The Risk Assessment of Edinburgh Trams Network Project in Scotland, UK

Abstract

The Edinburgh Trams Network (ETN) project was envisioned as a transformative infrastructure initiative aimed at enhancing public transportation, reducing traffic congestion, and promoting sustainability in Scotland. However, the project faced significant challenges, including cost overruns, construction delays, and governance issues. This study presents a comprehensive risk assessment of the ETN project, focusing on identifying, categorizing, and analyzing key risks using the STEEP framework (Social, Technical, Economic, Environmental, and Political risks).

The research highlights the critical role of risk management in large-scale infrastructure projects and examines the root causes of project inefficiencies. Using quantitative and qualitative analysis, the study evaluates the impact and probability of various risks, illustrating their contribution to financial and operational setbacks. Findings indicate that economic and technical risks were the most significant factors leading to budget escalations and timeline deviations.

Recommendations are provided to improve risk management strategies, including early risk identification, proactive stakeholder engagement, and enhanced project governance structures. The study underscores the importance of integrating risk management frameworks from project inception to ensure efficient execution and long-term sustainability. Future research is suggested to refine risk response mechanisms and compare risk factors across similar megaprojects.

Examining the safety of the Edinburgh Trams Network in Scotland, UK. This assessment evaluates potential risks and safety measures for the project.

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- Appendix D: Risk Impact Calculations
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The following text comprises the introduction of the study.

Introduction

According to Serpella, et al. (2014), an effective and efficient risk management approach requires an appropriate and systematic methodology, knowledge, and experience.

Overview of Risk Management

The duty of a project manager includes the management of risk within a project which is complex and is considered inefficient if the process of risk management is not conducted from the initiation of the project (Serpella, et al., 2014, p. 654).

Construction projects are exposed to risks from the time of their coming into actuality and then through the various stages making it imperative to consider what risks the project owner would want to counter with appropriate measures and the cost of using those measures to counter the risks (Schieg, 2010).

Transport, Sustainability and Visions Cross Cutting Exercise

The current study will apply risk management techniques to the Edinburgh Trams Network (ETN) megaproject that began as an idea in 2003 and its first service starting in 2014.

Overview of Case Study

In January 2004, a proposal was submitted to the Scottish Parliament for the reintroduction of a tram network to Edinburgh which later received Royal Assent in the spring of 2006 through the *Edinburgh Tram Line One and Two Act 2006*. The proposed tramline consisted of three lines as illustrated in figure 1.

Extensive analysis by the Scottish Parliament led to the passage of the Act in March 2006 but funding for construction of the entire network was considered impossible by the Parliament and only two of the lines received parliamentary permission; Line 1a and Line 1b. By 2007 the Final Business Case for the Edinburg Trams Network (ETN) was passed by the City of Edinburgh Council (CEC) (Scotsman, 2007). A solely owned subsidiary by the CEC was formed in 2002; Transport Initiatives Edinburg (TIE) a private limited company was hired to deliver the tram system and other major projects of the CEC. Conclusion of contracts to begin building the tram networks were concluded in May 2008 and a construction deadline

was given for the summer of 2011 with an estimated completion of £545 million (The Scotsman, 2007).

However, there have been multitudes of issues such as resulting in changes being made to the delivery of the original design plan noted in Figure 1. According to Johnson (2008) by April 2009, Phase 1b that were composed of tram lines between Roseburn and Granton Square was deferred because of the economic downturn during the period. Other issues such as delays, cost overruns, contractual disputes between TIE and Bilfinger Berger & Siemens (BBS), and funding issues resulted in extensive changes to the proposed route.

It was hypothesised by the CEC that the tram project would carry large volumes of passengers without being delayed by traffic due to their separate route system in addition to being environmentally friendly due to the system being electrically powered reducing vehicle emissions. The entire project's summary of basic information is presented in Appendix A; the Stakeholder Relationship Map in Appendix B; and Environmental Analysis in Appendix C. The actual system became functional in 2014 and went over budget to a cost of £1 billion including loan interests.

According to the PMI (2008), an appropriate risk management analysis which can be beneficial for the project includes risk management planning, risk identification, qualitative risk analysis, quantitative risk, risk response planning, and risk monitoring and control.

Risk Management Requirements for Analysis

According to Banaitiene and Banaitis (2012), risk management is considered the most difficult aspect of project management as a project manager is required to have the capability to identify the root causes of risks and trace the causes through the project to their outcomes or consequences (p. 431). Furthermore, a typical process that is chosen to conduct risk management includes the following key steps (adopted from; Wysocki, 2009);

1. Risk identification
2. Risk assessment
3. Risk mitigation
4. Risk monitoring

Risk identification is the foremost step and is considered the most imperative within the risk management process as it attempts to identify the sources and types of risks (Wang & Chou, 2003). It is through risk identification that further steps of the process can be initiated such as analysis and control of risk (Wang & Chou, 2003; Wysocki, 2009; Banaitis, 2012).

Risk management is effective through correct risk identification (Banaitiene & Banaitis, 2012).

Importance of Project Leadership in Managing the Risk in Offshore IT Outsourcing

The current study will go through the process of risk management to analyse the various risks that impacted the Edinburgh Trams Network (ETN) project. This process will start first with risk identification and continue with risk analysis/assessment to comprehend the risks that were present leading to cost and time overruns.

Risk Information and Data Collection

The current study uses the amplitude of data and sources to identify risk and compose a risk assessment analysis. The ETN project has been under a great deal of controversy since construction of the project began. Its constant time delay and overrun costs have brought it under fire throughout the Scottish government and publicly. The greatest source of information for the current study was the Edinburg Tram Inquiry web page developed to establish the reasons why the ETN project had incurred delays and cost more than it was originally budgeted. There are also preliminary hearings of the Edinburgh Tram inquiry that took place on 6th October 2015 which covered the process to date and the procedures for future oral hearings in regards to the project. The procedural hearings can provide a plethora of information about the project to identify the risks that were associated with the project and caused project delays. Information was also extracted from a council report (Kerr, et al., 2015) which detailed recommendations to the City of Edinburgh Council about the ETN project in terms of improving cost-effectiveness and project planning through risk assessment.

Risk Identification

According to An (2015), it is not possible to identify all the possible risks that can be associated with a construction project and it is also not possible to know for sure if all risks have been identified. The purpose of risk identification is to recognise the potential sources of risk for a specific project that are likely to have an impact on the project and a high probability of occurrence (An, 2015). For the current study, risk identification was conducted by brainstorming and using the “What if” process to identify potential risks (An, 2015). The risks were then categorised using STEEP (see Table 1); social, technical, economic, environmental, and political challenges which resulted in cost and schedule overruns for the ETN project. The categories of risk identified are discussed at length in section 6 of the report.

Level 1	STEEP Risks in the ETN Project				
Level 2	Social	Technical	Economic	Environmental	Political

Level 3	. Social grievances . Multi-level decision-making bodies . Legal Actions . Social Issues . Threats to person and asset security	. Ambiguity of project scope/scope changes . Ground conditions on given project sites . Inadequate project complexity analysis . Unforeseen modifications to the project . Inaccurate project cost estimate	. Economic recession . Material price change . Foreign exchange rate . Energy price changes . Project delays in all forms . Wage inflation . Taxation changes	. Environmental issues from works (pollution) . Unfavourable climate conditions (rain, winds, snow, sleet, etc.)	· Lack of political support . Political Opposition · Changes in government funding policy . Project termination . Political indecision · Delay in obtaining consent/approval . Legislative/regulatory changes

		. Failure to meet specified standards	. Project technical difficulties		. Delay in obtaining temporary Traffic Regulations Orders (TROs).
		. Project time overruns . Project cost overruns . Inadequate site investigation			

Table 2- Risk Identification ETN Project using STEEP

Risk Analysis

Risk assessment is the process used under risk management which includes activities of identifying, assessing, mitigating, and managing various risks that exist in a project. The process of risk analysis is important to a project's success. According to Bellasi and Tukel (1996) if there are no established processes the team of the project is considered to be operating with blindspots throughout the lifecycle of the project and they will be unprepared for what occurs as a resultant impact on the project scope, cost and schedule. Furthermore, contractual terms and conditions which are found to be vague are also considered as a significant factor for project failure. All parties that are participating in the project are going to misunderstand the requirements of the project leading to costly litigation processes.

Contractual risks, along with scope and project management risks have been identified throughout the ETN project. The risks were then quantified using a severity and frequency scale devised from a review of various literature (Bellasi & Tukel, 1996; Chen, et al., 2004;

Banaitiene & Banaitis, 2012; Lee, 2008; Wysocki, 2009) for risk occurrence and severity in terms of time overruns and cost overruns.

Table 3- Scale of severity in terms of cost overruns (Banaitiene & Banaitis, 2012; Bellasi & Tukel, 1996; Vargas, 2013)

Severity	Score	Description
Catastrophic	5	Variation (positive/negative) above £1,000,000
Critical	4	Variation (positive/negative) between £500,000 and £1,000,000
Moderate	3	Variation (positive/negative) between £250,000 and £500,000
Minor	2	Variation (positive/negative? Between £100,000 and £250,000
Negligible	1	Variation (positive/negative) lower than £100,000

Table 4- Scale of severity for time and deadlines (Vargas, 2013)

Level	Score	Description
Very High	5	Delays/Anticipation above 180 days or 6 months

High	4	Delays/Anticipation between 120 days to 180 days.
Medium	3	Delays/Anticipation between 60 days to 120 days
Low	2	Delays/Anticipation between 15 days to 60 days
Very Low	1	Less than 15 calendar days of Delays/Anticipation

Table 5- Scale of the probability of occurrence/frequency of risk (Banaitiene & Banaitis, 2012; Wysocki, 2009; Vargas, 2013)

Frequency	Score	Probability of Occurrence	Description
Frequent	5	90% or greater chance of occurrence	Hazard likely to occur
Probable	4	65% chance of occurrence <90%	Hazard will be experienced
Occasional	3	35% chance of occurrence <65%	Some manifestations of the hazard are likely to occur
Remote	2	10% chance of occurrence <35%	Manifestations of the hazard are possible, but unlikely

Improbable	1	<10% chance of occurrence	Manifestation of the hazard is very unlikely

Identified risks were then sorted to categorise which risks would be the most significant and impact the ETN project for cost overruns and time overruns. These selected risks were then used to calculate the threshold of risk using an *expected value* and a *quadratic mean (root square mean)* calculation (Vargas, 2013).

Expected Value= Probability x Impacts

Impact =

The variables of the impact equation, x, y, z, etc. are variable risks that impact the project. For the case of the ETN project, variables of time and cost were considered about the frequency of the risk occurring.

The calculated expected values have been illustrated below in the following table; Table 6- Expected value of Risk for selected Hazards

No.	Identified Risk	Cost Overrun Severity	Time Overrun Severity	The Probability	Expected Value of Risk
1	Ambiguity of project scope/scope changes (AS)	5	5	5	50
2	Inaccurate project cost estimate(ICE)	4	5	5	45
3	Ground conditions on given project sites (GPS)	5	4	4	36
4	Material price chang	4	4	3	24

	e (MPC)				
5	Unfavourable climate conditions (UCC)	4	4	3	24
6	Delay in obtaining temporary Traffic Regulations Orders (TROs). (DTRO)	4	4	5	40
7	Contractual disputes (CD)	3	5	4	32
8	Economic recession (ER)	4	5	4	36
9	Political Opposition (PO)	3	4	4	28

10	Changes in government funding policy (CGFP)	3	3	4	24

Based on the results of the tables above, a risk matrix was developed as illustrated below

	5				DTRO (40)	AS (50)	ICE (45)					
	4			CGFP (24)	CD (32)	GPS (36)	ER (36)	PO (28)				
Probability of	3				MPC (24)			UCC (24)				

Occurren												
ce	2											
	1											
		1	2	3	4	5	5	4	3	3	2	1
		Severity of impacts										

Figure 1- Risk Matrix for ETN Project

The quadratic value for impact has been separately calculated (see Appendix D). The final results of the total impact on the expected value have been illustrated in the table below.

No.	Type	Identified Risk	Cost Overrun Severity	Time Overrun Severity	The Probability	Total Impact	Expected Value
1	Threat	(AS)	5	5	5	5	(50)

2	Threat	(ICE)	4	5	5	4.69	(45)
3	Threat	(GPS)	5	4	4	4.36	(36)
4	Threat	(MPC)	4	4	3	3.70	(24)
5	Threat	(UCC)	4	4	3	3.70	(24)
6	Threat	(DTRO)	4	4	5	4.36	(40)
7	Threat	(CD)	3	5	4	4.09	(32)
8	Threat	(ER)	4	5	4	4.36	(36)
9	Threat	(PO)	3	4	4	3.70	(28)
10	Threat	(CGFP)	3	3	4	3.36	(24)
Total Risk Expected Value							(339)

Output Analysis and Discussion

Based on the risk matrix in Figure 2 and the tables that were developed for a total impact of expected values, the risks that have been identified for the ETN project are quite severe and are the reasons for the resulting cost and time overruns. The risks were colour-coded based on a predefined scale (Appendix E) which was used to score the risk's probability of occurrence and the impact on the project objectives. All threats have been identified as negative threats. For example, based on the project cost risks, all costs have had a negative impact as seen in Table () in which Material Price (MP), Inaccurate project cost estimates (ICE), Economic Recession (ER), and Changes in government funding policy (CGFP) have had large values of the expected value of risk which has significantly influenced the total expected value of risk being raised to 339. It is obvious from the results obtained that ambiguity in project scope and scope changes has had a large impact as being a significant risk. It is also thought that this particular risk is considered a root cause of project failure.

Stakeholders and managers of the project must make sure that the basic project needs a defined at the early stages of the project to avoid scope creep (Lock, 2007).

Organising the regular requirement gathering at the start of the project will mitigate the chance that the requirement is left incomplete. Therefore, stakeholders of the ETN project needed to conduct meetings and then revisit these meetings during the execution/ construction phase of the project to ensure that the existing requirements were easily achieved within the given time framework (Kerr, et al., 2015). For the ETN project, the governance arrangements during the initial five-year project were ineffective and complex resulting in responsibility lines that were vague and slower
decision-making. The board of the project had failed significantly as an appropriate decision-making forum leading to cost overruns and time delays (Lock, 2007).

- ## Social Risks

Before the actual implementation of the project, various consultants and stakeholders were extensively involved and consultations were carried out on the ETN project.
However, during the project’s construction phases, the social environment surrounding the project became accumulated with opposition and controversy. Delays on the trams added to the grievances and criticisms from the general populace and especially the business community that held shops along or around the tram routes (BBC News, 2008). Many business owners became opponents to the tram project has they asserted that income generation was severely affected by the long-term road closures at the centre of Edinburg (BBC News, 2008). Added obstruction of work in progress on the project occurred in January 2010; construction was suspended because unexpected freezing temperatures hit the country during winter (Edinburgh Evening News, 2010).

- ## Technical Risks

A leading technical issue was the project scope changes throughout the construction phase of the ETN Project. Due to the various scope changes, there were constant engineering and

design changes which furthered the technical risk. Various ground conditions led to the emergence of difficulties faced during utilities diversion.
Construction was disrupted at various times due to the exposure of wartime tunnels found under Haymarket. Concerns were raised by individuals who were residing along the tram lines about the suspension of their overhead electric cables from residential buildings. According to Marshall (2010), many property owners were refusing to permit the overhead cables to be attached.

- ## Environmental Risks

The Environmental Statement (ES) of the ETN Project for line one was published per the standing orders of the Scottish Parliament which had made it mandatory for projects to be approved by a private Act of Parliament and subjected to *Environmental Impact Assessment (Scotland) Regulations 1999*. A red flag that was present for environmental risk at the initial stage of the project was that line one of the ETN Project was already exceeding the limit set by the EIA Regulations of one hectare and many of the characteristics of the project pointed to significant environmental effects. Site visits between 2011 and 2013 revealed the need for repairs on Prince Street and Haymarket. These damages on the lines were hypothesised to be caused by extreme weather conditions that were witnessed in 2009 and 2010, a risk that neither contractors nor project owners had any control over.

- ## Economic Risks

The ETN project had faced a great deal of economic risk, especially with the unpredictable downturn of economic events leading to a recession in 2009. The capital costs of the project were greatly influenced by the constant fluctuations in the exchange rates of foreign currencies against the dollar (Chen, et al., 2004) at that time causing the government to alter their fiscal policies during the recession period which affected the project as it led to time overruns (Ling & Lim, 2007; Lee, 2008). The ETN project was also impacted by the financing nature and the various other levels of risk present during the life cycle of the project which are categorised as completion and market risks (Olper, et al., 1997). Completion risks commonly come forward during the investment phase of the project. On the other hand, market risks arise during the operational phases of the project (Olper, et al., 1997).

- ## Political Risks

Oftentimes major national projects are marred with political issues since inception, this was also the case with the ETN project. There were various political disputes taking place

between the Scottish National Party (SNP) which opposed the project and parties such as Labour, Conservatives, Green Party, and Liberal Democrats who supported the completion of the project. Further political grievances were generated when road closures occurred for the MUDFA contract which also led to the discontentment of public opinion over the project (Scotland & Commission, 2011).

Here are the study's suggested actions or advice.

Recommendations for Improvement

It is evident from the analysis of the literature that the ETN project had various consultations with industry leaders but there is no evidence of risk assessment and risk management from the initiation of the project. This led to cost overruns and time delays that had a significant impact on the support for the project and the government. Failure to conduct a risk assessment had led to various foreseeable risks to hurt the overall project lifecycle.

According to Chapman and Ward (2004), projects considered *mega projects,* particularly for improvements to the transportation system are composed of five subsystems;

1. Social subsystem
2. Technical subsystem
3. Economic subsystem
4. Environmental subsystem
5. Political subsystem

Each of these subsystem need to work coherently and in harmony to maximise their performance and deliver results. Therefore, it is recommended that project managers of ETN should consider all these systems before the construction of the project to ensure that all factors are equally important and incorporated during the development of the project lifecycle.

From the standpoint of the Edinburg Tram Network Project, the risk management system needed to be established that also required organising and connecting all actors within the organisation that allow for project development and evolution. This means that for risk management to be successful all skilled actors within the appropriate organisational contexts and institutional arrangements need to be involved at all times (Charmaz, 2006). With the ETN project, there was a great deal of actors and according to Chapman (2001), the more actors the greater the incurred risk of having an insufficient or inappropriate structure.

Future Work

The mathematical process that was used to turn the results of qualitative risk analysis into a numerical indicator has aided the report a great deal in developing risk response strategies. It is recommended that future work is needed in this process to develop improved risk response strategies for *mega projects* such as the ETN project that was analysed. Based on the results that are obtained using this method and the tolerance thresholds that are composed, the total risk exposure can be compared with other mega projects of the same industry and other corporate limits to define potential risk response plans.

There is a need for future research to examine and investigate the dynamics of STEEP risks and the impacts that they have on project performance within the whole project lifecycle. The findings of the current study can be used by academic professionals and industrial stakeholders as a reflective report for comprehending the risks involved in a project, specifically a megaproject for the transportation industry, to appropriately implement risk assessment.

The recommendations devised in the current study can be implemented in future projects to ensure that risk management is taking place from the start of the project. Through implementation of the new recommendations, their feasibility and practicability can be assessed and then concluded if the recommendations can be used for the project management industry.

Conclusions

The current study analysed the Edinburg Trams Network Project whose initial objective was to improve the public transport system in the country by utilising energy-efficient and environmentally friendly trams for public transport. The project aimed to reduce commuter traffic and pollution. However, the project faced a great deal of backlash because it had gone over the initial budget significantly and also there was a great deal of project time delay. The current study analysed the risks associated with the project by first brainstorming risks and categorising them using STEEP. Afterwards, the current study used a quadratic mean process to quantify the qualitative risk analysis (Vargas, 2013).

In summary, the ETN project had various risks associated with its delays and cost overruns. However, it is evident that economic risks and technical risks dominated and caused project cost and time overruns as construction progressed, followed by environmental, political, and social risks. For project managers of the current project under study, it was evident that they were unable to manage the inter-relations which were among the risks to make sure that effective reactions to problems in the working environment were taking place.

It is concluded from the current study that risk assessment and management are significant in ensuring the projects are completed on time and within the constructed budget.

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Appendix A

Summary of Basic Information of ETN Project

Project Title	**Edinburgh Tram Network Project**
Location	Scotland, UK

Purpose	· Support local economy by improving accessibility · Promote sustainability and reduce the environmental damage causes by congestive traffic · Reduce traffic congestion · Make transport system sager and secure for the daily commuter · Promotion of social benefits to the residents of Scotland
Scope	The Tramline was constructed to be double track in order to connect: · Edinburgh Airport to the City Centre · Developmental areas in the North and West of Edinburg

Contractual Outline	The major contracts are: · Development Partnering and Operating Franchise Agreement (DPOFA) · System Design Services (SDS) · Joint Revenue Committee (JRC) · Multi Utilities Diversion Framework Agreement (MUDFA) · Infrastructure Provide and Maintenance (INFRACO) · Vehicle Supply and Maintenance (TRAMCO)
Physical Dimension	· Total length of route: 24 km (two phases) · Phase 1a: 18.5 km · Phase 1b: 5.5 km

Cost (£ million)	· Originally planned project budget = 545 · Validated budget = 776 · Cost Variation = 231 · Actual budget = 1 billion
Year of Completion	· Original Project planned date: 2011 · Actual Project completion date:

	20 14

Appendix B

Stakeholder Relationship Map for ETN Project

Figure 2- Stakeholder Relationship Map for ETN Project (Boateng, 2014)

Appendix C

Project Environmental Analysis of ETN Project

Political Project Environment	The political project environment of the ETN had varied greatly as influence had changed based on the number of political seats or elected members within the City of Edinburgh Council (CEC) and the Scottish Parliament.

Legal and Regulatory Project Environment	The project was governed by various legal and regulatory frameworks that extended regionally, nationally, and the European Union. The following are the frameworks that governed the project: · Edinburg Trams Acts · New Roads and Street Works Act (NRSWA) · Code of Construction Practice (Buildings, Roads, Bridges) · The Road Traffic Regulation for the Tram · The Local Authorities Traffic Orders, Regulations 1999 · Environmental Impact Assessment (Scotland) · Environmental Impact Assessment (EU Regulations)

Economic Project Environment	Economic Project Environment for ETN was based on the economic benefits that are listed below: · Economic growth · Economic efficiency · Employment generation
	· Employment development · Reduction of Travel time · Residential Development

Appendix D

Quadratic value for Risk Impact (Calculations)

	Impact Time	Impact Time²	Impact Cost	Impact Cost²	Probability	Probability²	Mean	Root	Impact Score	

Ambiguity of project scope/scope changes (AS)	5	25	5	25	5	25	25	5	5	
Inaccurate project cost estimate(ICE)	5	25	4	16	5	25	22	4.690 41576	4.69	

Ground conditions on given project sites (GPS)	4	16	5	25	4	16	19	4.358 89894	4.36	
Material price change (MPC)	4	16	4	16	3	9	13.66 66667	3.696 8455	3.7	
Unfavourable climate conditions (UCC)	4	16	4	16	3	9	13.66 67	3.696 85001	3.7	

Delay in obtaining temporary Traffic Regulations Orders (TROs). (DTRO)	4	16	4	16	5	25	19	4.358 89894	4.36	
Contractual disputes (CD)	5	25	3	9	4	16	16.66 66667	4.082 4829	4.09	
Economic recession (ER)	5	25	4	16	4	16	19	4.358 89894	4.36	
Political Opposition (PO)	4	16	3	9	4	16	13.66 66667	3.696 8455	3.7	
Changes in government funding policy (CGFP)	3	9	3	9	4	16	11.33 33333	3.366 50165	3.36	

Table 7- Quadratic Value of Risk Impact Calculated

Appendix E

Predefined Scale

Level	Score	For Threats
High	Very High High	Red
Medium	Medium	Yellow
	Low	
Low	Very Low	Green

Table 8- Predefined Scale for qualitative risk analysis (Vargas, 2013)