipating them through preventive actions, monitoring implementation and updating the Risk Files and status. It is a continuous and iterative process integrated into our management systems relying upon communication and flexibility.

The main objectives of the Risk Management process are to:

- Anticipate and treat risks,
- Put in place Action Plans in order to manage, as early as possible, many risks and their

Consequences as possible by means of measures, respectively in mitigation and fallback plans,

- Inform the Client as soon as possible of the potential risks which may impact the project objectives in terms of quality, schedule, and cost.

This Risk Management process takes into account the potential events which can cause an impact on the Project including the safety and security risks.

This process is fully complying with the international Norms and Standards.

## **Objectives of the study:**

The study aims to achieve the following objectives:

**A.** Sets out the mandatory risk management process requirements for the project (Line 3-Phase 3). It provides the requirements for recording, monitoring and reporting risk management on the project and:

- To ensure that management has identified and assessed risks in a consistent and demonstrable way,
- To ensure that management has implemented effective control measures that continue to provide appropriate mitigation or avoidance of risks,
- To assure the Project Manager that risks are being appropriately managed throughout the project.

**B.** Provides a minimal framework to ensure risk of all types (cost, program, safety, environment, security, etc.) is managed and communicated throughout the project in a visible and demonstrable way. Objectives must be appropriately defined for these different parts and levels of the project, and identification of risk shall link to these objectives. It is intended that the designated Risk Coordinator will be through in identifying risk for the purpose of management and reporting for the appropriate part/level of the project.

## **Study hypotheses and questions:**

### **Definitions**

For usage in this thesis, the following terminology shall be used. If no definition is shown below, then the definitions given in ISO 31000 shall be used. In the case that this does not provide a definition, then those provided in the " Guide to the Project Management Body of Knowledge (PMBOK® Guide) — Fifth Edition — 2018" shall be used.

- -The Organization: Means The National Authority for Tunnels (NAT), the Client for the contract being tendered.
- VCGP: means the Contractor, Vinci Construction Grands Projects.
- The JV: means The Egyptian – French JV for Civil Works.
- Groups of works: means the 6 Groups of Works called for a tender by the Organization for the overall construction of the line 3 phase 3, as defined in the tenders' documents set out by the Organization.
- Group 2 (G2): the Contractor of the construction of the project responsible about civil, arrangement, electrical, plumbing and firefighting works.
- Risk: A potential event with identifiable causes, with a certain chance of occurrence that can impact project objectives: quality, schedule, cost, health & safety and environment.
- Danger: Potential source of injury or damage to people, property and the environment.
- Risk File: a form reporting all information about a risk.
- Risk List: a form listing all open risks with titles and scores.
- Risk Register: a reporting document of risk analysis.

- Acceptable Risks - Risks that can be mitigated, where efforts to do so are either in place, or the need for such mitigation efforts is or should be recognized.
- Allowable Risks - Risks that can be economically mitigated, but that NAT feels are inherent to its business, and are therefore accepted. An example would be the use of untested, yet ground-breaking technology on a Project. While providing NAT with an advantage, it is a risk to use untried technologies.

As Low As Reasonably Practicable (ALARP) - ALARP is a principle that identifies the schedule and cost effectiveness of responding to a risk. Risks that breach an Organization's risk tolerance threshold should be treated unless the cost of doing so is grossly disproportionate to the benefits gained. The ALARP principle addresses both whether or not something can be done about the risk and if the schedule or cost effectiveness of responding to the risk warrants any action.

- Condition - A state of being that correlates strongly with the occurrence of a risk.
- Control - Measure that is modifying risk. Controls include any process, policy, device, practice, or other actions, which modify risk. Controls may not always exert the intended or assumed modifying effect.
- Crisis Risk (HILP risk) - A crisis risk is a High Impact Low Probability risk, which is also called a HILP risk. The Risk Level of a crisis risk cannot be reduced by mitigating its impact. In order to be in control of these risks when they materialize, a Fall Back Plan / Business Continuity Plan should be in place.

- Current Risk Level - A measure of progress. Regular updates on the progress of risk treatment strategies can be valuable in helping to demonstrate progress or to secure additional resources for stalled treatment efforts. The tracking of current risk over time allows efficient shifting of resources to problem areas or to areas of opportunity. In addition, tracking the progress of current risk can help demonstrate the effectiveness of the Program RM framework.
  - Emerging Risk - Emerging risks are systemic in nature and span beyond the capacity of a single organization to contain. While their likelihood may have once been deemed low, their impact is so significant that it cannot be ignored. Emerging risks include:
    1. Completely new risks (e.g. financial crisis, cyber terrorism on rail system)
    2. Evolving risks (e.g. climate change)
    3. Recently unseen risks (e.g. asteroid, solar storm)
- Establishing the Context - Defining the external and internal parameters to be taken into account when managing risk and setting the scope and risk criteria for the RM policy.
- Event - Occurrence or change of a particular set of circumstances. An event can be one or more occurrences and can have several causes. An event can consist of something not happening. An event can sometimes be referred to as an "incident" or "accident". An event without consequences can also be referred to as a "near miss", "incident", "near hit" or "close call".
  - External Context - External environment in which the organization seeks to achieve its objectives.

- Frequency - Number of events or outcomes per defined unit of time.
- Hazard - Source of potential harm. A hazard can be a risk source.
- Inherent Risk Level - The initial level of risk that exists, not taking into account the effectiveness of existing controls prior to additional risk treatment actions being taken.
- Internal Context - Internal environment in which the organization seeks to achieve its objectives.
- Issue - An issue is an event which will definitely occur at some time in the future (unlike a risk, which may or may not occur). An example of an issue would be a new piece of legislation which was to come into effect on a particular date.
- Key Performance Indicator (KPI) - A measurement used to measure past performance and enable future performance.
- Likelihood - Chance of something happening. A qualitative or semi-quantitative description of probability or frequency.
- Loss Data External - The detailed information of a materialized risk event as captured by external parties for benchmarking purposes. An example of a source of external loss data is the Rail Industry RM database.
- Loss Data Internal - The detailed information of a materialized risk event as captured by NAT for benchmarking purposes. Details captured in NAT database include, but are not limited to: time, date and location of the materialized risk event, causes, possible interactions between discipline within NAT, and the various impacts of the materialized risk event.

- Monitoring - Continual checking, supervising, critically observing or determining the status in order to identify change from the performance level required or expected. Monitoring can be applied to a RM framework, RM process, risk or control.
- Opportunity - The possibility that an event will occur and positively affect the achievement of objectives.
- Original (Initial) Risk Level - Involves rating the exposure within its current control environment. Original or initial risk is a baseline against which you can measure progress. Reviews of loss histories, reviews of similar sectors' loss histories, and consultation with stakeholders can support the assessment process.
- Probability - Measure of the chance of occurrence expressed as a number between 0 and
- 10, where 0 is impossibility and 10 is absolute certainty.
- Residual Risk - The risk remaining after all risk treatment. Residual risk can contain unidentified risk and can also be known as "retained risk".
- Resilience - Adaptive capacity of an organization in a complex and changing environment.
- Risk - Risk is the effect of uncertainty on objectives. An effect is a deviation from the expected, positive and/or negative. Objectives can have different aspects (such as schedule, cost, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, Project, product and processes).
- Risk Acceptance - Informed decision to take a particular risk. Risk acceptance can occur without risk treatment or during the process of risk treatment. Accepted risks are subject to monitoring and review (see also Risk Retention).

- Risk Aggregation - Combination of a number of risks into one risk to develop a more complete understanding of the overall risk.
- Risk Analysis - Process to comprehend the nature of risk and to determine the level of risk. Risk analysis provides the basis for risk evaluation and decisions about risk treatment. Risk analysis includes risk estimation.
- Risk Appetite - The amount and type of risk that an organization is willing to pursue or retain.
- Risk Assessment - Overall process of risk identification, risk analysis and risk evaluation.
- Risk Attitude - Organization's approach to assess and eventually pursue, retain, take or turn away from risk.
- Risk Aversion - Attitude to turn away from risk. A risk-averse person or organization is not comfortable with accepting risks and usually tries to avoid risks unless the reward to take on them is high enough to outweigh the aversion of the risk.
- Risk Avoidance - Informed decision not to be involved in, or to withdraw from, an activity in order not to be exposed to a particular risk. Risk avoidance can be based on the result of risk evaluation and/or legal and regulatory obligations.
- Risk Category - Risk categories are defined as risk groupings that help organize consistent identification, assessment, measurement and monitoring across risks. Using consistent risk categories across an organization enables risks to be aggregated to determine their overall Impact on the Organization.
- Risk Criteria - Terms of reference against which the significance of a risk is evaluated. Risk criteria are based on organizational

objectives, and external and internal context. Risk criteria can be derived from standards, laws, policies and other requirements.

- Risk Delegation — the process of responding to an escalated risk by Senior Management.
- Risk Description - Structured statement of risk usually containing four elements: sources, events, causes and consequences.
- Risk Escalation - The process of raising risk attention to Senior Management within the organization.
  - Risk Evaluation - Process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude are acceptable. Risk evaluation assists in the decision about risk treatment.

Risk Exposure - Extent to which an organization and/or stakeholder are subject to an event and represent the maximum threats or opportunities that will be suffered or gained if an event occurs.

- Risk Financing - Form of risk treatment involving contingent arrangements for the provision of funds to meet or modify the financial impacts should they occur.
- Risk Governance - The risk-related roles, responsibilities and accountabilities among various constituent groups such as stakeholders, board members, management and employees, and the rules and procedures for making risk-related decisions.
- Risk Identification - Process of finding, recognizing and describing risks. Risk identification involves the identification of risk source, events, their causes and their potential impacts.
- Risk Impact (Risk Consequence) - Outcome of an event affecting objectives. An event can lead to a range of impacts. An impact can be certain or uncertain and have positive or

negative effects on objectives. Impacts can be expressed qualitatively or quantitatively. An initial impact can escalate through knock-on effects. An organization's impacts can range from "insignificant" to "catastrophic" and are expressed in terms of schedule impact, cost impact, reputation impact, health & safety impact, security impact, environmental impact, legal impact and quality & performance impact.

- Risk Level - Magnitude of a risk, expressed in terms of the combination of impact and their likelihood with an outcome of High, Medium or Low.
- Risk Management - Coordinated activities to direct and control an organization with regard to risk.
- Risk Management Audit - Systematic, independent and documented process for obtaining evidence and evaluating it objectively in order to determine the extent to which the RM framework, or any selected part of it, is adequate and effective.
- Risk Management Assurance — Provide assurance on core business processes in RM and governance.
- Risk Management Plan - Scheme within the RM framework specifying the approach, the management components and resources to be applied to the management of risk.
- Risk Management process - Systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analyzing, evaluating, treating, monitoring and reviewing risk.
- Risk Matrix - Tool for ranking and displaying risks by defining ranges for impact and likelihood.

- Risk Mitigation (Risk Elimination, Risk Prevention, Risk Reduction) - A selective application of appropriate techniques and management principles to reduce the threat likelihood, its impact, or both. Risk mitigation can also involve increasing the likelihood of a threat, if deploying such strategies also reduces the threat impact.
- Risk Owner - Person or entity with the accountability and authority to manage the risk.
- Risk Profile - Description of any set of risks. The set of risks can contain those that relate to the whole organization, part of the organization, or as otherwise defined.
- Risk Rating (Level of Risk) - Magnitude of a risk, expressed in terms of the combination of impact and their likelihood with an outcome between 1 and 25.
- Risk Register - Record of information about identified risks.
- Risk Reporting - Form of communication intended to inform particular internal or external stakeholders by providing information regarding the current state of risk and its management.
- Risk Treatment - Process to modify risk. Risk treatment can involve:
  - Avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk.
  - Taking or increasing risk in order to pursue an opportunity.
  - Removing the risk source.
  - Changing (mitigate, eliminate, prevent, reduce) the likelihood.

- Changing (mitigate, eliminate, prevent, reduce) the impacts (consequences).
  - Transfer/sharing the risk with another party or parties (including contracts and risk financing).
  - Accepting/retaining the risk by informed decision.
- Risk treatment that deals with negative impacts is sometimes referred to as "risk mitigation", "risk elimination", "risk prevention" and "risk reduction". Risk treatment can create new risks or modify existing risks.
  - Risk Treatment Owner - Person or entity with the responsibility and accountability to manage the risk treatment.
  - Risk Treatment Transfer - Shifting the responsibility of the risk treatment elsewhere within an organization or externally outside of the organization.
  - Risk Retention - Acceptance of the potential benefit of gain, or burden of loss, from a particular risk. Risk retention includes the acceptance of residual risks. The level of risk retained can depend on risk criteria.
  - Risk Source - Element that alone or in combination has the intrinsic potential to give rise to risk. A source can be tangible or intangible.
  - Risk Strategy - The planning of resources for their most efficient and effective use in implementing the RM program over a desired period of time and desired maturity level. The risk strategy aims to support the organization's Strategic Plan.
  - Risk Tolerance — An organization's or stakeholder's readiness to bear the risk after risk treatment in order to achieve its objectives. Risk tolerance can be influenced by legal or regulatory requirements.

- Risk Transfer (Risk Sharing) - Risk transfer is a form of risk sharing. Risk transfer or sharing is a form of risk treatment involving the agreed distribution of risk with other parties. Legal or regulatory requirements can limit, prohibit or mandate risk transfer or sharing. Risk transfer or sharing can be carried out through insurance or other forms of contract. The extent to which risk is distributed can depend on the reliability and clarity of the sharing arrangements.
- Stakeholder - Person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity. A decision maker can be a stakeholder.
- Strategic Risk - The risk associated with future business plans and strategies, including plans for entering new business lines, expanding existing services through mergers and acquisitions, and enhancing infrastructure. To mitigate strategic risk, the organization should have a strategic planning process that addresses its business goals and objectives.
- Target Risk Level - The rating based on the risk appetite and risk tolerance an organization wants to achieve after mitigation. In other words the Original risk rating should be mitigated until the Residual risk rating reaches the Target risk rating.
- Unacceptable Risks - Risks with no possibility of mitigation (i.e. risks that cannot be reduced or eliminated by any economic or practical method).
- Vulnerability - Intrinsic properties of something resulting in susceptibility to a risk source that can lead to an event with a consequence.

At Project level, the Project Manager is in charge of validating steps, results and confirms the roles and responsibilities dedicated to the

participants involved in the Risk Management Process. He is assisted by a Risk Coordinator who ensures the proper functioning of the process in terms of data collecting, reporting, risk meeting animation and risk assessment.

The whole operational management shall be strongly implicated in the Risk Management Process.

The main participants are:

- Project Manager
- Construction Manager
- Technical Manager
- Admin & Financial Manager
- Commercial Manager
- QHSE Manager
- Departments/Sections Managers
- Risk Coordinator
- And their deputies if any

The following outlines the roles and responsibilities which are assigned for the management of risks in the Project. Risk Management involves the above-mentioned participants to identify, evaluate and control risks. In addition to the Project Manager, the participants are implicated as follows:

Risk Coordinator: Brings support for risks identification and mitigation actions, performs analyses, reports and recommends. The Risk Coordinator works within the QHSE Department. His role is to organize the process and facilitate the circulation of information from the site to the Project Manager.

Risk Owner: Is the person who has the authority, competence or experience to ensure a proper follow-up of the risks and the Action Plans associated. He has to collaborate with the Risk Coordinator to identify, evaluate risks and propose appropriate risk mitigation actions assigned to a Responsible of Actions. (See definition below)

In case the Risk Owner is not the Contractor's employee, the responsible in charge of following the mitigation actions shall be indicated in the Risk File.

Responsible of Action: Person or party responsible to implement actions defined to mitigate risk criticality.

Main Subcontractors/Suppliers and JV Partners: They participate in the Risk Management process, collaborating in risk analysis, implementing mitigation actions where they are responsible, and providing feedback on the effectiveness of mitigation actions to the Risk Owner.

Client: The Client's contribution to the process is a factor of success for the Project. In agreement with the Client, this contribution shall be organized in order to benefit to the Project.

In a first place, the Contractor envisages to send the Risk Management Plan and the Risk Register to the Client. Further communications could be considered (periodic risk meeting, announcement of new significant risks, interviews...etc.) with the Client's approval.

## Study Approach:

The key activities in the project can be grouped into 3 main phases. This is illustrated in Figure 2:

- The Analysis: identification and evaluation
- The Control: Action Plan to mitigate the risks.
- The Reporting: risk quantification and periodic reviews

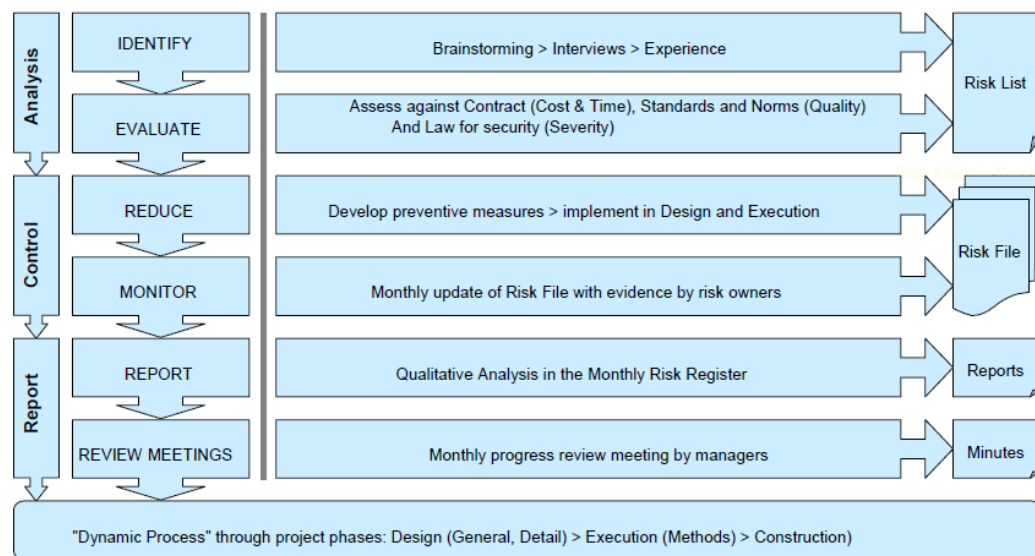


Figure 2 Risk Management flow diagram.

A fundamental feature of the process is the regular update and review cycle which ensures that, refer to Figure 3:

- Risks are always assessed with reference to the overall Project objectives.
- Regular risk assessments are undertaken to identify new risks and monitor existing ones.
- Regular reports and meetings are used to evaluate and take actions on risks.
- Plans and budgets are updated to include risk mitigation actions.
- Mitigation actions are monitored to ensure that they are effective.

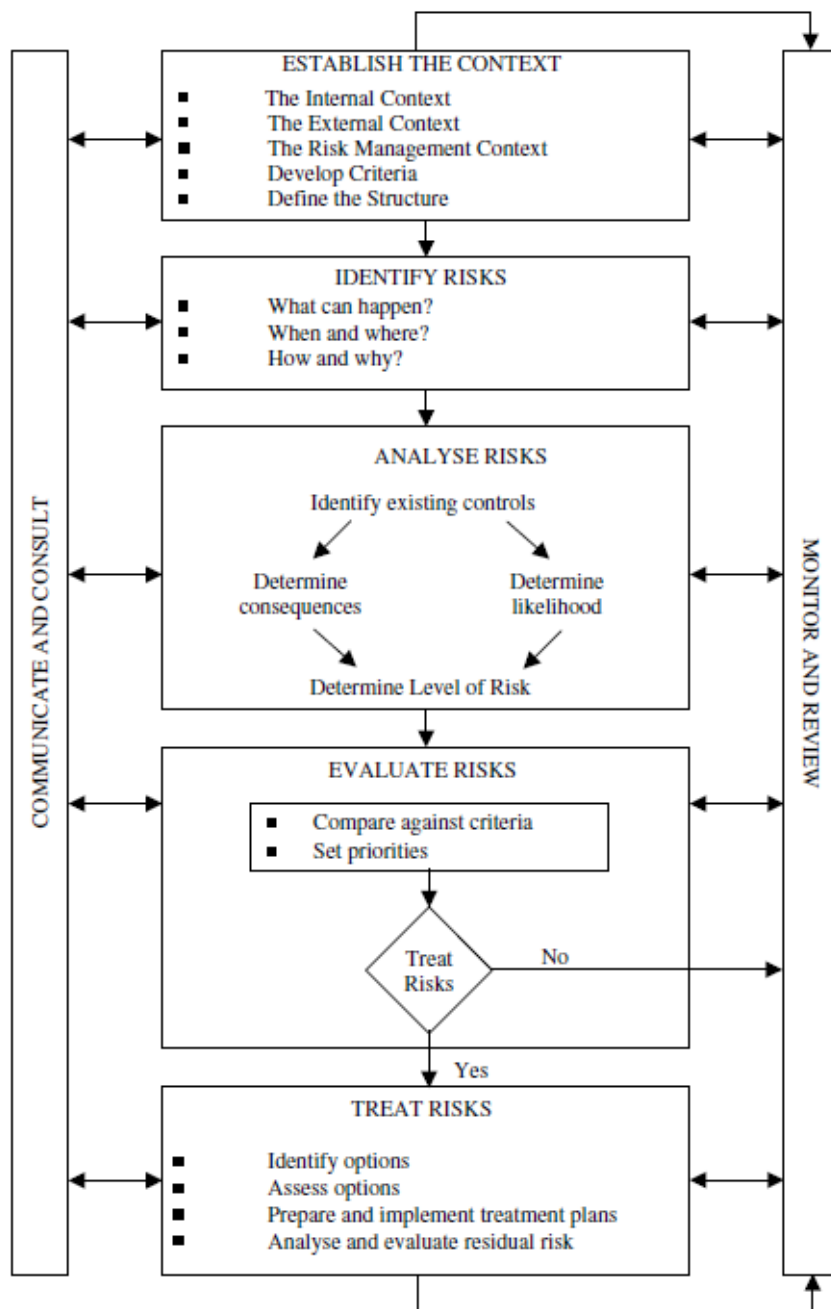


Figure 3 Risk Management Process

## **The limits of the study:**

The remainder of this Section describes in detail the tasks of the Risk Management Process as shown in Figure 4.

The risks are identified per activity (examples: earthworks, foundations, civil works and tunneling ...etc.) then the activity is broken down into tasks (excavation, reinforcement work, concrete works ...etc.).

For each task identified, a search for dangerous situations must be performed:

- Based on the inventories of risks available in the risk analysis file,
- By talking to the various persons involved and with experience,
- By watching the tasks actually performed at the various workstations.

For each identified risk, an investigation into the possible causes must be carried out. A list of causes is then put together and included in the risk analysis file.

All Project participants are encouraged to identify potential risks at any time and notify the Risk Coordinator about it.

To well identify risks, brainstorming meetings are organized by workgroups of G2 members.

Furthermore, on a regular basis, all persons involved in the Risk Management process are interviewed individually.

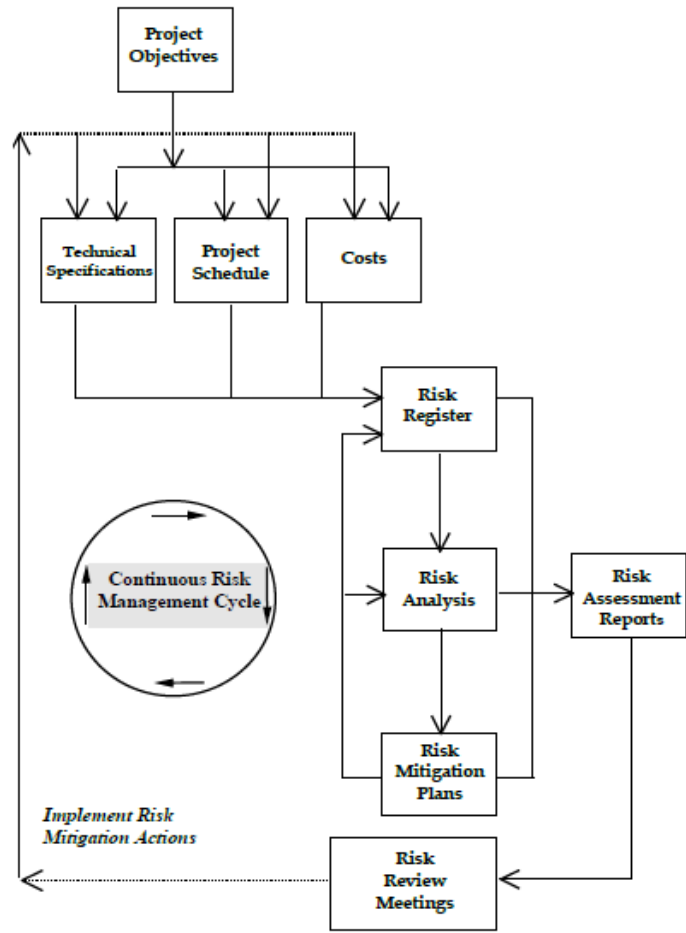


Figure 4 the Iterative Risk Management Process

**Spatial boundaries:**

Cairo Metro line 3- Phase 3

**Time limits: 2016-2024**

## **Study plan:**

The study includes three chapters:

### **Introductory Chapter: Approach of Risk Management Plan (RMP)**

#### **Section One:**

- 1. Risk Categories**
- 2. Types of Risk Analysis**
- 3. Qualitative Risk Assessment**

#### **Second: Risk Level and Risk Rating**

#### **Third: Risk Level Terms**

#### **Section Two: Risk Prioritization**

##### **First: Qualitative Risk Analysis Outputs**

##### **Second: Quantitative Risk Analysis (QRA)**

##### **Third: Quantitative Risk Analysis Inputs**

##### **Fourth: Quantitative Risk Analysis Tools & Techniques**

#### **Section Three: Quantitative Schedule Risk Analysis (QSRA)**

##### **First: Quantitative Cost Risk Analysis (QCRA)**

**Second: Quantitative Risk Analysis Outputs**

**Third: Risk Evaluation**

**Chapter One: Risk Treatment**

**Section One: Risk Treatment**

**First: Risk Treatment Options**

**Second: Risk Treatment Plan**

**Third: Implement Risk Treatment Plan**

**Section Two: Risk Treatment Plan Monitor**

**First: Risk Treatment Effectiveness**

**Second: Control Activities**

**Third: Integration with Risk Treatment**

**Fourth: Communication, Monitor & Review**

**Chapter Two: Case Study – Metro Line 3- Phase 3**

**Section One:**

**Introduction: Roles and Responsibilities**

**First: Risk Typology and Risk identifications**

**Second: Risk Assessment**

**Third: Probability of Occurrence and Potential Gravity**

**Section Two:**

**First: Risk Matrix**

**Second: Risk Reduction**

**Third: Risk Mitigation**

**Section Three:**

**First: Risk Monitoring**

**Second: Risk Reporting**

**Third:**

**3.1 Risk Review Meeting**

**3.2 Interface Management**

**3.3 Health & Safety and Environmental Risks**

**Conclusion**

**Results**

**Recommendations**

## **Introductory Chapter: Approach of Risk Management Plan (RMP)**

### **Section One:**

Risk is inherent in everything we do. When examining the risks associated with achieving the objectives of NAT, it is often prudent to ask, "How does the existing legislation, regulations, policies and practice guide how we do business" and "What other uncertainties might exist that could have an impact (positive or negative) on the Projects objectives?"

RM helps answer these questions and provides a process by which anyone can identify and assess the risks; evaluate them; develop prevention, mitigation and recovery strategies; and ultimately achieve NAT objectives most efficiently.

All Projects team members and stakeholders have a role to play in achieving the RM objectives, setting threats and opportunities priorities, and using RM in their day-to-day working environment.

This RMP is set at the Program-wide level, ensuring to provide a Program-wide threats and opportunities management process by which risks will be identified and assessed (including their impacts on schedule, cost, reputation, H&S, security, environment, legal, and quality). Furthermore this RMP sets out the risk escalation, treatment and control strategies to be followed in order to report risks relevant to the objectives of the Projects throughout their life cycles. In addition, it covers all categories of risks throughout the Projects phases and on all levels of the RM hierarchy.

The RM phases include:

- Enabling Work
- Design

- Construct
- Test
- Commission
- Handover to the Operations

Where this RMP should be applied?

- RM principles should be integrated into:
- Program strategy
- Strategic planning
- Business planning
- Policy development

Projects Objectives

- The Project objectives are defined in the Project Risk Management Plan
- The figure below shows the link between Nat's Vision, Mission, Strategic Objectives, related objectives and their risks.

How to State Risks

The recommended method for stating risk involves considering its three elements:

- event
- causes
- impacts

As shown in Figure 5 below



Figure 5 Triangle of Risk

Identifying risk by its three elements provides us with three options for treating it. Since risk is defined as "the effect of uncertainty on objectives", it is helpful to link the organizations objectives to the risk identification. The event is defined as something that could prevent achievement of an objective, milestone or target, or create an opportunity to exceed them.

**Conclusion:**

The present study reveals ten risk factors in construction projects. The factors include financial risk, design risk, project management risk, health & safety risk, contract risk, site condition risk, human capital risk, technical risk, force majeure and political risk. The following can be conducted:

1. Risks are considered as integral part of any construction project. So, it becomes predictable to consider the impact of these risks on cost and time.
2. By thoroughly identifying the risks before starting the project and adopting necessary risk management techniques like the quantitative analysis and response planning leads to better project plans.
3. Risk management deals with the risk events and the allocation of risks to the different parties through suitable contractual clauses and other risk allocation measures.
4. Based on the case study from Cairo Metro Line 3 phase 3 was carried out to study the Risk management analysis. Since construction projects are complex in nature and context specific so it is very difficult to find out the exact information required to investigate the risk management strategies in the construction progress.
5. The study focuses on how the risk management analysis has been done on the metro rail projects. This study reveals how the construction industry has taking the care of risk management in infrastructure projects. This study reveals how the risk management analysis has to be done and how they are affecting the project.

Moreover, empirical study of a large sample can be carried out further to substantiate the results of this study.

## **Results:**

The results indicate that:

1. Construction projects are characterized as very complex projects, where uncertainties are part of it.
2. Risk is an uncertain event or condition that, if it occurs, has a positive or a negative impact on one or more project objectives, such as time, cost, scope or quality.
3. Risk management includes the process concerned with the conducting the risk identification, analysis, responses and management planning and control on a project.
4. Risks are prioritized based on the risk index score which forms the probability-impact matrix and risk register is formed.
5. Due to the complexity and specificity of construction projects, obtaining exact information for investigating risk management strategies is challenging.
6. Every project involves a certain level of risk, particularly in infrastructure projects, which face numerous uncertainties and risks due to their scale and cost.

## **Recommendations:**

1. The study of Risk management analysis is an on-going research work in order to identify the new strategies to implement effectively in the construction industry especially for the infrastructure projects as the scope and the cost overruns are huge.
2. As there are a huge Rail Projects are under construction right now in Egypt, more studies for risk management before initializing the work.
3. Lesson learnt from the previous projects should be used as references for each new project especially for the projects with similar nature and location.
4. Special Care should be paid for construction risks and geotechnical risks.

**The reviewer:**

**Arabic references:**

**Foreign references:**

**1. Risk factors affecting the construction projects in the developing countries.**

R A. BAHAMID, S.I. DOHAND M A. AL-SHARAF

National Colloquium on Wind & Earthquake Engineering.

IOP Conf. Series: Earth and Environmental Science,

244 (2019) 012040 IOP Publishing doi:10.1088/1755-1315/244/1/012040.

**2. Risk management: The factors affecting civil engineering and construction process**

MITRA SALEHI

3<sup>rd</sup>. International Congress on Civil Engineering, Architecture, Building Material and Environment 28 2023

**3. Risk Factors on Civil Engineering Projects**

MUHAMMAD HAFIZUDDIN IDRIS, HAMIMAH ADNAN, HAR EINUR AZRIN

BAHARUDDIN, ZULKHAIRY AFFANDY MOHD ZAKI, WAN NORIZAN WAN

ISMAIL

ICRMBEE 2021 IOP Conf. Series: Earth and Environmental Science 1067

(2022) 012064 Risk Factors on Civil Engineering Projects.

IOP Publishing doi:10.1088/1755-1315/1067/1/012064.

**4. Risk Assessment of the construction of metro stations with open cut method based on fuzzy comprehensive evaluation method**

XIAOLONG LI, RONGQIANG WAN<sup>1</sup>, BO WU<sup>2</sup>, GUOWANG MENG AND HUIHAO CHEN

ICCAEM 2020, IOP Conf. Series: Earth and Environmental Science **636** (2021) 012029, IOP Publishing, doi:10.1088/1755-1315/636/1/012029.

### **5. Risk Assessment and Management of Underground Metro Construction (Bengaluru Scenario)**

SHAIK UMAR FARUQ, YALAMANJULA VENKATA ARCHAN, MADDIKERA LOKANATH REDDY

International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075 (Online). Volume-11 Issue-8, July 2022.

### **6. Hazards Identification and Risk Assessment in Metro Railway Line Construction Project at Hyderabad**

VISHWAS H S, DR. G D GIDWANI

International Journal of Engineering Research & Technology (IJERT)

<http://www.ijert.org> ISSN: 2278-0181

IJERTV6IS080126. Published by: [www.ijert.org](http://www.ijert.org) Vol. 6 Issue 08, August – 2017

### **7. Project Risk Management – Strategy and Analysis for Proposed AHMED ABAD-GANDHINAGAR Metro**

AALAP NAYAK, RINNI SHAH, KRUPA DAVE

IJARIE-ISSN(O)-2395-4396, 4238 [www.ijer.in](http://www.ijer.in). Vol-3 Issue-2 2017

### **8. Risk assessment of underground and elevated metro projects from clients**

OMAR DEEPAK KARMARKAR, SHIVRAM G. KRISHAN,  
VENKATA, SANTOSH KUMAR DELHI, NAGENDRA RAO VELAGA

Environment Project and Asset Management, Vol. 12 No. 6, pp. 887-  
905. <https://doi.org/10.1108/BEPAM-07-2021-0098>

### **9. Construction Risk Assessment of Metro Elevated Station Based on C-OWA Operator and Improved Extenics**

JINXIAN ZHAO, WEI MENG, AND FEI SUN

IOP CONF. SERIES: EARTH AND ENVIRONMENTAL SCIENCE **525**  
(2020) 012012.

IOP PUBLISHING DOI:10.1088/1755-1315/525/1/012012

### **10. Assessment of Risks Associated with Elevated Metro Rail Projects by using Fuzzy Failure Mode and Effect Analysis**

AMRUTHA A, KRANTI KUMAR

Indian Journal of Science and Technology 16(39): 3414-3422. <https://doi.org/10.17485/IJST/v16i39.1482>

### **11. Supporting a Decision for Metro Station Restoration Based on Facility Assessment: Application to Cairo Metro Stations**

WALAA M. MOHAMED\_

Mohamed Journal of Engineering and Applied Science (2022) 69:9  
<https://doi.org/10.1186/s44147-021-00060-6>