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Research Proposal - Risk Mitigation in the delivery of Engineering Projects

MODULE – RESEARCH METHODS AND PROFESSIONAL DEVELOPMENTS (ACFA7004)

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ABSTRACT

There are many risks present during the life cycle of an engineering project. The successful delivery of these projects is often dependent on effective risk management and mitigation practices that identify, assess, control and mitigate potential threats. This research proposal aims to identify the high risk elements in project delivery, review the most popular risk management methods, highlight the costs associated with project failure and suggest future research possibilities and development ideas for a new risk management tool.

The research methods utilised will be a compilation of qualitative and quantitative methods. The qualitative elements will include literature reviews, case study reviews, and, interviews. The quantitative stage will include questionnaires and surveys.

The project will conclude with a timing plan for the research and evaluation justifying the need and requirement for this research to be undertaken.

In general, the aim of this paper is to understand why project failure rates are high, develop a method to assist in improving the success level of project delivery and contribute to existing bodies of knowledge.

INTRODUCTION

A project is a temporary endeavour detailing a set of tasks that must be completed to arrive at a desired outcome or achieve a desired goal. The tasks may be simple or complex but ultimately can be broken down into objectives and the steps needed to achieve them (Yarborough, 2021)

Although many engineering projects are meticulously planned, it is reported that only 35% of projects undertaken worldwide are delivered successfully. This indicates that a staggering 65% of projects are unsuccessful in terms of delivery within budget, completion in agreed time scales or fulfilling stakeholders' expectations. (Nieto-Rodriguez, 2021)

According to a survey by Axelos, this 65% project failure rate costs the UK economy a colossal £250BN through additional spend and lost opportunities.

Given the current project failure levels within the engineering industry, I feel that a study to try and understand the key points of failure and how these can be mitigated could be a beneficial undertaking. Project management and project planning is not being implemented effectively as surveys show a high failure rate in project delivery.

Although there are many research papers on the management of project failure, there is a lack of focus on mitigating the chance of these failures occurring prior to the project being undertaken. The major issues that need to be addressed are, that the large risk areas are known based on the execution of other major projects, but the same errors continue to be a critical failure point in present projects. Understanding these failures and developing methods to mitigate these issues from occurring could aid in providing a successful project delivery and as a result a decrease in costs to stakeholders.

Risk mitigation refers to the process of identifying potential risks that could have a negative impact on a project, developing strategies to reduce the likelihood or eliminate those risks from occurring completely can be achieved through implementation of risk identification measures, risk assessment, risk response planning, risk monitoring and control and contingency planning (Ahmed, 2017).

These are the problems I would like to address in this paper.

As technology continues to evolve, the importance of delivering successful engineering projects is as prevalent as ever.

At Hornbill Engineering, we undertake multiple projects. Many of the issues investigated within this document are faced on many projects. The intent of this paper is to investigate the reasons why this happens, the effects it has on the project, and the most ethical, effective, and efficient way the resolve these issues and mitigate against recurrence.

LITERATURE REVIEW

Elements of failure

The search for factors that positively and negatively influences the success and failure of engineering projects has long been of great interest to both researchers and project delivery teams (PINTO & SAMUEL J. MANTEL, 1990). Several research streams have highlighted factors that consistently contribute to project failure. The most prevalent of these are detailed below.

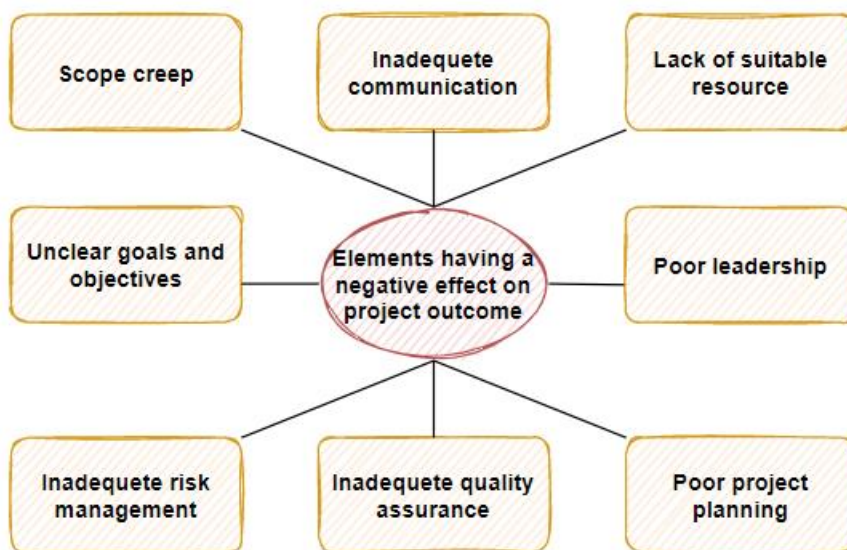


Figure 1 - Elements that have a negative effect on a project.

SCOPE CREEP

A project scope is the boundaries of a project, including goals, budgets, deadlines, and deliverables. Scope creep is anything outside of the boundaries and is a major issue in the delivery of projects caused by an incomplete definition of the scope. This in turn leads to changes in the scope that causes negative effects on time, costs, quality, and risks to project completion (Ajmal, et al., 2020). Scope creep is not a problem in specific sectors, it is a common issue among a range of industries and sectors. If the initial scope set out at the beginning of a project is poorly defined it is usually the cause of scope creepage (Mirza, et al., 2013). There are other elements that can contribute to scope creepage, project managers can tend to alter elements of a project to increase functionality or add features without appreciating the effects on boundaries and time (Gibson, et al., 2006), inadequate communication and changes in business environment.

UNCLEAR GOALS AND OBJECTIVES

Unclear goals and objectives can create confusion and leave unknowns open to interpretation. This can lead to a lack of direction and lower work output. When goals are unclear, this lends itself to wasted resource time and can cause the project team to become frustrated. Objectives should have a clear end requirement, and the steps detailed to meet that requirement. The objectives should have a set timeline and should be measured and monitored throughout the task timeline. Objectives should have an owner, someone who is responsible for ensuring completion, they need to communicate and feedback any problems to ensure the task is delivered on time, to standard and budget. Clear goals and objectives are critical for delivery of a successful project. Goal setting is valuable to project teams and the individuals involved that want to control the outcome, understanding the current state and the target objective can motivate workers to achieve the goals set out (Lopez, 2016).

INADEQUATE RISK MANAGEMENT

Substandard risk management can lead to not identifying, assessing, or mitigating risks or threats that could be detrimental to the successful delivery of a project. These risks could also damage reputations, lead to financial losses, and cause opportunities to be missed. There are many reasons why risk management may be inadequate, these may be lack of experience in risk management within the project team, failure to prioritise risk management, insufficient resources or insufficient risk analysis, management, or culture. The project team should choose effective tools to create a realistic project in the preparation phase and implement a precise process of the risk management process (Buganová & Šimíčková, 2019).

INADEQUATE QUALITY ASSURANCE

Quality assurance in a project ensures that the product or services being provided are up to the required standard and meet the specified requirements. Inadequate quality assurance during the design and preparation stage, during or on completion may result in that product or project being substandard and not meeting the required levels of quality. Issues with quality being substandard is usually down to time restraints during the project. Projects should have a quality control plan which stipulates standards to be met, procedures, processes, training requirements, review documents, industry standards and expectations and measures specific to the project (Salvi & Kerkar, 2020)

POOR PROJECT PLANNING

A project plan incorporates all elements of the project. It takes into consideration the scope of the project, the time schedule with milestones and deadlines, a breakdown of labour resource required to carry out tasks associated with the project, the risk management plan and budget information in relation to all elements of the project (Project Management Institute, 2008). Poor project planning can influence all aspects relating to the project.

POOR LEADERSHIP

A poor project leader can create a lack of clarity in the project and distort the goals and expectations. This can then cause the project to overrun, increase costs and cause frustration to team members, customers, and other stakeholders. A project leader should be interpersonal, person orientated and a social influence to ensure the project team are led in direction, course, action, and opinion (Müller, et al., 2022).

LACK OF SUITABLE RESOURCE

Resource refers to labour, plant and equipment, material, and facilities. Difficulty in acquiring any of the elements of resource could negatively affect the outcome of a project. Having a limited quantity of resource of any description will put additional strains on the project delivery. This can be off set using resource levelling methods which involves increasing time frames, delaying noncritical items, or using other resources that may not be utilised fully (Kidston & Haward, 2015).

INADEQUATE COMMUNICATION

Good communication is one of the most critical elements of project management. An effective communications route ensures that all stakeholders are well informed, kept up to date and are aware of project progress and any issues. Clear and concise communication assists with efficiency and creates a transparent, trusting, and credible environment for all parties involved. Communication has been referred to as the lifeblood of a project. A communication plan should be created, and all members of the project must understand the requirements of the system and how that system should be used (Zulch, 2014).

Risk management methods

The risk management process is in place to ensure that any weaknesses in product development or project planning are identified and captured. Also, a suitable measure put in place to avoid, transfer, reduce or mitigate the risk (Ahmed, et al., 2007).

There are many methods and tools available, many of which are widely used in many applications today, some of the most popular are detailed below.

RISK IDENTIFICATION MATRIX

A risk identification matrix identifies the potential risks by analysing the likelihood and the severity of various tasks. The multiplier outcome of these elements determines whether the task is a low, medium, or high risk.

Risk Matrix		Severity				
		Insignificant	Minor	Moderate	Major	Severe
Likelihood	Almost Certain	Medium	High	Very High	Very High	Very High
	Likely	Medium	High	High	Very High	Very High
	Possible	Low	Medium	High	High	Very High
	Unlikely	Low	Low	Medium	Medium	High
	Rare	Low	Low	Low	Low	Medium

Figure 2 - Risk identification Matrix

The risk matrix idea was first developed in the Electronic System Centre of the US Air Force. Since its introduction, the quantitative risk assessment method has been widely used and adopted by various industries because of its simplicity and effectiveness (Khan, et al., 2020). Initially it was used as a 2x2 matrix where the likelihood was plotted against the potential consequences. Now, it has evolved to incorporate more detailed levels of severity and likelihood, it is often depicted as in figure 2, above, with colours and descriptive text detailing the risk level.

DECISION TREES

When approaching a project, there are often several routes that could be taken to the end goal, projects are a multi-phase decision process. The decision tree technique is a model that is widely used for this application. The method assumes that for each decision, there are a finite number of options to review (Nowak, 2017). The image below depicts the layout of a typical decision tree.

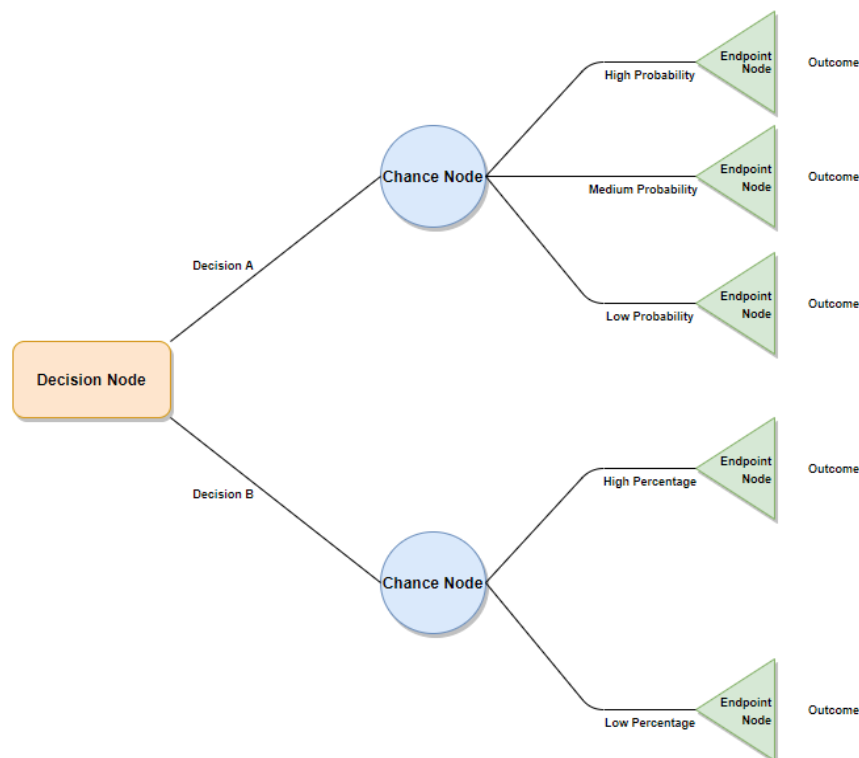


Figure 3 - Decision tree

The decision tree has 4 elements, decision nodes, chance nodes, end nodes and branches. The decision node indicates where there is a choice to be made, the chance nodes show uncertain outcomes, end nodes show the end point/ outcome, and, finally, there are branches, these join the nodes together (Thomas, 2022). The decision tree gives clarity through simple layouts, they are efficient because information can be input easily, and they can be adapted for multiple uses.

FMEA is a systematic and analytical tool used for identifying what could potentially go wrong with a product or service and was initially developed by the US Air Force in the 1940s to help reduce issues with weapon and ammunition production, it was then adopted by many other agencies including NASA, Society of Automotive Engineers (SAE) and several vehicle manufacturers to identify failures in design, manufacture, assembly, products, and services (Armenta, 2021).

The figure below shows the stages of the FMEA, the key elements are defining the scope or boundaries of the FMEA, these should be discussed using a diverse team, with different subject matter experts, this team should then generate the potential failure modes, determine the severity of the failure mode, should it occur, estimate the probability of the failure mode occurring, generate controls to detect the failure before it reaches the customer, produce a risk priority number (RPN), by multiplying the severity, by the probability and detection rating, produce an action plan to mitigate or eliminate the failure mode, and assign responsibilities and timelines for completion. Finally, following up on the action plan to ensure effectiveness of control measures.

[illegible]

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CONTINGENCY PLANNING

Contingency planning is an actionable plan that can be used for when a risk materialises causing delays to the progress of a project. Contingency planning does not necessarily mean that there is no confidence in the original project plan, it shows a dedication to the level of detail required to ensure that the project runs as planned, and ensures maximum preparation to deal with the issues if they arise (Wilson, 2022)

Although contingency planning forms part of the risk management process, risk management focuses on identifying and mitigating the risks, whereas contingency planning is the strategy that should be used to overcome the risk that has arisen (Wilson, 2022)

There are two approaches that can be used for estimating the cost of contingency, these are deterministic and probabilistic methods. The deterministic approach is more traditional, this method expresses risk contingency as a percentage of the project, generally, the initial stages will be larger as there will be more areas producing a higher number of risks, the percentage will decrease as the project develops, as the work scope is being completed, therefore, there are less elements contributing to the potential of risk. The probabilistic method breaks down the elements of costs contributing to the project and assigns them a probability distribution function (PDF). The PDF relates to the actual value of the task being undertaken, if the task was to be carried out more than once, this will then give a cumulative value to that task. This can be used to indicate potential increase or decrease to project cost based on changes to the cost components. There are different approaches to this method, one of them is expected value, where it is assumed that all risks to the project are adequately identified, this method calculates the impact value and probability of occurrence. These are then classified into variable or fixed risks, all the risks are evaluated on the maximum and average risk values, the average value is entered as the risk contingency value for the project. Method of moment is another method that goes a little further and calculates the standard deviation for each of the risks and the average and maximum risk values. The final value is expressed as a continuous probability distribution. Monte Carlo simulation simulates and trials the project, assigns a chosen value to each cost component depending on the parameters of the probability distribution. The values are summed to produce the project cost. This method is simple, understandable, and easy to use (Akinradewo, et al., 2019)

The figure below details a typical contingency table details the risk, probability, preparation task and response action.

<i>Risk</i>	<i>Probability</i>	<i>Preparation</i>	<i>Response</i>
Many employees call in sick.	High	Collect employee phone numbers or emails so you can contact them for an unscheduled shift.	Immediately contact employees requesting them to come in for an unscheduled shift.

Figure 5 - Contingency plan table

RISK REGISTER

A risk register is a document and tool used within project management to identify, assess, and prioritise risks that could have a detrimental impact on the success of a project. A risk register is a fundamental part of a project as it allows key stakeholders to identify and take steps to mitigate, reduce or manage the potential risks within the project. The document allows for the project to be audited and can aid in providing historical data of the project to enable learning, improve communication and increase the probability of success (Patterson & Neailey, 2002)

The key elements to be included in a risk register are detailed in the figure below. They include a risk ID number, a description of the risk, the person responsible for the risk, the event that triggers the risk to be highlighted, the area of the project to be effected, the probability of occurrence, the impact or severity level on the project, a totalised risk score (probability x impact), the expected result, the type of risk response, the trigger that will initiate a response to be undertaken, the person who will implement the response, a description of the response to be implemented and the expected outcome when the response has been completed.

Project 01 Risk Register													
	Positive Risk Response Options	Exploit	Share	Enhance	Accept			Risk	Something which has not happened, but might				
	Negative Risk Response Options	Avoid	Transfer	Mitigate	Accept			Issue	Something which has already happened				
	Alternate Response Options	Contingency						No longer active					
Risk ID	Description	Risk Owner	Risk Trigger	Risk Category	Probability (1-3)	Impact (1-3)	PI Score	Expected Result, No Action	Risk Response Type	Response Trigger	Response Owner	Response Description	Expected Impact of Response
	Description of the risk	Name of person who monitors the risk	How you know the risk is becoming an issue or has reached a point that requires action.	Group defines the types of risks (technology, financial, staffing, etc.)	Group sourced rough estimate of how likely this is to occur	Group sourced rough estimate of how significant the impact of this risk will be if/when it becomes an issue	Probability multiplied by Impact	What will happen if the risk becomes an issue and no action is taken	Decision made by group on how to respond to this risk (see above in blue)	How do you know it is time to put the response into play	Who is responsible for initiating the response	What is the response	What do you expect will result from the response
SF01	Key materials for the project to progress have been delayed.	John Smith.	Delivery date update from product supplier has slipped due to shortage of raw material required to produce component parts.	Financial/ Project delivery	2	3	6	We will not be able to deliver the project within the agreed timeline and incur liquidated damage costs.	Contingency	Further slippage of equipment delivery date will delay project.	Shaun Farthing.	Order equipment from another supplier before delay causing date cut off.	The response will incur costs from ordering of additional equipment, but will be less than incurred if project is not delivered on time. Claim to be made against original equipment supplier.

Figure 6 - Risk Register

The cost of project failure

The costs of the failure of a project can be vast, these costs are made up of direct and indirect costs.

Direct costs are generated from the measurable elements, these costs can be accounted for against tangible items, these include.

- Investigation costs (site visits, interviews).
- Communication costs (contacting clients, suppliers, contractors).
- Compensation/ refunds/ liquidated damages.
- Lost inventory costs.
- Fines/ claims.
- Loss of profit.
- Business/ productivity disruption.

The costs associated with indirect elements are far more difficult to capture and allocate a value too, these include.

- Company market value.
- Damage to reputation.
- Costs associate with improving brand image.
- Loss of customer confidence.
- Loss of future opportunities.
- Downturn in employee morale.
- Downturn of future employee applications.

I feel that the element which is most difficult to restore is the damage to reputation. A damaged reputation can lead to a loss of trust and negative perceptions, negative perceptions can spread through a multitude of platforms making rebuilding a reputation even more difficult, restoring a reputation is a time-consuming task that requires constant and consistent effort, if the brands reputation was previously excellent, there will be a lot of expectation to fix the mistakes and improve on what the brand previously was.

Review

Through the literature review, it has become evident that the causes of project failure are very common amongst many projects across multiple sectors and industries. These problems are constantly present in the greater part of projects, some projects appear to control and manage these issues, but the majority do not. The control and management methods mentioned in the literature review can counteract the failure points, but it is apparent that they are either not being implemented correctly or they are not being implemented at all. The fallout of both these issues creates costs to businesses because of the failure of the project, the stakes are high, and because of this reason I feel that a study into the issues mentioned is justified. Also, there is justification for creating a method that ethically and effectively assists in reducing, controlling, or mitigating these issues from occurring.

METHODS

To help understand the elements of project failure, the costs associated with project failure and to gain a better understanding of the effectiveness of current risk management methods, and to create an improved more beneficial model, the research methods that I plan to utilise during my research is a mixed method of qualitative and quantitative methods. The figure below shows the pros and cons of the research types.

Quantitative research methods	
Pros	Cons
Objectifies and accurate	Less detailed picture
Generalises as samples are large	Limited as answers are pre-set
Faster and easier as surveys can be digital	Lack of context and full understanding
Qualitative research methods	
Pros	Cons
In depth understanding as topics can be explored	Small sample size
Flexible as questions can be adjusted	Self-selection of participants can cause bias
More speculative over participants	Time consuming

Figure 7 - Pros and cons of research types

Qualitative

The qualitative methods used will be made up of multiple methods, these include the below.

One on one interviews – I plan on meeting project professionals to engage with them to determine the elements that they feel are most prevalent when the delivery of a project is unsuccessful. I also want to discuss what they feel could have been implemented to have changed or contributed to the project being delivered successfully. I would also like to understand what they feel is the biggest impact on the business when a project is unsuccessful. Finally, I would like to see if they have any ideas that could be developed to help aid project delivery.

Case study research – I want to delve into case studies of some of the larger infrastructure and engineering projects in recent times, both successful and unsuccessful, to understand the elements of the projects that were successful and those elements that could have been improved upon. I would like to look at the setup of the project team to help understand if there is a position that helps or hinders the project delivery. I would like to compare similar projects that have been a success against an unsuccessful project and analyse the differences to find out if there is a fundamental element that creates the outcome.

Phenomenology research – I intend to use phenomenology research to help understand the experience of the project stakeholders (client and project team). I feel that this method will aid in understanding the points of views of both parties to see whether their interpretation of the positive and negative elements of a project are shared or whether they have a difference of experience. This method could help develop a better collaborative relationship between client and contractor.

Quantitative

The quantitative method I plan on undertaking is detailed below.

Survey – This primary research method will allow for an online questionnaire to be undertaken. I feel that the remote access and pre structured answers that just require an answer to be selected will allow for quick and easy responses from participants. The outcome I hope to achieve is to find a majority response to which reasons project fail, what could be provided to enhance project delivery and main effect of project failure on companies.

RESULTS

Following initial research on the elements of project failure, the costs associated with these failures, current measures and methods utilised to overcome these issues, I plan to review the information gathered through interview, questionnaires/ surveys, and case study reviews, along with the information gathered in research to identify and create an improved risk mitigation strategy and tool. The information gained through interview and surveys of third parties should address the importance and critical nature of undertaking this research and highlight the areas of most importance to test the hypothesis. I feel that the outcome of the research and creation of a risk mitigation tool should incorporate the below elements.

- Automated alerts and messages to stakeholders.
- Real time risk detection and reports.
- Contain risk matrix and assessments as well as suitable contingency plan.
- Creates risk strategies.
- Produces risk reports.
- Tracks data and produces required documentation.
- Contains corrective and preventative actions for scenarios encountered.
- Directly linked to project accounts and project hours library.
- Simple and configurable.

Since beginning this avenue of research, I have found similar products available on the market, such as nTask and Resolver (Wilson, 2022). I do feel though, that the products available lack the interaction with project accounting, and labour time interaction that I think will be beneficial when planning contingency methods, as there will be a direct cost to the project for this element.

EVALUATION

The information acquired to date through the undertaking of this research proposal has proven that the subject area is a viable and an important research field. Whilst there are many research papers available and many systems, tools and methodologies developed to combat risk in engineering projects, a massive quantity of projects still do not deliver.

I feel that whilst the success rates of project delivery are as low as 35%, there is purpose for researching improvement methods for this area.

However, many people have already tried to develop and improve this area without success. The difficulty with implementing change within this field is that the methods developed will have to be used in a real project scenario, this may be risky and difficult to implement as it may still cause a negative effect on the project if unsuccessful. Another factor that may hinder research and development is time and financial constraints.

Overall, I feel that the research area is justified and viable and may contribute to future research areas dependent on what information is gathered during this study.

GANNT CHART

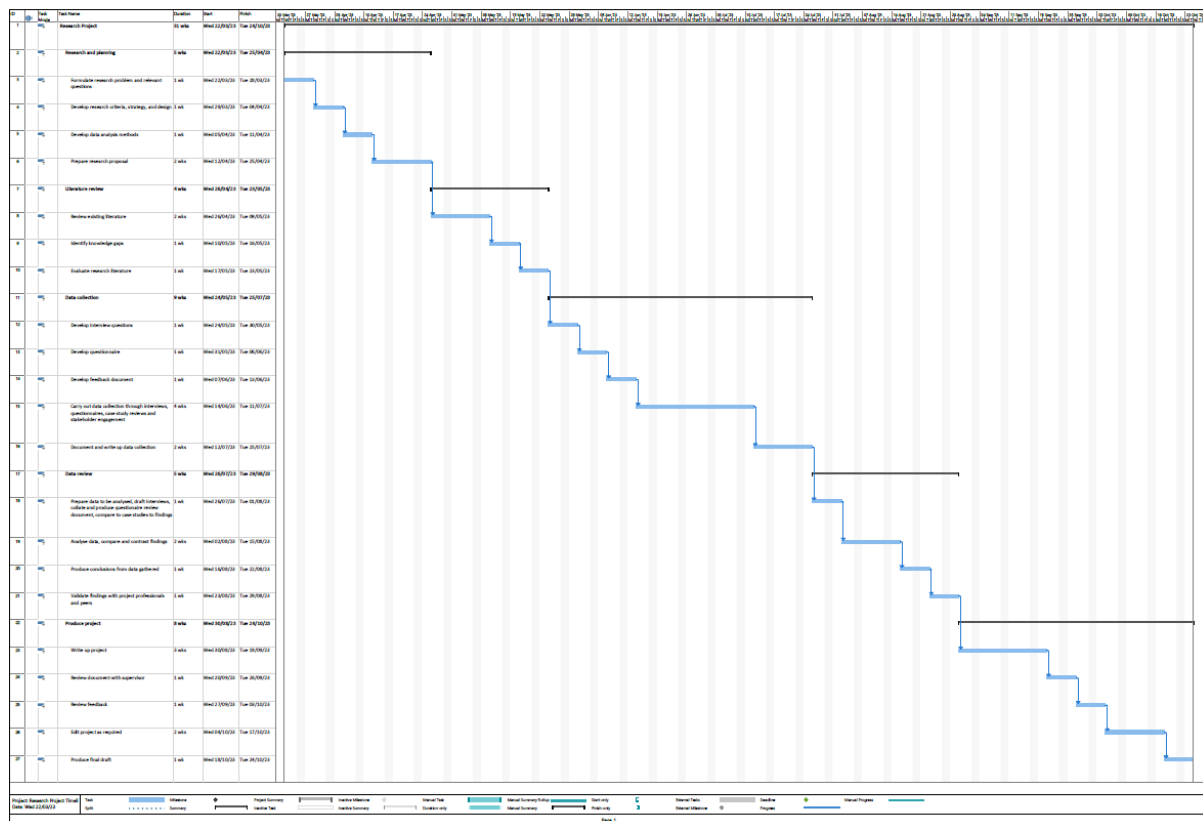


Figure 8 - Timing plan

The above Gantt chart documents the timeline for the research project, inclusive of all elements required to produce the project. The information is also copied below for clarity and ease of viewing.



Research Project
Timeline.pdf

Task Name	Duration	Start	Finish
Research Project	31 wks	Wed 22/03/23	Tue 24/10/23
Research and planning	5 wks	Wed 22/03/23	Tue 25/04/23
Formulate research problem and relevant questions	1 wk	Wed 22/03/23	Tue 28/03/23
Develop research criteria, strategy, and design	1 wk	Wed 29/03/23	Tue 04/04/23
Develop data analysis methods	1 wk	Wed 05/04/23	Tue 11/04/23
Prepare research proposal	2 wks	Wed 12/04/23	Tue 25/04/23
Literature review	4 wks	Wed 26/04/23	Tue 23/05/23
Review existing literature	2 wks	Wed 26/04/23	Tue 09/05/23
Identify knowledge gaps	1 wk	Wed 10/05/23	Tue 16/05/23
Evaluate research literature	1 wk	Wed 17/05/23	Tue 23/05/23
Data collection	9 wks	Wed 24/05/23	Tue 25/07/23
Develop interview questions	1 wk	Wed 24/05/23	Tue 30/05/23
Develop questionnaire	1 wk	Wed 31/05/23	Tue 06/06/23
Develop feedback document	1 wk	Wed 07/06/23	Tue 13/06/23
Carry out data collection through interviews, questionnaires, case study reviews and stakeholder engagement	4 wks	Wed 14/06/23	Tue 11/07/23
Document and write up data collection	2 wks	Wed 12/07/23	Tue 25/07/23
Data review	5 wks	Wed 26/07/23	Tue 29/08/23
Prepare data to be analysed, draft interviews, collate and produce questionnaire review document, compare to case studies to findings	1 wk	Wed 26/07/23	Tue 01/08/23
Analyse data, compare and contrast findings	2 wks	Wed 02/08/23	Tue 15/08/23
Produce conclusions from data gathered	1 wk	Wed 16/08/23	Tue 22/08/23
Validate findings with project professionals and peers	1 wk	Wed 23/08/23	Tue 29/08/23
Produce project	8 wks	Wed 30/08/23	Tue 24/10/23
Write up project	3 wks	Wed 30/08/23	Tue 19/09/23
Review document with supervisor	1 wk	Wed 20/09/23	Tue 26/09/23
Review feedback	1 wk	Wed 27/09/23	Tue 03/10/23
Edit project as required	2 wks	Wed 04/10/23	Tue 17/10/23
Produce final draft	1 wk	Wed 18/10/23	Tue 24/10/23

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