Identification of Project Risk Factors in a South African Train Manufacturing Project

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ABSTRACT

The South African train manufacturing industry has been dormant over the past 40 years, resulting in a decline in the industry. Undertaking a project to manufacture new trains for the country, a South African train manufacturing company is faced with many challenges that pose as risks to the project's success. These include challenges in economics, infrastructure, skills, value chain/supplier base, etc. This research aims to identify project risk factors in this South African train manufacturing project considering the nature of the project environment. Using a phenomenological approach to qualitative research, interviews were conducted with 11 participants to identify project risk. A questionnaire was then conducted to determine which risks were as a result of the South African environment. A total of 25 project risk factors were identified. The top risk factors included risks related to the supplier's capacity to support the project, the project's ability to fulfil contractual obligations, risks brought about by employee competence, and risks related to project finance. The most significant project risk factor was the inability of suppliers to meet the project capacity demands. This risk was also found to be as a result of the South African environment. The research results can be used as a basis/reference for risk identification in future train manufacturing projects in similar environments, as well as to guide local government's efforts in improving the industry. Potential further studies could consider risk relationships and the impacts of those relationships on the project.

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1 INTRODUCTION

1.1 Background to the Study

Established as a consortium of South African companies and an international majority shareholder, a train manufacturing company was tasked to revitalize the South African passenger rail industry by manufacturing new metro passenger trains. Considering its scale, this project is the first of its kind in South Africa.

The main objectives of the project are to deliver fully functional trains which are of good quality to the customer per the contractual delivery schedule; failure of which would incur penalties for the project.

The project is complex and involves complex technologies, systems, and processes that are new to the South African Rail Industry. This complexity and unfamiliarity with the imported technologies and systems give rise to risks that need to be managed (Barber and Burns, 2002). Project risks associated with the manufacture of trains in South Africa have evolved over time. Before the social changes that took place in South Africa in the 1980s that saw a suppression of investments in railway, the South African manufacture of rolling stock produced record-holding locomotives that boasted world-class technology. For the following two decades, the industry lay dormant, until the year 2000 when manufacturing restarted (JICA, 2013). The extended dormancy of the industry resulted in many challenges and risks for new train manufacturing projects including the shortage of skilled and experienced workers, and a weak supply chain (Crompton *et al.*, 2017). The Bureaucratic, societal, and governmental influences on various issues in projects imposed further constraints that impacted project performance (Vrchota and Řehoř, 2019).

The South African expertise in the train manufacturing industry is limited to specific component manufacturing and train/locomotive assembly in collaboration with other foreign countries that provide technical expertise and specialized components (JICA, 2013; Crompton *et al.*, 2017). A project to manufacture electric diesel locomotives by Transnet Engineering in collaboration with General Electric (GE) was undertaken in 2011 (JICA, 2013); besides this, there has not been a full-fledged train manufacturing project in South Africa. The rail cars for the Gautrain project, which was a design, construct, and operate project for the first high-speed train in South Africa, were manufactured at Bombardier's Union Carriage and Wagon (UCW) Partnership in Derby, United Kingdom. 15 of the cars were assembled in Derby, and the remaining 81 were assembled in South Africa, allowing for a degree of skills transfer. However, most of the parts required to assemble the trains were manufactured in Derby, and could not be manufactured or replaced by South African firms (Thomas, 2013). Skill is

therefore identified as a large barrier to progress in train manufacturing (Crompton *et al.*, 2017). Although localization projects invest largely in up-skilling employees through training and transfer of technology programs, effective skills development tends to lack (Crompton *et al.*, 2017). With the average age of commuter trains being over 40 years, it's likely that many veteran engineers and workers are reaching retirement age. With few platforms to transfer relevant skills between veteran and new generation engineers, South Africa has little to no train manufacturing skills, making it difficult to secure a quality workforce. Further to this, and in line with the findings of Authority (2004), with no clear indication of which direction the train manufacturing industry will take after each project, once orders stop it will be difficult to maintain the technical expertise gained from the project, and there is a high chance that the hard-earned skills will be lost again (JICA, 2013).

Coupled with this, the industry is still plagued by an aging infrastructure and governance issues (Whom, 2021). With the investment in railway being extremely limited for over 27 years, available facilities are obsolete, and the rolling stock has aged, causing frequent failures and safety problems. Investments and improvements to the railway system are likely, however with such a wide technological gap between the technology currently being used, and the available technology of the day, a large portion of the investment will have to go into training and upskilling of personnel to become familiar with the new technologies, and be able to perform quality control and maintenance of the trains (JICA, 2013). With the current drive in South Africa being towards the refurbishment of the existing rail infrastructure, without significant investments from the private sector in the passenger transport environment, it is hardly expected that much focus will be put into adopting the latest technology (Mulaudzi and Mokonyama, 2007), which may further expose the industry to obsolescence risks.

Low investments by State Owned Enterprises have undermined sustainability and eroded the capability of the domestic rail industry (Crompton *et al.*, 2017) contributing to poor economic growth. The poor economy has led to lower production, with less freight to transport, resulting in lower investment in expansion, and reducing the demand for additional rolling stock for freight (Whom, 2021). In efforts to improve the industry that would have otherwise struggled to re-emerge and to boost the economy, development-oriented public procurement initiatives were implemented to provide larger markets to domestic producers. This procurement strategy, common in the US, South Africa, Brazil, India, and the UK, often uses price preferences or set-asides, with offsets that include licensing of technology, investment requirements, and counter-trade requirements. Evaluating and enforcing these requirements however proved challenging, necessitating the use of tactics like tying deliverables to the project supply chain. The South African public procurement policy pursues secondary policy objectives such as industrialization, localization, transformation, skills development,

job creation, and enterprise and supplier development, which are integrated as obligatory objectives of many public-funded manufacturing projects. The Gautrain project, for example, had socio-economic development obligations built into its contract that included a commitment by the private sector partners to local job creation, black empowerment, and the employment of historically disadvantaged groups (Thomas, 2013). The exposure to penalties, therefore, becomes an increasing risk for projects that are unable to meet the set objectives (Crompton *et al.*, 2017).

As companies direct their focus more towards their core competencies, the importance of partners along the value chain, be it in the outsourcing of parts design or manufacturing, or supply chain management, increases, as many of the socio-economic development obligations extend to these external parties. It is in the project's best interest to closely manage and monitor suppliers' compliance with their obligations for socioeconomic development. Oftentimes companies and partners in a value chain act globally, and the communication and coordination challenges add further complexity to the task (Oehmen *et al.*, 2010).

According to Crompton *et al.* (2017), the minimum local content threshold for rail rolling stock projects in South Africa is 65%. To comply with these requirements, the project faces further potential cost increases associated with supplier development, maintaining the sustainability of international suppliers that have localized their operations, and the higher costs of locally produced materials, among other costs (Crompton *et al.*, 2017).

Another major challenge is regarding the supply of the core components used for controlling the output of the trains. These electronic parts are not produced in South Africa, so apart from negatively contributing to the project’s socio-economic development obligation on local content, their purchase is subject to fluctuating exchange rates, customs tariffs, delays, etc. (JICA, 2013).

In a study on the Gautrain project, Thomas (2013) discussed some of the economic constraints as well as the social and political implications of such a megaproject, highlighting potential risks that can be associated with a project of this kind within the South African context.

The Gauteng provincial government's funding for the project was initially projected to cost R7 billion, but by 2011, the costs had risen to R30 billion. The provincial government had to forego funding other areas of development due to the project's significant cost overrun (Thomas, 2013). The project was opposed on many fronts, especially given the obvious need for more comprehensive and efficient public transportation, as it was perceived to only serve an elite group of people while utilizing unprecedented amounts of public funding (Turok, 2012; Thomas, 2013). This incident raised concerns about the government’s transport intervention priorities. The intention to build a high-speed rail link

between Durban and Johannesburg is another such project that raises questions about government's spending priorities (Mulaudzi and Mokonyama, 2007). According to Mulaudzi and Mokonyama (2007), many large rail projects have frequently underperformed their financial projections and required operating subsidies from governments. The Gautrain project, which is referred to as the "legacy" project of the former Gauteng premier, is seen as being more politically motivated than technically motivated, as is this potential high-speed rail link project (Mulaudzi and Mokonyama, 2007; Thomas, 2013). The implications of this raise a potential risk for government-funded projects: that government spending priority may change impacting the funds allocated to the project (Thomas, 2013).

The significant difference in planned and actual costs for the Gautrain project also demonstrates either inaccurate and poor planning, which speaks to the project team's lack of skills and competencies, or a deliberate underestimation of costs to secure the project, which then raises deeper concerns about corruption, and the maturity and ethical competencies of the project team (Thomas, 2013).

A further challenge faced by the project is related to the labour system that governs the project environment. Seidman (1994) provides insights into the South African labour environment and describes the labour movements as highly politicized, which is still the case to date. Strikes are integral to the system of collective bargaining; however, experience has shown that the success and/or failure of the bargaining process, is dependent on the level of maturity and strength of the workers' and employers' organizations or their representatives. Generally, parties resort to a strike when they have reached a deadlock in their negotiations (Selala, 2014).

The section above highlights some of the challenges faced by the South African train manufacturing industry that may have significant impact on new train manufacturing projects. Although some of the challenges/issues may present as risks that can be mitigated within the project (internal risks), others are purely environmental, and the project may have no control over them (external risks). Challenges such as these reinforce the need to identify both internal and external risk factors early in the project to manage and minimize their impact on project performance. There is a vast amount of research on risk identification and risk management covering different project types across the globe, however, there is limited literature particular to the South African train manufacturing industry that considers the South African environment. As described above, trains for the more recent projects e.g., Gautrain, were not manufactured but rather assembled in South Africa, resulting in little to no data/literature on the risks involved in the train manufacturing process within the South African context. This research, therefore, aims to start closing this gap in literature. Being able to identify the risk factors associated with a train manufacturing plant of such significance in South Africa will create a platform for understanding the risk factors and their potential causes, thereby providing opportunity for

mitigating strategies to be established. The findings of the research can also be used as a starting point for risk identification in similar new projects, assisting them to identify and manage potential risks earlier in the project before they negatively impact the project objectives.

1.2 Problem Statement

The research problem to be investigated in this study can be stated as such:

The train manufacturing project undertaken by a train manufacturing company in South Africa faces many risks that, if materialize, may adversely impact the performance of project objectives. A comprehensive list of these risks, that would aid in risk mitigation, is yet to be provided.

1.3 Research Questions

The research seeks to answer the following questions:

1. What are the project risk factors associated with train manufacturing?
2. Which of the identified risks are as a result of the South African environment?
3. How do these risk factors compare to risk factors in other manufacturing projects?

1.4 Research Aim

This research aims to identify risk factors in a South African train manufacturing project considering the nature of the project environment.

1.5 Research Objectives

The objectives of the research are to:

1. Identify project risk factors associated with the train manufacturing project
2. Identify which of the project risk factors are as a result of the South African environment
3. Highlight the differences or similarities between the identified project risk factors and risk factors of other manufacturing projects

1.6 Structure of the Research Report

The Research Report is structured as defined below:

Chapter 2 is a literature review that engages with literature related to the research problem and discusses the findings of similar studies that have been gathered by other researchers.

Chapter 3 explores the research methodology used in this study

Chapter 4 presents and discusses the findings of the investigation

Chapter 5 reflects on the objectives of the study, provides conclusions based on the findings, and presents recommendations for further studies on the topic

2 LITERATURE REVIEW

This chapter aims to survey literature on risk factors associated with the train manufacturing industry or related industries. It will begin by addressing the definition of project risk factors, as well as describing the process of Risk Identification. The scope of studies that will be reviewed will include both train manufacturing and operation activities, since some manufacturing risks may only occur during train operation (Rahmayana and Purba, 2019). The review will also investigate external influences on manufacturing projects, covering risks affecting direct suppliers to the train manufacturing industry and related industries such as the automotive industry.

2.1 Project Risk Factors- Definitions and Characteristics

Various authors have differing definitions for the term 'Risk' or 'Project Risk'. Loosemore *et al.* (2006) define risk as being concerned with unpredictable events that might occur in the future whose exact likelihood and outcome are uncertain but could potentially affect interests/objectives in some way (normally adversely). According to ISO31000, risk is considered to be the effect of uncertainty on an organization's objectives (Chiarini, 2017). Project risks are defined by Fang *et al.* (2012) as identified, analysed, and treated failure events that may be caused by unexpected conditions or planning errors, which undermine the successful realization of the project on numerous parameters such as time, cost, scope, quality, safety, security, health, and environment. PMI (2017) defines risk as an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives.

The definitions of risk presented above are just a few examples of the several definitions of risk existing in literature. The various definitions however present some fundamental characteristics about risk that can be agreed on; that risk is a possible future event or condition - distinguishing it from an 'Issue', and that its occurrence has an impact on project objectives.

Project risk management scholars often describe uncertainty from the point of view of not only negative impact on the project outcomes and danger of not meeting project objectives, but also as changes that might bring new opportunities into the project (Perminova *et al.*, 2008). This characteristic of risk having either a positive or negative impact is addressed by various authors including Suh (2000); Marcelino-Sádaba *et al.* (2014); PMI (2017) however, in line with the research objectives, this study focussed only on the negative impact of risk on a project's objectives.

As can be seen in some of the above definitions for risk, the terms 'Risk' and 'Uncertainty' are often likened to one another or used interchangeably (PMI, 2017), however, these two terms are not synonymous (Perminova *et al.*, 2008). Loosemore *et al.* (2006) and Ahmed *et al.* (2007) create a very clear distinction between the terms 'risk' and 'uncertainty'. While risk is on the assessable end of the

continuum where there may be statistical data to produce an evaluation and determine probability of occurrence, uncertainty is on the less assessable end of the continuum and is not measurable; it can be estimated through subjective assessment techniques where there is more reliance on informed opinions to make evaluations (Loosemore *et al.*, 2006; Ahmed *et al.*, 2007). Risks can be understood as one of the implications of uncertainty, in contrast to the traditional risk management approach which assumes risk is uncertainty (Perminova *et al.*, 2008). The Risk Management process of Risk Assessment sees a transition taking place from uncertainty to risk; from a state where probability of occurrence is not known, to where it is known (Loizou and French, 2012). This study uses the terms 'risk' and 'uncertainty' in a consistent manner in line with the definitions given above.

Risks are integral to a project due to the uncertainties and unknowns associated with the project's unique nature (Wu *et al.*, 2017). Risk is said to be a function of the uniqueness of a project and the experience of the project team (Nicholas and Steyn, 2017). As such, this literature review will endeavour to focus specifically on train manufacturing projects and other closely related projects, to identify risks that may be uniquely associated with train manufacturing.

2.2 Project Risk Management

Project Risk Management is a systematic process that aims to identify and manage risk to act on its appearance by implementing systems and procedures to identify, analyse, evaluate, and address risks inherent to any project (Marcelino-Sádaba *et al.*, 2014). Risk management is an important process within a project as it helps minimize project and product-related risks such as budget and schedule overrun; it also helps towards achieving product cost and quality targets. Risk management is especially important for complex projects that involve high levels of risk and uncertainty (Oehmen *et al.*, 2010). Project risk management aims to improve efficiency, reduce the amount of unplanned costs, and achieve the planned objectives (Gembalska-Kwiecien, 2017). Wu *et al.* (2017) identify the practice of risk management and planning for risk as critical for successful realization of outcomes. The effectiveness of Project Risk Management directly relates to and influences project success and is highly dependent on a comprehensive and exhaustive risk identification process (PMI, 2017). Risks that have not been identified cannot be assessed or managed (eliminated, minimised, or controlled), and when unmanaged, have the potential to cause the project to deviate from the plan and fail to achieve defined project objectives (Marcelino-Sádaba *et al.*, 2014; PMI, 2017).

There are several variations to the project risk management process that have been proposed by various authors (Boehm, 1991; Fairley, 1994; Dorofee *et al.*, 1996; Chapman, 1997; Chapman and Ward, 2003; Nicholas and Steyn, 2017; PMI, 2017; Kliem and Ludin, 2019). There is however a consensus on what is included in the process, with variations based on the level of detail and on which

activities are assigned to steps and phases. (Raz and Michael, 2001). The traditional risk management process focuses on four main process elements: Risk Identification, Risk Assessment, Risk Response Planning, and Risk Monitoring and Response. This study however only focusses Risk Identification.

Since risks are defined as impacting project objectives, it is important for the risk identification process to ensure that the project objectives and all relevant key aspects of the project are clearly defined so that everyone involved has a shared understanding of the project and the possible areas of risk impact (Chapman, 1997). In an approach to risk identification presented by Klober-Koch *et al.* (2018), the first two sub-processes involve a thorough definition of the system under analysis followed by a collection of data relevant for risk identification. This 'Define' phase/process highlights the importance of the risk management process in contributing to define and contextualise the different project objectives through which risks can be identified (Chapman, 1997; Marcelino-Sádaba *et al.*, 2014).

The paragraph below therefore presents a definition of the project scope and objectives, and will assist to guide the risk identification process:

The main objectives of the train manufacturing project under study are to manufacture and deliver a defined number of passenger trains to the customer according to a contract schedule, complying with a set of quality standards, and within a budget that would ensure the company shareholders attain the expected profit margins. The larger percentage of the rolling stock is to be manufactured locally, and this would be supported by a Transfer of Technology program that would provide impetus in advancing local railway systems technology, improving the skill of local employees, advancing the development of the local supply chain, and providing industrialization support to commission the plant, tools, and equipment. Economic development targets including localization and local content requirements also form part of the project objectives and are targeted at improving the local rail industry.

2.3 Risk Identification

Risk identification is the first and most important step in the Risk Management process (Marcelino-Sádaba *et al.*, 2014). Typically, in a project, potential risks are identified before they occur to prevent them from occurring or to minimize their impact (Widiasiha *et al.*, 2015). Obvious, straightforward, and independent risks are the ideal case in risk management, however, the reality is usually more complex, as risks have unpredictability and interconnectedness as some of their characteristics (Barber and Burns, 2002; Klober-Koch *et al.*, 2018).

Very important to the risk identification process are the sources of risk, which are tangible or intangible elements that alone or in combination have the intrinsic potential to give rise to risk

(Chiarini, 2017), as well as the identification techniques that can be used to identify the risks and risk sources.

The following section presents a review of literature related to the identification of risk factors in or impacting the train manufacturing industry.

2.4 Risk Factors Impacting Railway Manufacturing Projects

Project risks originate from the uncertainty that is inherent to any project, regardless of its nature. This uncertainty can come from a variety of sources, including technical, managerial, environmental, and commercial factors (Hillson, 2003; Perminova et al., 2008). Risks lurk in many areas in the increasingly complex and dynamic business environment, and can stem from technical issues, social factors, organizational dynamics, and technological developments etc. (Thamhain, 2013). Manufacturing risk refers to factors and events that affect the ability of companies to produce goods and services, the ability to produce quality, the timeliness of production activities, and the overall profitability of the company (Kumar et al., 2018). Research studies have suggested that much of the root cause of project-related risks can be traced to the organizational dynamics and multidisciplinary nature that characterizes today's business environment (Thamhain, 2013).

According to Ellis (2016), the categories of risk associated with railway projects include:

1. Technical risks, including risks related to design, quality control, labour, technology, and obsolescence.
2. Commercial and procurement risks, which consider the size of the project and its links to other procurements, budget and time constraints, and dispute resolutions.
3. Interface risks
4. Financial risks, related to funding and budget constraints, changes in exchange rate, and inflation.
5. Legal and Political risks, including government policy, uncertain regulatory environments, taxation, and public perception.

Ellis (2016) also identifies some of the critical risks in rail projects as:

1. Cost overruns
2. Project Delay
3. Safety issues concerning both construction and operation
4. System integrity and reliability.

Although (Ellis, 2016) does not provide insight into the methods used to determine the above data, as a reputable international law firm and legal sponsor of the International Railway Summit 2016, this data presented by K&L Gates can be seen as credible. The list of critical risks presented by Ellis (2016) speaks directly to the Quality, Cost, Delivery, and overall Performance (QCDP) performance metrics that are monitored by the train manufacturing company to determine project success.

The Belt and Road Initiative (BRI) is a Chinese development strategy to connect and deepen cooperation between China and other countries. Rail is seen as the most efficient means of transportation, and through this initiative, a significant number of railway projects are planned to be constructed. Andrić *et al.* (2019) make use of literature reviews and brainstorming techniques to identify 24 critical risks in railway projects implemented under the BRI. A questionnaire and survey of industry experts was then used together with a method based on fuzzy and sensitivity analysis to determine the top risks of those identified. The risk factors, which include economic risk, political risk, law risk, cultural and social differences, design errors, poor site organization and management, lack of labour, poor planning and management, and poor team communication, were grouped into 6 categories: BRI, External Factors, Environment, Design Process, Construction Process and, Human Resource. The results of the analysis identify changes in design, design errors, cooperation between China and the BRI country, and loan risk as some of the most critical risks in railway projects; with the most critical risk category being related to the design process (changes in design and design errors).

Deloitte (Association, 2013) made use of literature reviews, and national and international analysis supported by consultations with government agencies and rolling stock manufacturers to present a report on opportunities for improved procurement of passenger rolling stock for the Australian rail industry. The report discussed some of the risk factors that affect or may potentially affect existing and new passenger train manufacturing projects. Some of the identified risks included the following:

1. Risks to the long-run longevity of the rail manufacturing industry due to challenges in remaining relevant and competitive in a global environment.
2. Risk of rolling stock supply chain inefficiencies due to limited visibility of the production pipeline, i.e., uncertainty regarding the type, timing, and frequency of orders. This limits the ability of suppliers to make informed anticipatory decisions related to staffing and training among other things.
3. Investment risk due to limited visibility of work, which results in reduced investments in innovations, equipment, and technologies to increase manufacturing efficiencies, and in reduced opportunities to develop new markets, etc.

4. Manufacturing capacity risks due to volatility in production levels, resulting in the inability to meet future rolling stock demands.
5. Risk for reduced competitive tension from potential new rolling stock and supply chain providers.
6. Risk of technical obsolescence due to lengthy procurement processes, as well as due to changing standards and new technologies.
7. Risk of increased non-recurring costs due to implementation of new standards on an ad-hoc basis through a new platform
8. Risk of non-availability of funding due to political factors or turbulence in the economy
9. Supplier capacity risk, where the local industry's capacity can't meet the demands of the rolling stock manufacturer, leading to the use of international supply chains.

This study provides insight on both focus research questions by highlighting both internal and external risk factors of a train manufacturing project. The identified external risk factors paint the picture of an Australian train manufacturing industry negatively influenced by inefficiencies, lack of investments, uncertain orders, a weak supply chain, and a turbulent economy. The South African train manufacturing industry has also been described similarly by various authors: as having a weak supply chain (Crompton *et al.*, 2017), having governance issues and a poor economy (Whom, 2021), lacking significant investments, and facing obsolescence risks (Mulaudzi and Mokonyama, 2007).

In a report developed to provide a perspective on the long-term outlook for passenger rolling stock in the UK, RDG (2018) makes use of expert views from its cross-industry members, including representatives from rolling stock owners, and rolling stock manufacturers and operators, and highlights a few risks that may impact the manufacture and operation of rolling stock in the UK. The risks included:

1. Risk of obsolescence before the end of vehicle design life due to the development of new technologies, or implementation of new standards, e.g., banning of diesel engines in the UK from 2025.
2. Investment risk resulting in an increased overall cost of funding to the rail industry.
3. Risk of delays in train delivery resulting in a knock-on impact on the release of the vehicles being displaced.
4. Manufacturer sustainability risk, where a "feast/famine" situation in the new train component supply chain causes capacity to exceed demand in some instances, and demand to exceed capacity in other instances, with adverse local economic impact.

5. Risk of wasted effort and cost in the deployment of European Rail Traffic Management System (ERTMS) due to uncertainties in the planning for fitment, considering train remaining life.
6. Train reliability risk due to shortened time for reliability enhancing testing to meet on-time delivery schedules.
7. Reputation risk due to poor reliability of trains
8. Risk of investment to meet short-term peaks in demand which threatens business viability.
9. Risk of unexpected contract variations by the client impacting delivery obligations.

The risks identified by RDG (2018) highlight the potential impact of what they term a “feast/famine” situation. It manifests itself as inconsistencies in new train orders, discourages investments, hinders the growth of a stable supply chain, and causes manufacturer sustainability risks. Contract variations may further exacerbate the “feast/famine” situation, especially when the variations relate to changes in delivery schedule.

The passenger rail system is very important in developing economies, as it helps to improve social and economic welfare. Passenger rail services have many challenges that can impede their success. In order to manage the Transport Manufacturing sector's risk, its officials must look at past accidents and near misses in the rail industry in order to learn from them and ensure that the lessons have been learned and applied in the manufacturing process (Workgroup, 2017). In a study on risk management in railway during operation and maintenance, Rahmayana and Purba (2019) make use of literature reviews to identify and discuss the risks related to the many train accidents which cause material and non-material losses, the causes of which can oftentimes be traced to the initial train manufacturing process. The study then presents several risk analysis models that can be used to identify and assess major hazards/risks in train operation.

According to Rahmayana and Purba (2019), the dominant risks in train construction projects, grouped into four categories, include:

1. Internal technical factors: methods, technology, and complexity risks
2. Internal non-technical factors: management, schedule, cost, and cash flow risks
3. External predictable: inflation, environment, and weather risks
4. External unpredictable: natural disasters

The risk level associated with the identified internal technical risks (methods, technology, and complexity) may particularly be elevated in train a manufacturing project in a country like South Africa which has had a dormant train manufacturing industry for over forty years. There would be an

apparent lack of exposure to modern train manufacturing methods, relevant new technologies, and skills to deal with project-specific complexities (Crompton *et al.*, 2017).

In a discussion on risk allocation and insurance requirements for a contract between two parties government(employer) and tender holder(contractor) towards the manufacture of passenger trains, Workgroup (2017) make use of literature reviews and contributions from industry experts to discuss some of the risks that need to be considered that can lead to damage or loss to the trains during construction, testing, delivery, or for a longer initial operational period for which indemnity should be received. The identified risks include:

1. Risk for accidental loss until final handover of the train to the employer
2. Force majeure e.g., natural perils or non-damage delays
3. Risk of accumulation of trains in the rail yard before handover
4. Risk of damages to manufacturing material or components due to accidental losses during material handling
5. Location risk, driven by natural disasters which the area is prone to
6. Risk of injury or damage to third parties or existing property
7. Contract risks exacerbated by grey areas in the contract.
8. Risk of loss to components at supplier manufacturing site
9. Risk of accidents in early operation due to product failure
10. Risk of incidents e.g., during testing and commissioning, before defined operational handover.
11. Reputational risk
12. Low-reliability risk

Although the majority of risks identified by Workgroup (2017) can be covered by some form of insurance as part of the project's risk transfer strategy, they would still have an impact on the operational performance of the manufacturing project, whether resulting in increased costs, further project delays, reliability/quality concerns, etc. In an environment that may be prone to events of such nature due to the immaturity of the industry, it becomes important to continuously assess and set up mitigating actions to minimize or completely avoid these risks (Workgroup, 2017).

In a report discussing the train manufacturing sector's recent, current, and imminent trends, McKinsey&Company (2016) make use of industry expertise, proprietary analyses, and insights from client discussions to, among other topics, discuss some of the risks that impact new train manufacturing projects. One of the risks discussed is related to project risk exposure brought about by the financial health of Original Equipment Manufacturers (OEMs) and suppliers, or their failures to meet project requirements. For customers to protect themselves against counterparty default, they

include clauses in the project contracts defining guarantees, penalties, and compensation covering delivery timing and product quality levels. These penalties are however borne by the manufacturing project, and depending on the complexity of the project, may be very high, increasing financial pressure and straining project capabilities.

Another risk discussed by McKinsey&Company (2016) is related to suppliers /OEMs' defaulting on their debt during a project. This risk is informed by the supplier /OEMs' credit rating based on historical default rates. This risk has a direct impact on the manufacturing project's supply chain, as any supplier going into e.g., liquidation may result in a shortage of parts during manufacturing and may lead to delivery delays and penalties.

McKinsey&Company (2016) also highlight reputational risk, and the risk of exclusion from future projects due to both the company's inability to stay abreast of new technologies or industrial standards, as well as the manufacturer's overall track record in testing and operations.

Fartaj *et al.* (2020) conducted a study in which they analysed the critical transportation disruption factors of the supply chain of an automotive parts manufacturing company. These disruption factors are risks that impact the supply chain of the manufacturing company, and as such, their identification and prioritization are major contributors to risk management in sustainable automotive parts manufacturing supply chains (Fartaj *et al.*, 2020). Making use of literature reviews and inputs from experts, 12 disruption factors were identified. Following this, the best-worst method (BWM) and rough strength-relation analysis method were used to determine the weights of the experts' inputs and rank the disruption factors. The identified factors were categorised into 4 groups: Natural factors, Man-Made factors, Financial factors, and Technological factors; and included disruptions caused by inadequate skilled labour/ labour strikes, the volatility of transportation costs, import-export restrictions/tariff, frequent changes in product delivery time, inflation and change in currency exchange rates, and other factors. The results of the study identified infrastructural bottlenecks/congestion, inadequately skilled labour, and frequent changes in product delivery time as the top three transportation disruption factors for the automotive parts manufacturing supply chain.

Through the aid of an expert panel consisting of senior representatives from key organisations involved in bringing new trains into service, as well as through consultation with key stakeholders, Authority (2004) conducted a study in which they, among other objectives, identified and discussed the key risk factors associated with the manufacture and introduction of new and modern trains in the UK. The identified risk factors that may impede or cause delay in bringing reliable passenger trains into service in good time and within budget include:

1. Risk related to the poor reliability of the new trains, stemming mainly from mechanical failures and electronic system failures, etc. The new trains are found to be less reliable than the older existing trains, therefore causing higher costs and schedule delays.
2. Risk related to the complexities in processes between all the parties involved, including customers and suppliers, that cause major delays in the project. There is a lack of strategic direction or design of the process by a single central body.
3. Risk that includes manufacturing and managerial problems, such as delays to sub-contractor's supplies and faulty parts, which in turn delay the delivery of many new vehicles to the customer.
4. Shortage of manufacturing and managerial expertise within the UK railway industry due to paucity of orders. Once the orders surged, the lack of experience had a negative effect on on-time delivery of trains.
5. Compatibility of manufactured trains with the available railway network infrastructure, and how they will affect or be affected by the infrastructure. These uncertainties may lead to design changes that impact the project financially and in schedule.
6. The risk that the customer infrastructure will not be sufficiently equipped to allow collection and operation of the manufactured trains.
7. Availability of national testing facility to test all trains from different manufacturers before final acceptance. This is related to the compatibility of the infrastructure with the different train variations.

One of the risk factors identified by Authority (2004) directly relates to delays in manufacturing due to delays in receipt of supplier parts. Although the supplier is external to the project, risks encountered by the supplier can directly impact the performance of the manufacturing project; these are classified as external risks. An example of this is shown in a study on project risks in the steel manufacturing industry. Dewi *et al.* (2020) make use of a purposeful sample of experienced project stakeholders in the steel industry to conduct a technical consultation/interview to identify risks associated with the steel manufacturing industry. They identify unrealistic schedules, inappropriate skills, unavailable equipment, fluctuations in steel material prices, wrong specifications from customers, incorrect interpretation of specifications, misinterpretation of drawings, material storage, and incorrect installations as major risks that affect project performance. Since steel is one of the main components of the manufactured train, this study provides insights both into the risks encountered by a major supplier to the train manufacturing industry that in turn affect the project supply chain; and an understanding of how the manufacturing project may act as a source of external risk to suppliers, ultimately causing a cycle of risk.

In an investigation into the high costs of scrap metal being borne by an automotive manufacturer in Slovakia, Lestyánszka-Škůrková (2017) made use of Pareto analysis to determine that the majority of manufacturing process errors were caused by the painting process employed during manufacturing. Manufacturing process errors contribute to the manufacture of incorrect/non-conforming parts, which is a risk for the project (Padiyar *et al.*, 2006; Sütőová and Grzinčič, 2013; Chiarini, 2017; Lestyánszka-Škůrková, 2017). Based on these findings, an investigation was launched into the painting process making use of a QRQC (Quick Response Quality Control) process, which is aimed at identifying root causes of a problem and providing and implementing a solution quickly and effectively. The results of the investigation presented issues with the work instructions, respect for the work order, control of standardized work, the amount of time allocated for the process, as well as visibility/ available lighting within the work area. The findings highlight some of the root cause issues or sources of risk that contributed to the risk of manufacturing non-conforming parts. Looking beyond the manufacture of non-conforming parts, these factors can be seen to contribute to the risks of cost overruns and low production quality.

From the study of Lestyánszka-Škůrková (2017), we can see the cascading impact of risk and uncertainty. It reemphasises the importance of creating a project-wide awareness/ culture of risk identification as well as the need for risk identification to be a continuous process and a process that involves all levels of employees (Barber and Burns, 2002). Risks related to processes may only be identified by the employees performing the processes, so it is vital to include them in the identification process.

Suh (2000) conducted a review on the Korean Seoul-Pusan high-speed railway (KTX) project and evaluated the risk management experiences and major risk factors based on the experience from the project inception through to the final test run stage. The identified risks associated with this project were grouped into three categories based on their nature: technical risks, which include engineering and construction risks and depend on the technical complexity of the project; financial risk, mainly caused by cost overruns and securing funding; social and political risks, which include the political decision-making process, public perceptions on safety and the project as a whole.

As part of the discussion Suh (2000) looks into the risks that are associated with unclear or undefined project goals, and highlights that this may lead many different decision bodies to approach the project with different and often conflicting goals. This is harmful to the cost and duration control of the project.

Government cooperation or the lack thereof also contributes to delays in project progress. Politically motivated decisions, or indecision because of political concerns have far-reaching consequences for

the train manufacturing project and industry as a whole Suh (2000). Inefficiencies in coordination and planning across government organizations involved in the train manufacturing industry have been seen to diminish the rolling stock manufacturing base. Association (2013) found that the sudden surge in rolling stock orders in Australia increased the pressure on the Australian train manufacturing industry and subsequently brought about the risk that all production would be sourced internationally due to capacity constraints. The lack of continuity of production is seen to exacerbate inefficiencies in the rolling stock supply chain, as it limits suppliers' abilities to plan investments and optimise production costs over a long period. In the UK this lack of production continuity was found to add 20% to the cost of rolling stock between 1988 and 2010 (Association, 2013)

The scope of activities for supply chain within the manufacturing industry has changed over time. As the aim of manufacturing organisations move towards mass production with high circulation and focus on producing high-quality products with fewer costs, activities that were previously performed at company level such as providing materials, production planning, warehousing, inventory control, distribution, delivery, and customer service, are now being performed at a supply chain level. It follows from this that supply chain risks have direct impacts on the project performance; although the risks may be classified at supply chain level, they can still be seen as project level risks as they were traditionally project/company level activities (Berenji and Anantharaman, 2011).

The most important goal of supply chain risk management is to ensure that supply chains continue to work as planned, with smooth and uninterrupted flows of materials from initial suppliers through to final customers. Supply chain management has had a substantial positive impact on the automotive industry. It has assisted to reduce operating costs, and improve the financial positioning of the manufacturing company (Fartaj *et al.*, 2020). An inefficient supply chain management process may act as risk source to drive the risks of a vulnerable supply chain, the inability to withstand unexpected issues in the supply chain, an unsustainable supply chain, and a fragile or sensitive supply chain, which would be detrimental to a train manufacturing project with strict budget constraints and a tight delivery schedule. The key property of supply chain risk is that the risk extends beyond the boundaries of the company, so both internal and external risks are involved (Berenji and Anantharaman, 2011).

Globalization has made supply chain networks more complex and interdependent, increasing the risk exposure of manufacturing companies engaging on the global front. Automotive supply chain networks are thus becoming more vulnerable to disruptions from the failure of one link within the network, which could result in the collapse of the entire system (Fartaj *et al.*, 2020). Through literature review, Canbolat *et al.* (2008) compiled a list of risk factors associated with global sourcing to support the design and manufacture of complex components and subsystems. The risk factors include political

and economic instability, currency fluctuations, market price increases, supplier capacity constraints, number of available suppliers, financial health of suppliers, cost reduction capabilities, process technological changes, quality, product design changes, inventory management, etc. Other studies include Mburu *et al.* (2017), who identified low supply chain resilience, supply chain disruptions or interruptions, and low capacity of suppliers to enhance their supply chain performance as major risk factors that may impact the successful realization of a manufacturing project.

2.5 Common Approaches to Risk Identification

One way to identify risks as prescribed by Nicholas and Steyn (2017) is to proceed according to the project chronology and identify risks associated with each of the phases; as they each present unique problems that may act as sources of risk. Another way to identify risk is by type of work or technical function, such as production risks associated with the manufacturability of a product or the availability of raw materials (Nicholas and Steyn, 2017). This study identifies risk by type of work, looking into project risk associated with the manufacturing of passenger trains.

Table 1 below summarizes the methods used to identify project risks in the above literature review. From the table, we see that Literature Reviews, Interviews with industry experts, and expert opinions are the most common methods used to identify risks.

Table 1 Summary of Risk Identification Methods in Literature Review

		Interviews					
	Literature Review	Experience/ expert opinion	Consultation with key stakeholders	QRQC	Document Analysis	Brainstorming	Questionnaire/ Survey
Andrić *et al.* (2019)	✓					✓	✓
Association (2013)	✓		✓				
RDG (2018)		✓	✓				
Rahmayana and Purba (2019)	✓						
Workgroup (2017)	✓	✓					
McKinsey&Company (2016)		✓	✓		✓		
Fartaj *et al.* (2020)	✓	✓					
Authority (2004)		✓	✓				
Dewi *et al.* (2020)		✓	✓				
Lestyánszka-Škůrková (2017)				✓			
Suh (2000)		✓					
Mburu *et al.* (2017)	✓						✓
Total	6	7	5	1	1	1	2

The following paragraphs discuss the two most frequently used approaches. It will then review other techniques used in literature to identify project risks.

2.5.1 Interviews

Interviews, which were the dominant method for risk identification in the above literature review, are defined as active interactions between two or more people leading to negotiated contextually based results (Fontana and Frey, 2005). They are information-gathering techniques in which selected participants are asked questions either in a structured, semi-structured, or unstructured manner to provide insight and meaning to their lived experiences (Berg *et al.*, 2004; Merriam and Tisdell, 2015). In this research study Suh (2000); Authority (2004); Association (2013); McKinsey&Company (2016); Workgroup (2017); RDG (2018); Dewi *et al.* (2020); Fartaj *et al.* (2020) made use of interviews to identify and or categorise risk factors in manufacturing projects.

Individual project risks and sources of overall project risk can be identified by interviewing experienced project participants, stakeholders, and subject matter experts to ensure that the information gathered through the interviews is meaningful and can be used to draw conclusions about the project risks (Hiles, 2010; Widiasiha *et al.*, 2015; Qazi *et al.*, 2016; PMI, 2017). Of the reviewed studies, Suh (2000); Authority (2004); McKinsey&Company (2016); Workgroup (2017); RDG (2018); Dewi *et al.* (2020); Fartaj *et al.* (2020) performed interviews with industry experts to determine project risk factors based on their experiences of past projects in the industry, and Authority (2004); Association (2013); McKinsey&Company (2016); RDG (2018); Dewi *et al.* (2020) interviewed key project stakeholders to get their perspectives on the project based on their knowledge of the industry and the project's objectives and constraints. Canbolat *et al.* (2008) do not specify who their interview participants are or their industry experience.

2.5.2 Literature Review

A literature review is an information gathering technique, focussing on information analysis and synthesis, that is used to explore existing scholarly information relevant to the topic of study; summarizing the substance of the literature and drawing conclusions from it (Randolph, 2009). Many authors use extensive literature reviews to identify manufacturing project risks, as findings from similar/related projects are very valuable in identifying potential risk factors in new projects. In this research study Association (2013); Mburu *et al.* (2017); Workgroup (2017); Andrić *et al.* (2019); Rahmayana and Purba (2019); Fartaj *et al.* (2020) made use of literature reviews to collect data and identify risk factors in the studied manufacturing projects.

2.5.3 Other Approaches to Risk Identification

Mburu *et al.* (2017) administered a questionnaire to all 153 manufacturing companies in Kenya to determine what techniques are used to identify project risks in their manufacturing projects. Figure 1 below depicts the results of the questionnaire. In order of prevalence, the risk identification techniques are audit reports, personal experience, past performance, industry practice and joint stakeholder meetings.

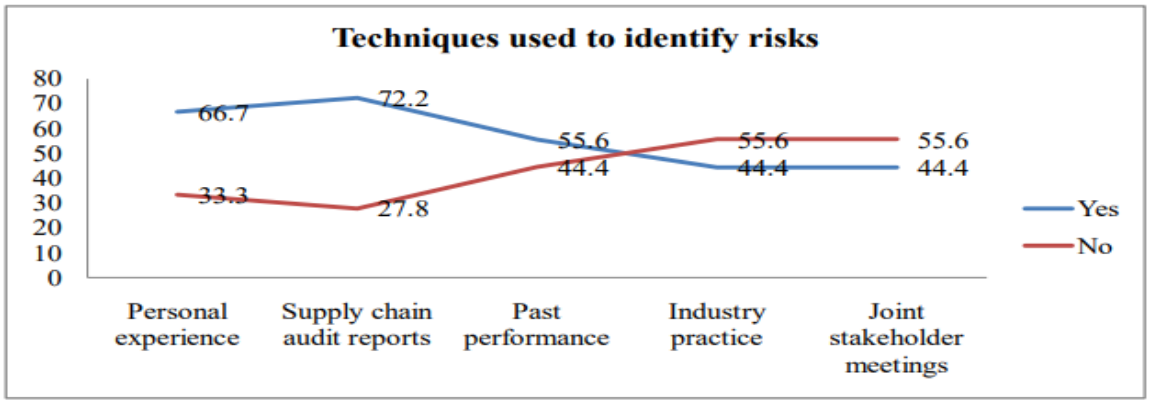

Figure 1 Techniques Used to Identify Risks (Mburu et al., 2017)

Burduk and Chlebus (2006) model and simulate a manufacturing system to verify the different solutions in production planning before selecting the optimal one to start production. They propose a method of risk evaluation that assists to determine the risk level of the chosen production line and eventually for the whole manufacturing system. To identify the risks associated with the different production line solutions, they proceeded through each individual area in the manufacturing system and identified the risks associated with the area and its functions. Figure 2 represents the results of the simulation with the risk factors identified in each area. This approach is similar to the approach described by Nicholas and Steyn (2017).

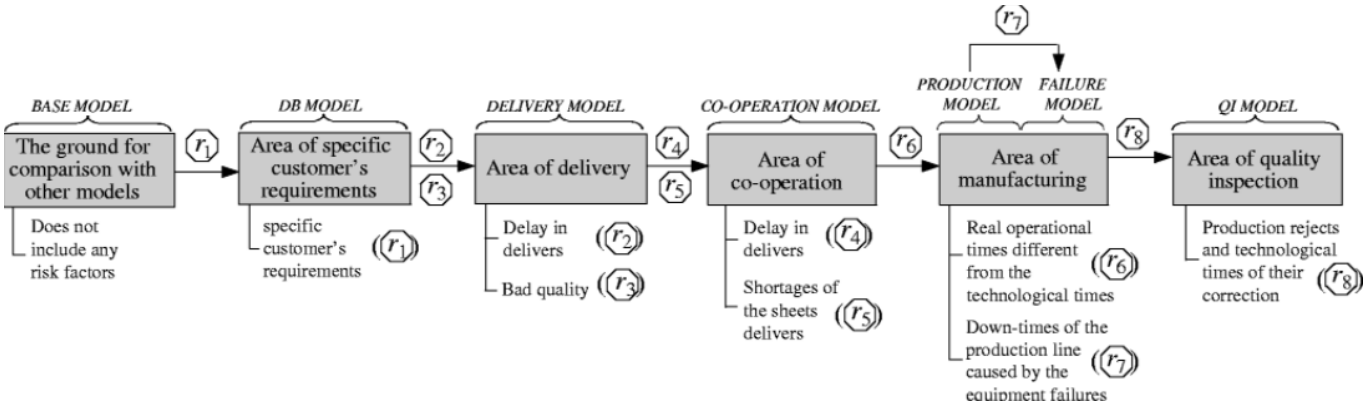

Figure 2 Models and Analysed Risk Factors in the Areas of Production Process(Burduk and Chlebus, 2006)

Moreira *et al.* (2020) make use of Failure Mode and Effects Analysis (FMEA) to identify 22 failure modes associated with the new product development process in the areas of logistics risks, supply risks, design risks, and product and manufacturing technology-related risks; and were thereby able to identify 12 high-priority risks and reduce the riskiness of each of them. The FMEA method is used to identify conditions leading to system failure and thus subjecting the project to risk (Nicholas and Steyn, 2017), and helps in the reduction of unrecognized, unmanaged, or unmitigated failure modes and risks (Ahmed *et al.*, 2007).

There are many other techniques/approaches that can be used for risk identification. These include:

1. Expert judgement: Project managers consult with experts who have knowledge about similar projects or businesses in order to identify potential sources of risk and to assess the individual risks involved in the project.(PMI, 2017; Klober-Koch *et al.*, 2018)
2. Brain Storming: The project team usually brainstorms with a multidisciplinary set of experts who are not part of the team to generate ideas and produce a comprehensive list of individual project risks and sources of overall project risk. The brainstorming sessions can be informal or structured. In a structured brainstorming session, strategic frameworks are often used to aid the team in idea generation e.g., a prompt list, which is a predetermined list of risk categories that might give rise to individual project risks or act as sources of overall project risk. (Widiasiha *et al.*, 2015; PMI, 2017; Klober-Koch *et al.*, 2018).
3. Checklists: Risk checklists are developed based on historical information and knowledge accumulated from similar projects and other information sources, and may relate to the project as a whole or focus on specific phases or processes. The checklist can be developed from the organization's past projects or a generic one from industry. They capture lessons learned from previous projects, listing project risks that occurred previously and may be relevant to this project. The risk checklist is updated as new experiences are gained during the current project (Hiles, 2010; Nicholas and Steyn, 2017; PMI, 2017).
4. Root cause analysis: Root cause analysis is used to discover the underlying causes that lead to a problem and develop preventive actions. It can be used to identify both threats and opportunities by starting off with a problem or benefit statement, and then exploring the threats or opportunities that may result in the initial problem or benefit being realized (Widiasiha *et al.*, 2015; PMI, 2017).
5. Assumption and constraint analysis: Assumption and constraint analysis explores the validity of the assumptions and constraints on which the project was conceived or developed and determines which pose a risk to the project. Inaccuracy or incompleteness of assumptions may result in threats; and constraints may give rise to opportunities through removing limiting factors that affect the execution of the project or a specific process (PMI, 2017).
6. SWOT analysis: The SWOT analysis is used to increase the breadth of identified risks by including internally generated risks. It examines the project from each of the strengths, weaknesses, opportunities, and threats perspectives, and identifies any opportunities that may arise from the identified strengths, and any threats resulting from weaknesses. It also examines the degree to which strengths may offset threats, and if weaknesses might hinder opportunities (Widiasiha *et al.*, 2015; PMI, 2017).

7. Document analysis: Document analysis entails a structured review of project documentation including plans, assumptions, contracts, technical documentation, constraints etc. to identify project risks. Uncertainty, ambiguity, and inconsistencies found in the documentation serve as indicators of risk in the project.
8. Work Breakdown Structure: Using a work breakdown structure, each work package in the project is scrutinized for problems with management, customers, suppliers, equipment, or resource availability, and is assessed based on both internal and external risks (Nicholas and Steyn, 2017).

2.6 Summary of Literature Review and Research Motivation

In the process of risk identification, various methods are used to collect information about the project and to identify project risks. In the reviewed literature, we see information gathering and risk identification being performed through interviews with industry experts or project stakeholders, performing reviews on related industry literature, or a combination of other techniques. Table 1 presents a summary of the approaches used in the studied literature to identify risk factors.

Of the identified manufacturing project risks from the studied literature, a dominant theme related to supply chain risks, i.e., globalization, supplier failures, supply chain inefficiencies, and outsourcing of some manufacturing processes. Common risks were regarding whether the suppliers had the capacity to deliver the required quantity of products on time and at the right quality, as well as whether the suppliers had sufficient financial health/stability to support the manufacturing project. External risks are seen to have significant impact on project performance if not managed well. Other external risks that are less under the control of the project included investment risks or increased costs of project funding, risks due to the turbulent economy, political risks fostered by misalignment on goals/objectives within government departments, indecision, or politically motivated decisions. Internal project risks included finance risks, schedule risks, complexity risks, quality risks, reliability risks, communication risks, risks relating to employee skill and expertise, risks surrounding manufacturing equipment efficiencies, and reputation risk which can expose the project to high levels of competition. The cascading impact of risk within the project was also noted as imperative to consider.

Most of the studies were however conducted in developed countries, or countries external to Africa, whereas this study is being conducted in South Africa, a developing country that does not have a lot of experience in train manufacturing. One of the gaps in literature is regarding whether these identified risk factors are easily transferable to a project within a different socio-economic climate, or whether the project environment has a significant impact on the project risk factors.

The suppression of investments in the South African Rail industry over many years is seen to have impaired the industry and has resulted in a shortage of skills and expertise, a weak supplier base, aging infrastructure, the use of obsolete technology, and no obvious direction for the future; causing all new train manufacturing projects to start at a disadvantage. With aim to revitalize the current rail infrastructure, new policies to boost the economy and revive the industry have been put in place. This has seen the integration of stringent socio-economic development obligations such as localization, skills development, and job creation, into new project objectives; non-achievement of the objectives resulting in additional penalties for the project. Although these initiatives encourage investments from private partners into the South African economy, the current state of the industry makes some of the objectives very difficult to achieve. Other factors that may impact new train manufacturing projects in South Africa include political pressures, financial constraints due to shifts in government funding priorities, strikes/unrest by communities or labour unions etc.

A gap identified in the literature is the shortage of information about risk identification in South African train manufacturing projects, as there hasn't been a full-fledged train manufacturing project in South Africa for many years. This study aims to close this gap. The research will consider both external risks and risks that may arise from within the project due to its constraints and objectives. This study also aims to propose a ranking to the identified risk factors based on their perceived risk significance.

This research aims to build on the findings of JICA (2013) within the setting of a manufacturing project. The advantages being that the findings will reflect the actual risk factors identified within that project, and which have already become 'issues'. Additionally, the findings will discuss the major areas of impact for the project. The approach is more focused, as it specifically targets an existing project. The findings can be used to contribute to more effective risk management for future similar projects in South Africa and other developing countries with similar economic, social and political environments.

3 RESEARCH METHODOLOGY

Creswell (2014) defines three different approaches to research: quantitative research, qualitative research, and mixed methods research. Table 2 highlights the differentiating characteristics of qualitative versus quantitative research as presented by Sorin-Peters (2004). Qualitative research, which has an emergent/inductive nature, is defined by Creswell (2014) as an approach that makes use of the analysis of words to explore and understand the meaning ascribed to a social or human problem by individuals or groups. The focus of qualitative research is to describe and explain the essence of a social phenomenon and its meaning in participants' lives. According to Choy (2014) and Sorin-Peters (2004), qualitative methods typically refer to a range of data collection and analysis techniques that use purposive sampling and semi-structured, open-ended interviews, where the qualitative researcher adopts a learning role to find out about a phenomenon. Conversely, quantitative research is defined as an approach for testing objective theories by examining the relationship among measurable variables, allowing for the numerical data to be analysed using statistical methods (Creswell, 2014). Quantitative research uses a rigorous and controlled design to examine phenomena using precise measurement (Rutberg and Bouikidis, 2018). In contrast to qualitative research where the researcher takes on a learning role, the quantitative researcher adopts a testing role, where a hypothesis is subjected to possible falsification (Sorin-Peters, 2004). Finally, the mixed method to research is a combination of both qualitative and quantitative approaches, and is believed to provide a more complete understanding of a research problem than either approach alone (Creswell, 2014).

Graneheim and Lundman (2004) assert that reality can be interpreted in various ways and the understanding is dependent on subjective interpretation. The same can be said about risk. The presence or absence of risk is highly dependent on the perception and experience of the actors involved in the risk identification process. The risk identification process can therefore be described as a subjective one (Zhang, 2011). As can be seen in Table 2, the process of understanding and describing project risk factors from the perspectives of project participants requires a flexible and evolving or semi-structured approach, coupled with inductive reasoning on the part of the researcher to make any meaningful conclusions (Sorin-Peters, 2004). This research to identify project risk factors was based on data collected through interviews with selected project participants. The interviewees each described their shared experience of project risk factors, which was the phenomenon under investigation; and as such, a qualitative research approach was used to describe the phenomenon (Graneheim and Lundman, 2004; Creswell, 2014).

Table 2 Differentiating characteristics of qualitative versus quantitative research (Sorin-Peters, 2004)

Point of comparison	*Qualitative research*	*Quantitative research*
Focus of research	Quality (nature, essence)	Quantity (how many, how much)
Philosophical roots	Phenomenology, symbolic, interaction	Empiricism, logical positivism
Associated phrases	Fieldwork, ethnographic, naturalistic, grounded, subjective	Experimental, empirical, statistical
Goal of investigation	Understanding, description, discovery, hypothesis generating	Prediction, control, confirmation, hypothesis testing
Design characteristics	Flexible, evolving, emergent	Pre-determined structure
Setting	Natural, familiar	Unfamiliar, artificial
Sample	Small, non random, theoretical	Large, random, representative
Data collection	Researcher as primary instrument, interviews, observations	Inanimate instruments (scales, tests, surveys, questionnaires, computers)
Mode of analysis	Inductive (by researcher)	Deductive (by statistical methods)
Findings	Comprehensive, holistic, expansive	Precise, narrow, reductionistic

Data collection and analysis took place simultaneously considering the emergent nature of qualitative research (Merriam and Tisdell, 2015). Emphasis is placed on the emergent nature of the research, as themes emerged from the narratives of the interviewed participants. The collected data then provided guidance towards certain hypotheses pinpointing potential project risk factors, that could be verified through further investigation allowing for study refinement (Merriam and Tisdell, 2015). The study had an interpretivist/constructivist, inductive approach using qualitative methods to gather and analyse data to identify the project risk factors and answer the research questions. A characteristic of qualitative research is that the researcher is the primary instrument for data collection and analysis. Being flexible and responsive to the context, the researcher can adapt applied research techniques to the circumstances, process new data immediately, clarify and summarise collected data as the study evolves, and can explore anomalous responses (Sorin-Peters, 2004). Even though the researcher will not suggest or impose premeditated ideas to the participants, the researcher plays a very significant role in ensuring the quality and content of information collected from the participants.

3.1 Research Approach and Design

Rutberg and Bouikidis (2018) assert that it is important to keep in mind the unique attributes of qualitative research in selecting the design or methodology for a research study. To understand the problem under study, qualitative research methodology may involve multiple means of data collection such as observation and interviews. Qualitative research is also flexible in that it adapts to new information based on the collected data, hence its emergent nature (Merriam and Tisdell, 2015), and

the required learning role of the researcher (Sorin-Peters, 2004). In order to assume this learning role, the researcher needs to perform a self-assessment and self-reflection, as situated within the social context, on any personal presumptions and biases toward the topic (Choy, 2014; Rutberg and Bouikidis, 2018). Other considerations include selecting the design that best fits the study, the time necessary to devote to the study, a data collection plan and resources available to collect the data (Rutberg and Bouikidis, 2018).

Polit and Beck (2014) describe five types of qualitative research designs or methodologies, these include: ethnography, phenomenology, grounded theory, historical research, and case studies. An additional approach discussed by other authors is Narrative research (Creswell, 2014; Khan, 2014). Table 3 contrasts the characteristics of the different approaches to or types of qualitative research. Ethnography reveals the way culture is defined, the behaviour associated with culture, and how culture is understood. It allows the researcher to investigate shared meanings that influence behaviours of a group (Rutberg and Bouikidis, 2018). Phenomenology is used to investigate the essence of a lived phenomenon by studying several people that have shared the experience, thereby uncovering meanings of this experience (Khan, 2014). Grounded theory investigates actions and the effects of the behaviour in a culture. Historical research examines the past using recorded data such as photos or objects, to provide a historical perspective on the research topic (Rutberg and Bouikidis, 2018). The case study approach refers to a group of methods which emphasize qualitative analysis. Making use of multiple data collection methods it seeks to understand the problem being investigated and provides the opportunity to ask penetrating questions to capture the richness of organizational behaviour. However, the conclusions drawn may be specific to the particular organizations studied and may not be generalizable (Choy, 2014). Narrative research is a qualitative strategy in which the researcher studies the lives of individuals and asks one or more individuals to provide stories about their lives. This information is then often retold by the researcher into a narrative chronology (Creswell, 2014). The ethnography, grounded theory, historical research, case study, and narrative research methods do not seem appropriate or well suited to establish lived experiences in a context that would lead to risk identification for this study.

According to Denney (2020), phenomenology is the ideal approach for understanding the state of the practise in risk and opportunity management, which also caters to risk identification, since its main focus is on the lived or practised experience of the interviewed individuals. The characteristics of a phenomenological approach to a qualitative study are presented in Table 3 below. Khan (2014) also asserts that the phenomenological approach is best suited to research problems that aim to understand the lived experiences of people in relation to a phenomenon, its unit of analysis being the several people who have shared the experience. The approach also offers a means to obtain a

descriptive representation of authentic perspectives, context and experiences (Hickson, 2015). This view is also shared by Auerbach and Silverstein (2003). This research therefore adopted the phenomenological approach as it explores the phenomenon of project risk factors through the lenses of the selected expert project participants, and allows for the development of both an understanding of the phenomenon as well as of a description of how the individuals experienced the phenomenon (Auerbach and Silverstein, 2003; Hickson, 2015). Information was primarily gathered through interviews, and the findings were based on the participants' experiences and perceptions of project risk, making the participants central to this research as the unit of analysis.

The phenomenological and grounded theory approaches both collect the perspectives of a number of participants; however, rather than theorizing from these perspectives and generating a theoretical model as is done in grounded theory, the phenomenological approach aims to describe what all participants have in common as they experience a phenomenon. (Creswell, 2014). Also, instead of abstracting from the participants statements to construct a model from the researchers interpretations, the researcher works more from the participants' specific statements and experiences to ultimately reduce the participants' experiences to a description of the universal essence (a "grasp of the very nature of the thing" (Creswell, 2014), or in the case of this research, the list of project risk factors.

Table 3: Contrasting Characteristics of Five Qualitative Approaches (Khan, 2014)

Characteristics	Narrative Research	Phenomenology	Grounded Theory	Ethnography	Case Study
Focus	Exploring the life of an individual	Understanding the essence of the experience	Developing a theory grounded in data from the field	Describing and interpreting a culture-sharing group	Developing an in-depth description and analysis of a case or multiple cases
Type of problem best suited for design	Needing to tell stories of individual experiences	Needing to describe the essence of a lived phenomenon	Grounding a theory in the views of participants	Describing and interpreting the shared patterns of culture of a group	Providing an in-depth understanding of a case or cases
Discipline background	Drawing from the humanities including anthropology, literature, history, psychology, and sociology	Drawing from philosophy, psychology, and education	Drawing from sociology	Drawing from anthropology and sociology	Drawing from psychology, law, political science, medicine
Unit of analysis	Studying one or more individuals	Studying several individuals that have shared the experience	Studying a process, action, or interaction involving many individuals	Studying a group that shares the same culture	Studying an event, a program, an activity, more than one individual
Data collection forms	Using primarily interviews and documents	Using primarily interviews with individuals, although documents, observations, and art may also be considered	Using primarily interviews with 20 – 60 individuals	Using primarily observations and interviews, but perhaps collecting other sources during extended time in field	Using multiple sources, such as interviews, observations, documents, artifacts
Data analysis strategies	Analysing data for stories, "restoring" stories, developing themes, often using a chronology	Analysing data for significant statements, meaning units, textural and structural description, description of the "essence"	Analysing data through open coding, axial coding, selective coding	Analysing data through description of culture-sharing group; themes about groups	Analysing data through description of the case and themes of the case as well as cross-case themes
Witten report	Developing a narrative about the stories of an individual's life	Describing the "essence" of the experience	Generating a theory illustrated in a figure	Describing how a culture-sharing group works	Developing a detailed analysis of one or more cases

3.2 Data Collection Methods

Many methods exist to identify potential risks, these include in-depth interviews, brainstorming, questionnaires, historical documents, judgement based on experience and direct observation, meetings, and other data gathering and data analysis processes (root cause analysis, SWOT analysis etc.) (Widiasiha *et al.*, 2015; PMI, 2017). Creswell (2014) lists interviews, observations, documents,

and audio-visual data as possible data sources for research, and highlights that interviews which make use of open-ended questions are commonly used to gather information for qualitative data. Interviews are also noted by Ritchie *et al.* (2003) as one of the most common methods for data gathering in qualitative research. Interviews are identified as the primary data collection method for the phenomenology approach (Auerbach and Silverstein, 2003; Creswell, 2014; Khan, 2014), and as such interviews were used as the primary method to collect data for this research.

Berg *et al.* (2004) describe three basic types of interviews which vary according to the degree of rigidity between them regarding presentational structure: the standardized or structured interview, the semi-standardized or semi-structured interview, and the unstandardized or unstructured interview. A summary of these interview types and their characteristics are presented in Figure 3 below.

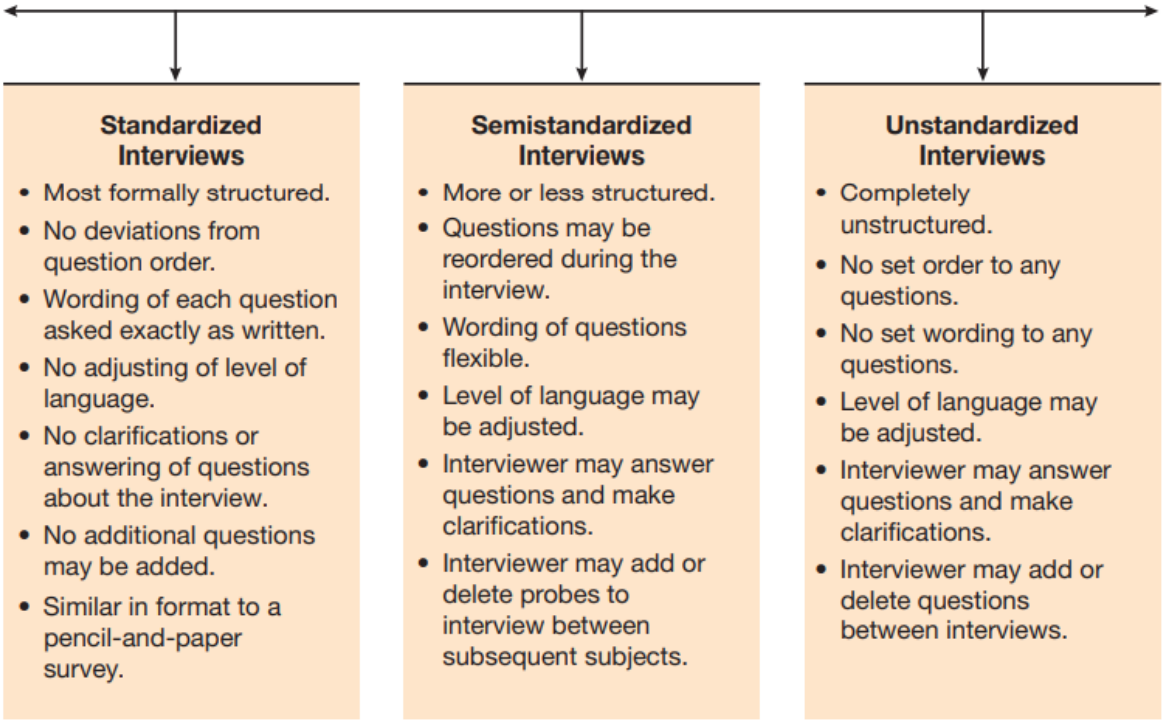

Figure 3 Interview Structure Continuum of Formality (Berg et al., 2004)

In a structured interview, the interviewer asks the participants a series of pre-defined questions with a limited number of response options. Because the questions are designed to elicit rational responses, the underlying assumption is that if they are phrased correctly, they will uncover all relevant information about the topic. As a result, the process of organizing and quantifying the findings is relatively simple. Structured interview researchers are also able to study a relatively large sample when compared to other qualitative interview types because the process of using the same questions with all interviewees and the ability to analyse responses to these questions takes significantly less time. (Qu and Dumay, 2011).

The unstructured interview process resembles a regular conversation in which the researcher responds to the informant as much as the informant responds to the researcher; the flow of topics is determined by the subject rather than the interviewer. (Berg *et al.*, 2004). It can be seen to be on the complete opposite end of the continuum from structured interviews. With unstructured interviews, questions do not need to be scripted; researchers generally prepare a loose set of topics or issues to be discussed, possibly with a preferred order of discussing them. These guidelines serve as notes or a checklist for the interviewer. Interviewers must develop, adapt, and generate questions and follow-up probes appropriate to each given situation and the central purpose of the investigation. The unstructured interview process shapes to the individual situation and context, intending to make the interviewee feel relaxed and unassessed (Berg *et al.*, 2004; Qu and Dumay, 2011).

The Semi-Structured interview is in the middle of the continuum of rigidity between structured and unstructured interviews. It offers the structure of a structured interview, wherewith the interviewer can prepare a set of standard questions; but also, the flexibility of unstructured interviews, allowing the interviewer to reorder the questions, adjust the language, answer questions, and add or delete probes to the interview. In this type of interview, validity and reliability depend, not upon the repeated use of the same words in each question, but upon conveying equivalence of meaning (Nugraha, 2015)

The advantages of a semi-structured interview, as listed by Nugraha (2015) are that:

1. It has the potential to overcome the poor response rates of a questionnaire survey
2. It is well suited to the exploration of attitudes, values, beliefs, and motives
3. It provides the opportunity to evaluate the validity of the respondent's answers by observing non-verbal indicators, which is particularly useful when discussing sensitive issues
4. It can facilitate comparability by ensuring that all questions are answered by each respondent
5. It ensures that the respondent is unable to receive assistance from others while formulating a response

For this research, data about risk factors associated with train manufacturing in South Africa was primarily collected through semi-structured interviews facilitated by means of open-ended questions and specific probes/ targeted questions (Creswell, 2014).

A questionnaire is another data collection method (Widiasiha *et al.*, 2015; PMI, 2017) that has been used successfully by various authors to identify risk factors (Canbolat *et al.*, 2008; Gandhi *et al.*, 2012; Mburu *et al.*, 2017), as well as to identify risk significance (Wu *et al.*, 2017), and was therefore also used in this research to answer the last research question. The findings of the questionnaire were summarized in a Pareto chart.

Although focus groups with a combination of all relevant stakeholders in the project would have been very useful to gather the required data and to easily identify the top or most prevalent identified risk factors, the constraints surrounding the project make it impractical; it would be impossible to remove key players in the manufacturing process from their duties to attend a focus group for the research. The advantage of one-on-one interviews however is that they allow the respondent to provide a detailed account and interpretation of their experience as well as to assign meaning to the experience (Merriam and Tisdell, 2015). The one-on-one semi-structured interviews therefore suitably supported the focus of this phenomenological study by ultimately allowing us to have a richer picture and understanding of the phenomenon of project risk factors through the detailed experiences and perceptions of the interview participants within the context of the South African train manufacturing project (Hickson, 2015).

Prior to data collection, the research procedures were approved by the University ethics committee. Consent was obtained from all participants to both interview them and record the interview. The interviews were then transcribed verbatim.

3.3 Sample Selection and Research Participants

PMI (2017) defines a list of participants that should be involved in the risk identification process of a project, who collectively have a large pool of knowledge to define the high-level preliminary risks associated with the project that can be addressed. This group includes project team members, subject matter experts, end users, operations managers, project stakeholders etc (PMI, 2017).

Due to the emergent nature of qualitative research, it was important to select participants who will be able to provide meaningful insight and information on the research topic based on their knowledge and experiences. This ensured that the quality of data collected would be enough to make meaningful conclusions.

The two basic types of sampling used in qualitative studies to select research participants are probability sampling and non-probability sampling (Merriam and Tisdell, 2015). Probability sampling is defined as a sample in which each member of the population has an equal chance of being selected, allowing the researcher to extrapolate the study's findings to the entire population (Galloway, 2005) (Merriam and Tisdell, 2015). In non-probability sampling on the other hand, some members of the population have a greater but unknown chance of selection (Galloway, 2005). Since generalization is not a goal of qualitative research (Merriam and Tisdell, 2015), non-probability sampling was used for this research.

Purposeful sampling, a form of non-probabilistic sampling, is used to discover, understand, and gain insight. It involves selecting a sample from which the most can be learned. A purposive sample is used because of their special experience and competence (Merriam and Tisdell, 2015).

A purposeful sample of participants was used for this research and all the participants are employees of the train manufacturing company. The following criteria was used to select sample participants and aided in ensuring the gathering of relevant and useful information during the interview process to address the research objectives outlined in Chapter 1 of this study:

Participants who are well versed with the concepts of risk, risk identification and management; who have specialized knowledge and exposure to the various aspects of the project that pose a risk or source of risk; who are exposed to and manage internal and or external project risks daily as part of their job functions and are in positions to make decisions that address the given risks.

This sample of participants, with their experience, provided meaningful and useful information in identifying project risk factors associated with the train manufacturing project as well as risk associated with the project environment within the South African context.

Following the above, and to demonstrate achievement of the sample selection, the interview questions established that the participants, within their various scopes or areas of work:

1. Are familiar with the concept of risk management
2. Understand the importance of identifying project risk factors
3. Have experience in risk identification and management within this project
4. Can identify project risk factors

Convenience sampling, which is a selection of participants based on time, location, availability etc (Merriam and Tisdell, 2015), was used to select the purposeful sample. The intended sample included the Project Manager and project managers in the various departments such as Sourcing, Supply Chain, Testing, Project Planning, Project Operations, Project Quality etc. However, if the intended participant was not available, suitable representatives were nominated who also fit the above given criteria.

3.4 Sample Size

The sample size of a research project depends on the qualitative design being used (Creswell, 2014), however, there is no defined answer to the exact number of people that should be in the sample (Merriam and Tisdell, 2015). Qualitative interviews cannot study a very large or random sample of people, due to the large amount of time and effort involved and limitation of access (Qu and Dumay, 2011). For a phenomenology research design, Polkinghorne (1989) and Creswell (2014) recommend

interviewing 5 to 25 individuals to develop the possibilities of experiences. The sample size is however influenced by many factors such as the amount and depth of information gathered, the length of time it takes to conduct an interview, the questions being asked, the analysis in progress and the available resources to support the study (Merriam and Tisdell, 2015). Polit and Beck (2014) suggest that the sample size of qualitative research depends on the information needed and can increase until the point of data saturation - this is a point where data is no longer collected, categories or themes are saturated, and new data no longer sparks new insights or reveals new properties (Creswell, 2014). The approach for data saturation is also recommended by (Lincoln *et al.*, 1985). Essentially, the size of the sample cannot be known until the end of the research, and is therefore emergent (Patton, 2014).

The determination of data saturation was facilitated by simultaneous data collection and analysis processes (Merriam and Tisdell, 2015). During the data analysis session conducted after each interview, the researcher decided whether the data collected added anything new to what had already been collected or was redundant of it, and whether further data collection became counter-productive. Practically, if the researcher heard the same comments repetitively in multiple interviews, data saturation was being reached. Identifying the point or state of data saturation was therefore a matter of the analyst's decision and was a cumulative judgement made by the researcher based on the information already collected and analysed from past interviews. This then determined whether further interviews needed to take place (Saunders et al., 2018).

The sample size for this research was determined by the point of data saturation– where no new information was being uncovered and no new risk factors were being identified; and was only known after data analysis was concluded.

3.5 Interview Design

Berg *et al.* (2004) provide very useful guidelines towards interview design. They assert that the starting point is to determine the nature of the investigation and the objectives of the research, this will allow for the identification of the kinds of data needed to meet those objectives, be it the description of events, feelings, ideas etc. In the preparation of interview questions, they assert that the starting point is to develop an outline, listing all the broad categories or conceptual areas that may be relevant to the study, and then to develop sets of questions relevant to each of the outlined categories. This will allow the researcher to have an idea of the number of questions that will be asked per category to collect the required data. The questions can be refined, changed, shortened, or reworded at a later stage (Berg *et al.*, 2004).

For this research study, the phenomenological approach used puts a focus on the lived experience of the interview participants. It looked at the detailed descriptions and meanings that the individuals assign to the phenomenon of project risk factors and derived the essence of experience through an analysis of the individual accounts. Stemming from this and based on the individual participants experiences, the broad categories that were explored include:

1. Participants' perception of the importance of risk management and risk identification – this category of questions provided a view on the participants experience with risk management and was used to demonstrate the achievement of sample selection criteria. The responses to the set of questions in this category allowed the researcher to confirm whether the participants were familiar with and understood the importance of risk management, were able to identify both internal and external project risks and were able to apply risk management effectively in their work environments.
2. Identification of project risk factors – this is one of the main objectives of the research study addressing the research question "What are the risk factors associated with train manufacturing", and highlights the various project risk factors identified by the interview participants
3. Identification of project risk factors brought about by the South African environment - this is one of the main objectives of the research study addressing the research question "Which of the identified risks are as a result of the South African environment "and aims to identify project risks that are brought about by the project environment, specifically the South African environment. These risks may be either internal or external risks.

Berg *et al.* (2004) provide some guidelines to the design of interview questions. They state, regarding the sequence of questions, that although there may not be a hard and fast rule for interviews, it is recommended to begin with questions that will be easy for the participant to answer, and which are largely questions that are not sensitive or threatening. This helps to establish a rapport between the interviewer and the interviewee and fosters a sense of commitment on the interviewee's part, as he or she will have already invested time in the interview by answering the simple questions. It's also vital to be aware of how often short, seemingly irrelevant questions are asked, as this can lead to a pattern of short questions and short answers, which can discourage deeper responses when they're needed. As a result, it might be best to start with simple questions that are directly related to the research. (Berg *et al.*, 2004).

Following this guideline, the following interview schedule was developed for this research:

1. How familiar are you with the concept of Risk Management? (Wu *et al.*, 2017)

2. Do you think Risk Management is important and necessary for this project? why? (Wu *et al.*, 2017)
3. What is your understanding of the term "Identifying Risk Factors" in the Risk Management process? (Wu *et al.*, 2017)
4. In your position, are you able to identify project level risk factors?
5. What are the risk factors associated with this project?
6. Which of the identified project risk factors are as a result of the South African environment?

Question 6 above was addressed by means of a post-interview questionnaire. The questionnaire took the form of a "Multiple Response Question" as these are commonly used for their ability to capture respondents' views and attitudes to pre-formatted information, or in this case the list of identified risk factors (Santos, 2000). A Multiple Response Question allows the respondents to select either a set number or varying number of responses to a question. Not limiting the number of responses elicits from the participants all the items that match a particular definition or that conform to a particular condition(Cook and Perli). Analysis of the frequency counts of each item can then be used as a basis for deducing its importance or significance as a response to the question, allowing the items to be ranked by this measure (Santos, 2000).This simple approach makes for easy discussion and interpretation of results, and was therefore used in this research.

Since the objective being addressed is to recognize which of the identified risk factors are as a result of the South African environment, the participants should be able to make an independent decision for each presented risk factor with no consideration for the other factors (Verbić, 2012), especially since the relationships between the risk factors are not being studied. Limiting the number of selections that the participants can make (to either one, two, three options, etc.) overlooks the possibility of more viable answers (Stephen and SAZ, 2018), preventing the recognition of some factors that are influenced by the environment, and may give the impression that:

1. The number of risk factors that fulfil the criteria are equal to the number set in the limit – which may distort the view of the participant from giving an informed opinion to wanting to provide the "correct answer" or a best fit option(Stephen and SAZ, 2018).
2. Some risk factors are more relevant or significantly impacted by the South African environment, requiring the participants to compare the factors to select the significant few. Although it may be the case that some factors are more significantly impacted by the environment than others, this analysis of level of impact was not an objective of this research and should therefore not influence the results of the questionnaire.

Once all the interview data (responses to questions 1-5) had been collected and analysed, the resulting list of identified risk factors was compiled into a questionnaire which was presented to the same group of participants. In the questionnaire the participants were asked the following question:

"Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?"

The participants were then required to tick the boxes next to as many risk factors they believed to be as a result of the South African environment. The results were tallied and presented in the research findings with the aid of a Pareto chart.

As described above, apart from questions targeted at the research objectives that aim to identify the project risk factors and risk factors specifically related to the South African environment, some of the above questions also provided evidence that the selected participants met the selection criteria. Since the research participants were selected because they fulfil the sample criteria, this set of questions was designed to demonstrate the knowledge the participants possess that justifies their inclusion in the sample. The questions also gather information on the participant's experiences of risk management and risk identification to enable a richer description of the phenomenon based on their experiences.

Table 4 below summarizes the purpose of each of the above questions and how they relate to the research study.

Table 4 Motivation for Interview Questions

Interview Question	Direct Link to Research Objective	Research Objective	Purpose of Question	Negative answer resulting in Disqualification?
How familiar are you with the concept of Risk Management?	No	NA	This is an introductory question to establish rapport with the participant and lay down the basis for the discussion. This question falls under the first category of questions that seek to uncover the participant's perception of the importance of risk management and risk identification and demonstrate achievement of the sample selection by revealing the participants familiarity with the concept of risk management. It will allow them to reflect on their past experience with risk management and the different aspects of it they have been involved with.	Since this question is used to demonstrate achievement of the sample selection, all participants are expected to answer this question in the positive, i.e., be familiar with risk management. Since the question will also be answered by means of scale from 1-10; all scores below 6 will disqualify the participant.
Do you think Risk Management is important and necessary for this project? why?	No	NA	This question will provide a view on the participants experience with risk and risk management, with a focus on the project under study. It will allow the participants to reflect on various project risk events and the impact of risk management activities (or the lack thereof) in addressing those risk events. It will thus also provide evidence that the participant meets the sample criteria as their experience should highlight their involvement in and knowledge surrounding risk management activities in the project.	Yes, since this question is used to demonstrate achievement of the sample selection, all participants are expected to answer this question in the positive. Their experiences should evidence the clear importance and necessity of risk management for the project.

Interview Question	Direct Link to Research Objective	Research Objective	Purpose of Question	Negative answer resulting in Disqualification?
What is your understanding of the term “Identifying Risk Factors” in the Risk Management process?	No	NA	This is an introductory question to lay down the basis for the next topic of discussion which focuses on risk identification. This question also relates to demonstrating achievement of the sample selection criteria as it will provide evidence that the participant understands the concept of risk identification and can thus effectively apply it in their various work environments to identify project, contract, or work package level risks.	Since this question is used to demonstrate achievement of the sample selection, all participants are expected to answer this question in the positive, i.e., to understand the concept of risk identification. Since the question will also be answered by means of scale from 1-10; all scores below 6 will disqualify the participant.
In your position, are you able to identify project level risk factors?	No	NA	This question will allow each research participant to confirm their ability to identify project level risk factors, providing evidence that they fit the selection criteria of being exposed to and interacting with project risks on a daily basis as part of their job functions.	Yes. Although participants are selected based on their perceived ability to identify project risk factors, a participant may disqualify themselves from the interview by declaring that they are unable to identify risk factors, perhaps due to lack of sufficient exposure etc. in which case the interview would end.
What are the risk factors associated with this project?	Yes	What are the risk factors associated with train manufacturing?	This question directly addresses one of the objectives of this research and directly asks the participant to identify the risk factors associated with the project. The participants are free to answer with as little or as much detail as they can provide; the more detail providing a richer understanding of the identified risk factor. Participants may also be probed to further elaborate on the information they have provided.	NA

Interview Question	Direct Link to Research Objective	Research Objective	Purpose of Question	Negative answer resulting in Disqualification?
Which of the identified project risk factors are as a result of the South African environment?	Yes	Which of the identified risks are as a result of the South African environment?	This question directly addresses one of the objectives of this research and directly asks the participant to highlight which of the identified risk factors are as a result of the South African environment within which the project exists	NA

The interviews were scheduled and conducted based on the availability of the participants, and took place over the Microsoft Teams application, which allowed for both the recording of the interview for later transcription, as well as having the participant in a comfortable and familiar environment where they do not feel pressured or interrogated, allowing them to provide a richer depth of responses (Doody and Noonan, 2013). The interview was designed to take 15-30 minutes depending on the depth of content and length of the interview responses. Prior to the interviews, the participants were given a brief on the purpose of the research and were informed that the interview will be recorded; they then had to sign a consent form indicating consent to be interviewed and recorded.

The questionnaires were distributed to all research participants via email, in both an interactive MS Word and PDF format; to cater to those who would prefer to fill it in directly on their computers, and those who prefer to print it out, fill in by hand, and submit.

3.6 Data Analysis

"The goal of content analysis is to provide knowledge and understanding of the phenomenon under study" (Downe-Wamboldt, 1992: 314). The data analysis process entailed a thorough examination of the language transcribed from interview data in order to code the text into a manageable number of categories that represent similar meanings (Hsieh and Shannon, 2005). According to Saldana (2008) coding requires one to put on their researcher's analytical lens, and the filter that covers that lens determines how the data is perceived and interpreted. A person's level of involvement as a participant observer also filters how they perceive, document, and thus code the data. The process of coding is essentially a judgment call since we bring our subjectivities, personalities, and predispositions to the process.

The coded categories and themes were built up from the bottom by being organised into increasingly more abstract units of information. Due to the richness of the captured data, it was impossible to make use of all the information, therefore the data was winnowed by focussing on some parts of the information and disregarding the rest. This process had the effect of aggregating data into a small number of themes or categories (Creswell, 2014). The categories can represent either explicit communication or inferred communication (Hsieh and Shannon, 2005).

A movement was then made from an inductive mode of thought, where categories were discovered and constructed, to a stage where categories were both discovered and verified, and finally to a deductive process where categories were tested to determine if more evidence can support each

theme or whether they need to gather additional information, and confirmed till there was a saturation of information and nothing new came forth (Creswell, 2014; Merriam and Tisdell, 2015).

For this research, the data analysis was assisted by NVivo software. After each interview, the interview data was transcribed and entered onto the software, then coded. The NVivo software was also used to determine the ranking of the identified risks by means of frequency counting – which is a feature that counts the number of references to each risk factor, as well as the number of participants that referred to the risk factor. This method of ranking presents the risks in order of "significance", based on the assumption that the risks with the higher numbers of references are more prevalent or of more significance than those with fewer references. The advantages of using the software are that it provides an organized filing system for easy coding and retrieving of data and analysis, which saves time and in turn allows for more time to be spent thinking about the meaning of the data; the program encourages a close examination of the data, enhancing the rigor of the study. (Merriam and Tisdell, 2015).

Creswell (2014) asserts that qualitative data analysis proceeds on two levels; the first is the general data analysis procedure which can be seen on the right of Figure 4 below (adapted from (Creswell, 2014: 247), and the second would be the analysis steps embedded within the specific qualitative design, in this case the phenomenological design. Phenomenological research uses the analysis of significant statements, the generation of meaning units, and the development of an essence description.

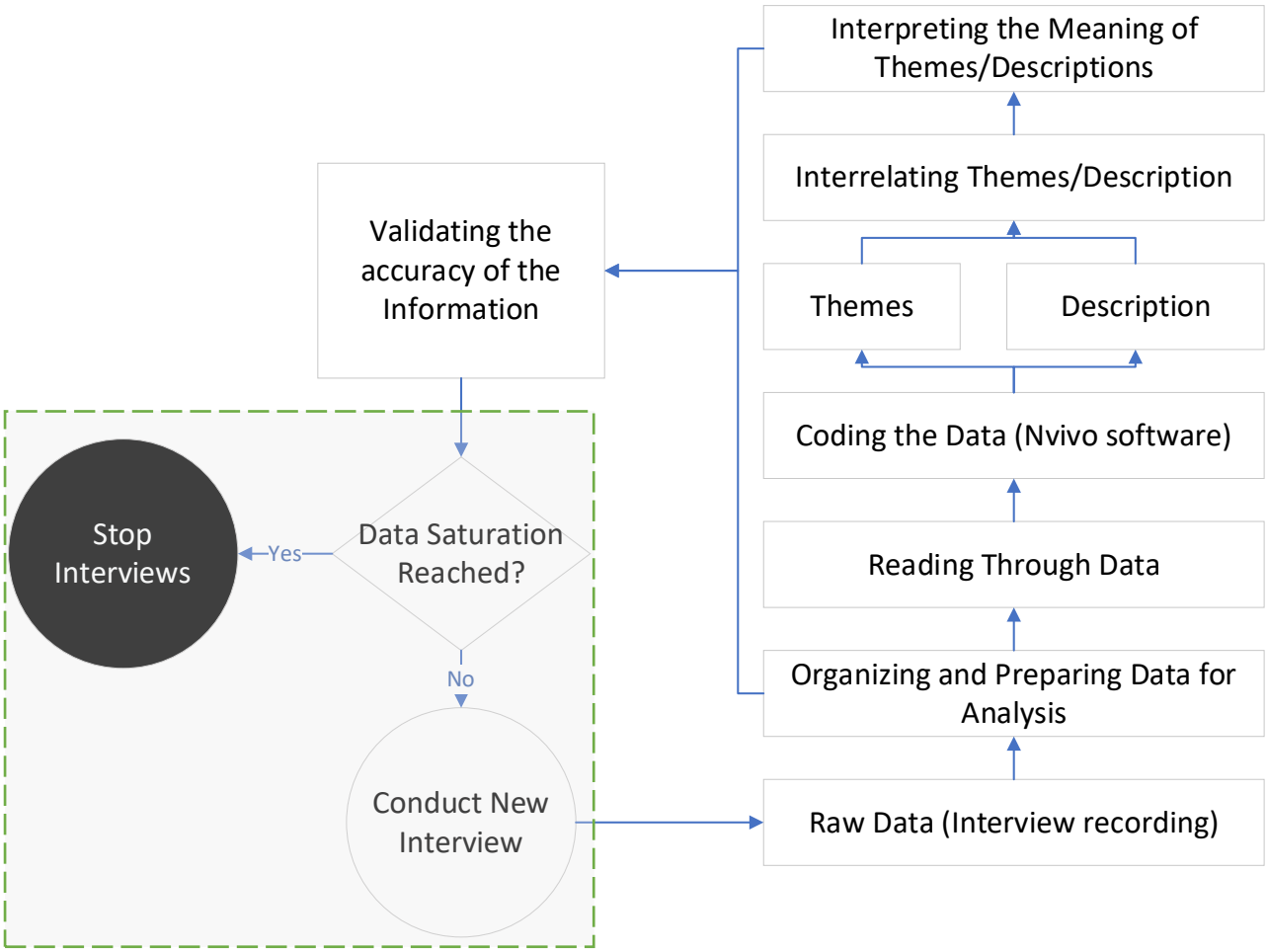

Figure 4 Data Analysis in Qualitative Research adapted from (Creswell, 2014: 247)

The process illustrated in Figure 4, derived from Creswell (2014), was used to guide the process of data analysis during this research. Creswell (2014) describes the six main steps involved in the process:

Step 1 involves organizing and preparing the data for analysis. In this case referring to the process of transcribing the interview data.

Step 2 provides the opportunity for the researcher to gain a general sense of the information by reading through it, and an opportunity to reflect on its overall meaning.

Step 3 is the coding phase in which the data is organised by bracketing text into categories and labelling those categories with a term often based on the actual language of the participant.

Step 4 is the generation phase, where both descriptions and themes or categories are formed from the coded data. Description involves a detailed rendering of information about people, places, or events in a setting. The coding is also used for generating five to seven themes or categories which often represent the major findings for the study. The themes are shaped into a general description

usually displaying multiple perspectives from individuals and are supported by diverse quotations and specific evidence.

Step 5 Advances how the description and themes will be represented in the qualitative narrative. A narrative passage in the form of a discussion is used to convey the findings of the analysis and may include a chronology of events, the detailed discussion of several themes, or a discussion with interconnecting themes.

Step 6 involves making an interpretation of the findings or results of the research by looking into the lessons learnt, thereby capturing the essence of the research.

In order to abide by the approach for data saturation that guides the sample size, a slight modification was applied to the process defined by Creswell (2014). Data analysis was conducted after each interview, allowing for the determination of data saturation prior to conducting subsequent interviews. This is as opposed to conducting data analysis after the collection of all interview data. This modification to the process defined by Creswell (2014), that makes consideration for the data saturation approach, is included in the illustration in Figure 4.

A simple approach described in section 3.5 above was used to analyse the results of the questionnaire. Once all questionnaire responses had been collected, the frequency counts for all risk factors were tabulated, and a Pareto chart was generated to present the results.

3.7 Trustworthiness of Research Findings

Qualitative research validity, which is often addressed with terms such as trustworthiness, credibility, or authenticity, is one of the strengths of qualitative research. It is a process that occurs throughout the various steps of research through which the researcher determines whether the findings are accurate from the standpoint of the researcher, the participant, or the readers of an account. Creswell (2014) recommends the use of multiple strategies/approaches for checking the accuracy of findings as this both enhances the researcher's ability to assess the accuracy of findings, as well as convincing the readers of that accuracy. Ensuring validity and reliability in qualitative research involves conducting the investigation in an ethical manner, and these ethical practises are important in establishing the trustworthiness of the research (Merriam and Tisdell, 2015).

Both Creswell (2014) and Sorin-Peters (2004) assert that the approaches for assessing trustworthiness in qualitative research are different from the approaches used in quantitative research. Since qualitative research is based on assumptions about reality, different from those of quantitative

research, the standards for rigor in qualitative research necessarily differ from those of quantitative research (Merriam and Tisdell, 2015).

Creswell (2014) describes eight primary strategies for demonstrating trustworthiness. The first four strategies described below were used in this research, and contributed towards demonstrating the internal validity of the data:

1. *Use a rich, thick description to convey the findings*: detailed descriptions of a setting or offering different perspectives of a theme make the results more realistic and richer. It may transport the reader into the setting and gives the discussion an element of shared experiences.
2. *Present negative or discrepant information that runs counter to the themes:* discussing contrary information or evidence that goes against the general perspective of a theme adds to the credibility of the research, as it demonstrates the realities of life in which there exists different perspectives which do not always align.
3. *Spend prolonged time in the field*: this allows the researcher to develop a richer understanding about the phenomenon under study, and to convey details about the site and participants involved in the study, which lends credibility to the account.
4. *Clarify the bias the researcher brings to the study:* This allows the researcher to reflect on any biases or influences their background may have that may shape the interpretation of the findings.
5. *Triangulate different data sources of information by examining evidence from the sources and using it to build a coherent justification for themes:* a convergence of the data collected from the multiple sources of information will add to the validity of the study. This test will not be used as only one source of data, i.e., interviews with research participants will be used.
6. *Use member checking to determine the accuracy of the qualitative findings:* this involves having the research participants validate the accuracy of the final research findings, themes, and descriptions, based on what was collected during the initial interviews. This test will not be used as the research participants have very limited availabilities to support with further research activities post the interviews.
7. *Use peer debriefing to enhance the accuracy of the account:* this involves having a peer review and ask questions about the study to ensure that it resonates with people other than the researcher. Due to time constraints and the practicalities of having an external party review the study, this test will not be used.
8. *Use an external auditor to review the entire project:* This involves having an external auditor, not known to the researcher to look over the different aspects of the research and provide an objective assessment based on those various aspects, e.g., relationship between research

questions and data, accuracy of transcription etc. This test will also not be used to demonstrate validity due to time constraints and the potential cost implications of employing an auditor.

4 REASEARCH FINDINGS AND DISCUSSION

This section gives a high-level description of the data collection and analysis processes. It then presents a detailed analysis and discussion of the research findings and application of trustworthiness considerations.

4.1 Data Analysis Procedure

The process followed to convert interview data to meaningful information is as depicted in Figure 5 below:

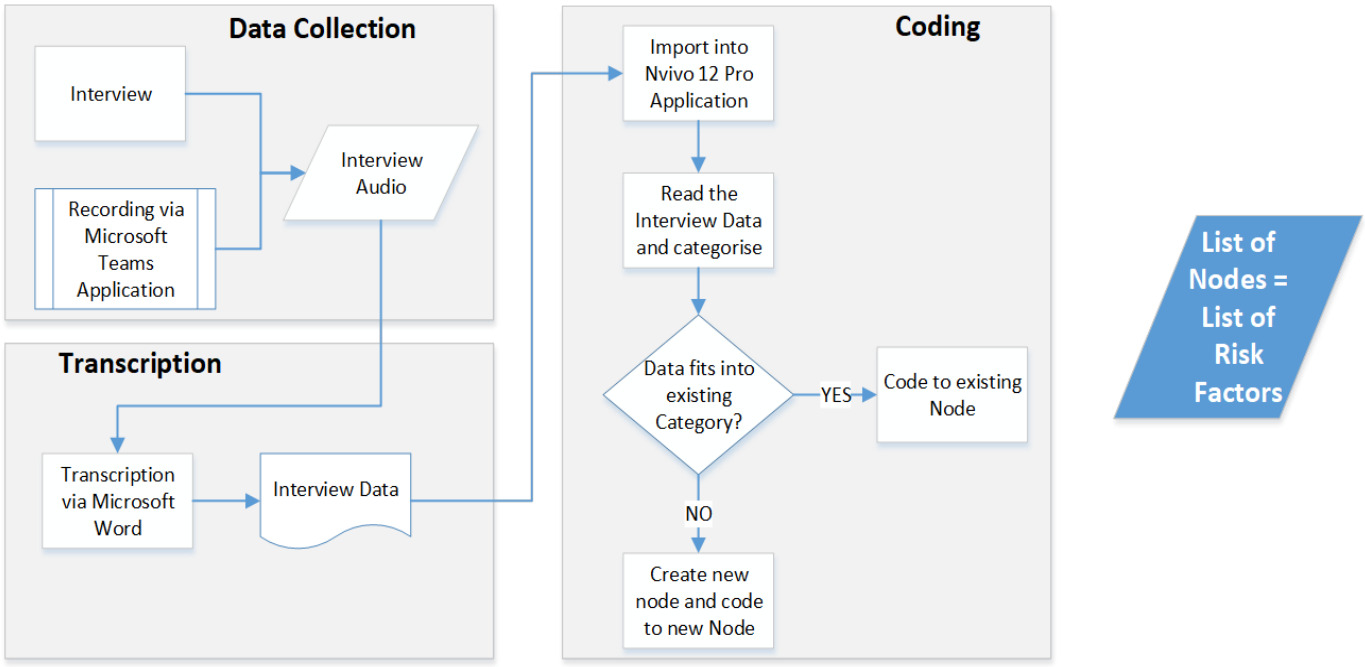

Figure 5 Interview Data Collection, Transcription and Coding

Each interview took between 15 and 30 minutes depending on the amount of information provided by each participant. Interviews were recorded using the Microsoft Teams application and the audio files were stored securely in a folder identified by Participant ID. The audio files were then transcribed verbatim using the Microsoft Word application and resulting text files were stored according to the same convention as the audio files.

To begin the coding process, the text files were imported into the NVivo application. “Case” profiles were defined for each participant, where the answers to the preliminary questions that demonstrate achievement of the sample selection were captured. The interview data was read, coded, and analysed following the guidelines for coding defined in the Data Analysis section of this research. The codes or resulting categories represented risk factors that were being identified in the project. Moving

from the inductive process where categories were being defined, the deductive process of verifying and testing categories began, which saw many categories being merged under a central theme.

Coding is a method that allows the grouping of coded data into categories because they have commonalities or share some characteristics (Saldana, 2008). As an employee of the train manufacturing company, my familiarity with the project, its contractual obligations, and active risks allowed me to identify similarities between identified risks and categorize them according to those similar characteristics. For example, risks related to Economic development such as not achieving skills development and localization targets, were grouped under the Economic Development category as they are both related to the project's economic development obligations. In line with the trustworthiness criteria, my time spent in the field provided me insight into this relationship between the risks and allowed me to categorize them together.

This classification reasoning and my tacit and intuitive senses allowed me to determine, during the data analysis phase, which codes to categorize together (Saldana, 2008).

4.2 Research Participants

The research was assisted by 11 interview participants who formed the purposeful sample. The participants were selected based on their experience, having worked in key positions in the train manufacturing project. The selection criteria focused on participants who are well versed with the concepts of risk, risk identification and management; who have specialized knowledge and exposure to the various aspects of the project that pose a risk or source of risk; who are exposed to and manage internal and or external project risks daily as part of their job functions and are in positions to make decisions that address the given risks.

Based on the data analysis, data saturation was reached at the 11th interview. This point of data saturation happens to fall within the guidelines of between 5 and 25 participants provided by Polkinghorne (1989) for phenomenological studies. Table 5 below presents a list of the participants together with their designation or area of expertise.

Table 5 Research Participants and Area of Expertise

Participant ID	Designation/ Specialization
Participant 1	Test and Commissioning
Participant 2	Project Operations & Manufacturing
Participant 3	Project Quality
Participant 4	Operations Planning
Participant 5	Project Sourcing
Participant 6	Project Planning
Participant 7	Industrialization and Facilities
Participant 8	Project Management
Participant 9	Supply Chain
Participant 10	Project Sourcing
Participant 11	Product Quality

To get an idea of the participants' understanding of and familiarity with the concept of risk management, and to gauge the perceived importance and attitude each participant had towards risk management, the interview began with the following four questions:

1. How familiar are you with the concept of Risk Management?
2. Do you think Risk Management is important and necessary for this project?
   2.1. Why?
3. What is your understanding of the term "Identifying Risk Factors" in the Risk Management process?

These questions were also used to demonstrate achievement of the sample selection criteria.

In response to the questions, each participant had to provide a rating out of 10 from a qualitative scale, depicted in Table 6, to indicate the most relevant option applicable to them.

Table 6 Qualitative Scale of Responses

Question	Qualitative Scale
Question 1	0 (Not Familiar) - 10 (Very Familiar)
Question 2	0 (Not Important) - 10 (Very Important)
Question 3	0 (No Understanding) - 10 (Very Good Understanding)

Figure 6 represents the analysis of the responses to the question: "How familiar are you with the concept of Risk Management? ". The results indicate that about 91% of the participants are familiar

with the concept of risk management, with a single participant being slightly familiar with the concept (with a score of 6).

Figure 6 Results of Question 1: Participants' Familiarity with Risk Management

Figure 7 is the summary of responses to the question: "Do you think Risk Management is important and necessary for this project?". The result indicates that all the participants recognize risk management as important and necessary for the project. Data collected during the interviews also indicated that each of the participants practised risk management either formally or informally as part of their job requirements.

Figure 7 Results of Question 2: Participants' Perceived Importance of Risk Management

To further probe the responses to the question about the importance of risk management, a follow-up question was posed, where the participants were asked why it is important to perform risk management. The resulting nodes from the research analysis representing the answers to this question are as shown in Table 7 below:

Table 7 Coded Nodes Question 2: Reasons to Perform Risk Management

- Reasons to Perform Risk Management
  - Anticipation
  - Mitigation Actions
  - Project Continuity
  - Project Performance

The participants identified Anticipation, Implementation of Mitigation Actions, Project Continuity and Project Performance as the main reasons to perform risk management. An analysis of the frequencies of the responses can be seen in Figure 8 below. The "Number of Participants" columns represent the number of participants that referred to each reason, and the "References" columns represent the total number of references made towards each reason.

Integrating the responses to this question based on the data collected during the interview, there is a consensus that Risk Management is performed to anticipate potential risks that may affect the project performance and to put in place mitigation actions to ensure that the risks are addressed thereby driving project continuity. 81% of the participants discussed anticipation and the implementation of mitigation actions as means to improve project performance

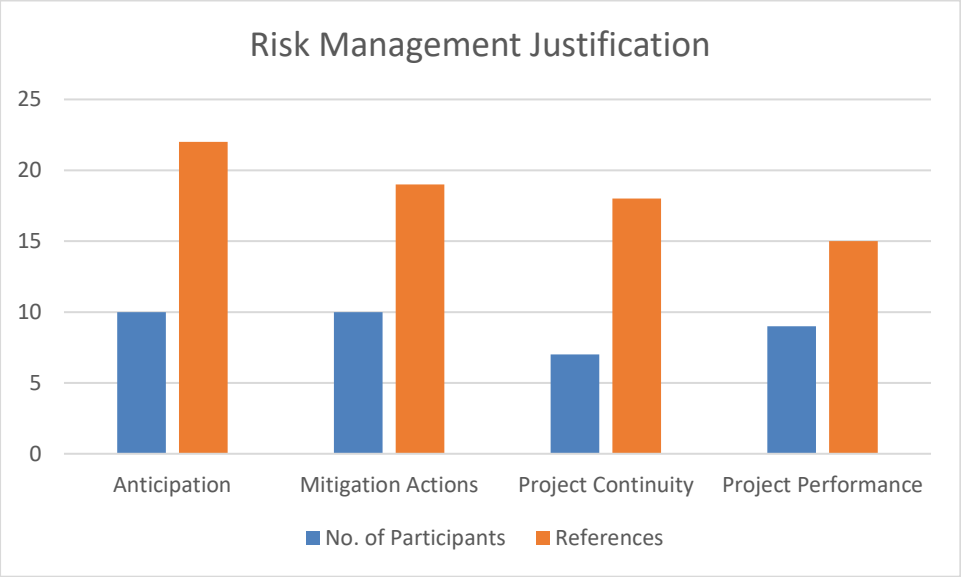

Figure 8 Risk Management Justification

Figure 9 represents the analysis of the participants' understanding of the term "Identifying risk factors" within the Risk Management process. The results indicate that 91% of the participants have a good understanding of the term, and a single participant has a slight understanding of the term (with a score of 6).

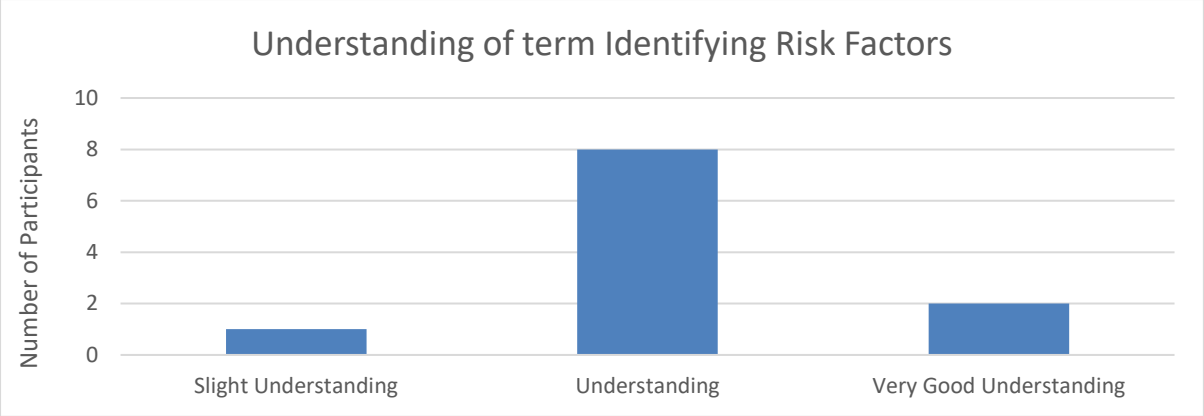

Figure 9 Results of Question 3: Participants' Understanding of Term Identifying Risk Factors

The combination of the above four results indicate that the interview participants are familiar with project risk management and have a good understanding of identifying project risks. A significant outcome of these preliminary questions is also that the interview participants have a positive perception of risk management; they understand its importance and its significance to project performance.

A further question posed to the participants was used to verify their qualification to participate in the interview, as it gauged whether they could identify project level risk factors in their current position. All respondents positively confirmed their ability to identify project level risk factors.

4.3 Project Risk Factors

In response to the question "What are the risk factors associated with this project", participants were encouraged to identify as many project level risk factors as they could, as well as provide information about those risks, what the sources of the risks could be, the risk impact etc. During the coding process it was important to ensure that the identified categories represented project risk factors, according to the definition provided in Section 2.1. Table 8 lists all the nodes coded during the research analysis process, where each node represents an identified risk factor.

Table 8 Coded Nodes: Risk Factors Associated with the Project

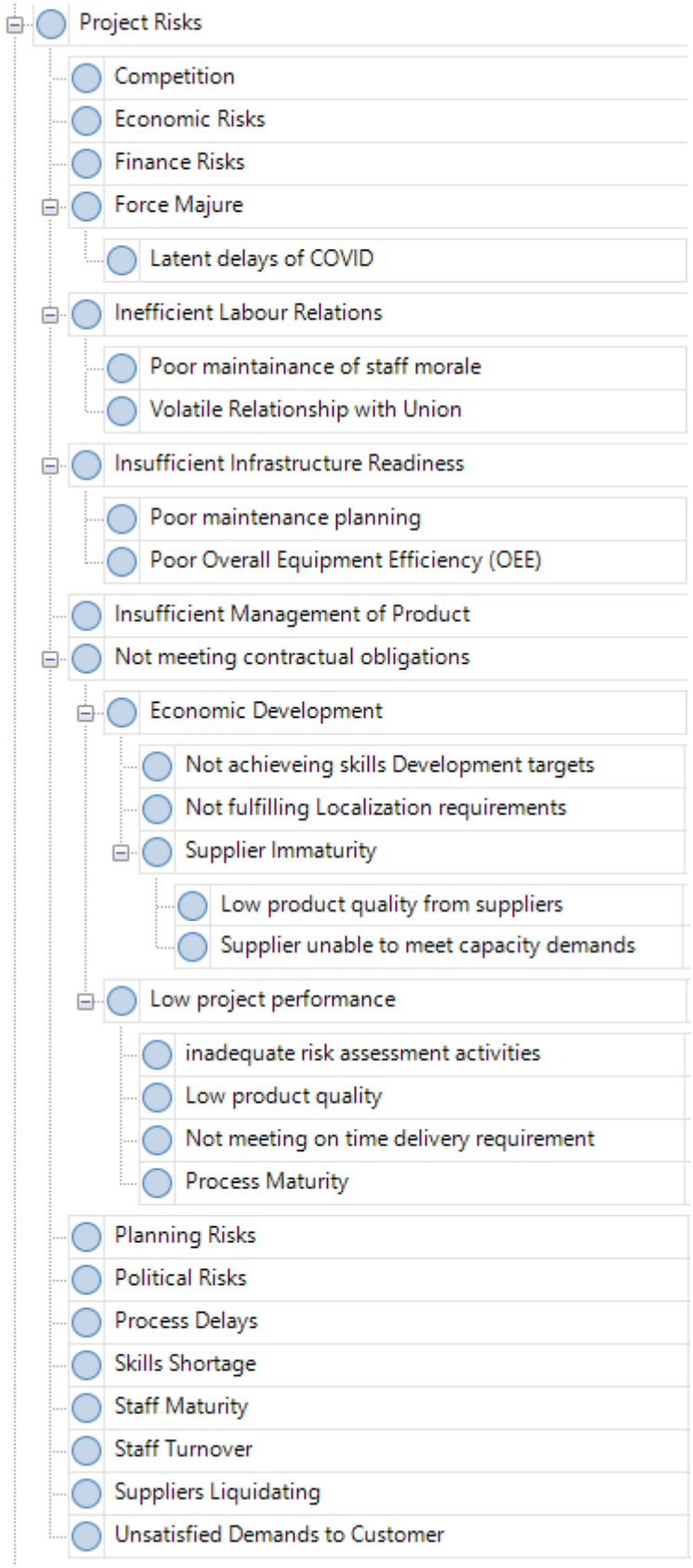

Table 9 presents a summarized description of each identified risk category and risk factor based on the descriptions and details provided during the interviews. This is to ensure the internal validity of the data and to present the risk factors as they are experienced in the project.

Table 9 Project Risk Factor Descriptions

Project Risks	Description
Competition	Not being able to maintain a competitive advantage over competitors by making use of latest technologies, optimising costs, and getting to market faster, resulting in lost business opportunities
Economic Risks	Risk that government priorities towards funding the project will change due to uncertain and depressed economy; negatively impacting the project financially.
Finance Risks	Risk that the project will not have sufficient finances to achieve its objectives, e.g., cost overruns
Force Majeure	Unpredictable events
Latent delays of COVID	The negative impact of COVID19 on the project, both directly and indirectly, affecting the supply chain, project employees, project performance etc. and leading to delays and financial implications
Inefficient Labour Relations	Mismanagement of transparency of communication and alignment of priorities with staff and labour unions, leading to project delays and impacting performance
Poor maintenance of staff morale	Not maintaining the social aspects of the business, or making sure the staff is aligned with management; the lack of transparency resulting in mistrust from employees
Volatile Relationship with Union	Union involvement in the project and the amount of impact/influence they have on the project and business which oftentimes lead to delays
Insufficient Infrastructure Readiness	Specific earmarked infrastructure not ready/available when needed to improve project efficiency, significantly impacting planned project performance
Poor maintenance planning	Maintenance planning for site infrastructure not sufficient to address short, medium, and long-term maintenance activities, and to maintain infrastructure in good working order, affecting project throughput
Poor Overall Equipment Efficiency (OEE)	Plant reliability issues, high incidents of plant failures, low quality, reliability, and efficiency of equipment, affecting throughput, and leading to unplanned financial expenditure

Insufficient Management of Product	Insufficient management of product design, evolution and obsolescence of parts affecting product configuration
Not meeting contractual obligations	Not meeting contractual obligations and incurring associated penalties
Economic Development	Not meeting contractual obligations for economic development thereby incurring associated penalties
Not achieving skills Development targets	Not meeting contractual obligations for skills development of a target group and incurring associated penalties
Not fulfilling Localization requirements	Not meeting contractual obligations for localization of labour, materials, etc. thereby incurring associated penalties
Supplier Immaturity	Immaturity of value chain and suppliers to cater to the needs of the project
Low product quality from suppliers	Low quality of products being received from suppliers due to issues faced by the suppliers, resulting in high level of part failures and thus causing project delays
Supplier unable to meet capacity demands	Suppliers unable to meet production demands and to cater to ramp up plans, resulting in major project delays and impacting project performance
Low project performance	Compromised project performance through mismanagement of internally controllable factors
Inadequate risk assessment activities	Overly optimistic risk assessment resulting in a misjudgement of the criticality and impact of identified project risks
Low product quality	Producing low quality products, through the fitment of incorrect or defective parts, not following defined procedures or special processes, skills shortages etc. resulting in production delays and high costs of rework
Not meeting on time delivery requirement	Not delivering the contractually agreed number of trains on time and according to the defined schedule; and incurring the resulting penalties
Process Maturity	Immaturity of overall operations processes. Lack of continuous improvement of processes contributing to increased costs and low throughput
Planning Risks	Project plan is very optimistic and is not fully informed by clinical analysis of the project environment. Return of experience is not integrated into the plan as continuous improvement, resulting in unrealistic or unachievable targets
Political Risks	Impact by the unstable political environment causing project disruptions
Process Delays	Internal processes, such as supplier onboarding, have long method times, the impact being further delays to the project

Skills Shortage	Shortage of skills and required expertise in South Africa impacting the ability of the project to produce at the expected rate and quality
Staff Maturity	High complement of young staff with little maturity and no experience in the project area, requiring extra efforts from management to ensure productivity. Low technical experience leading to poor product quality
Staff Turnover	Loss of people with key skills directly impacts project continuity. Further unplanned funding and time allowance is required to train new people
Suppliers Liquidating	Key part or component suppliers liquidating due to bankruptcy, not having enough business to sustain themselves, or other challenges they are not able to resolve. This leading to high costs for overseas backups, and for securing replacement suppliers
Unsatisfied Demands to Customer	Inefficiencies dealing with the customer on contractual matters, process delays, delayed payments etc. all impacting project cash flow.

A total of 25 project risk factors were identified through the interview process, some of which were grouped into 7 categories and subcategories.

To further the analysis on the identified risk factors, a comparison was made between the number of participants who referenced each risk factor, and the total number of references to the risk factors throughout the interviews. Although this comparison does not provide the exact significance of each risk factor as there are more factors to consider such as impact and likelihood, it will offer insight into the perceived significance of the risk factors based on the experiences of the interview participants. The comparison is illustrated in Figure 10 below.

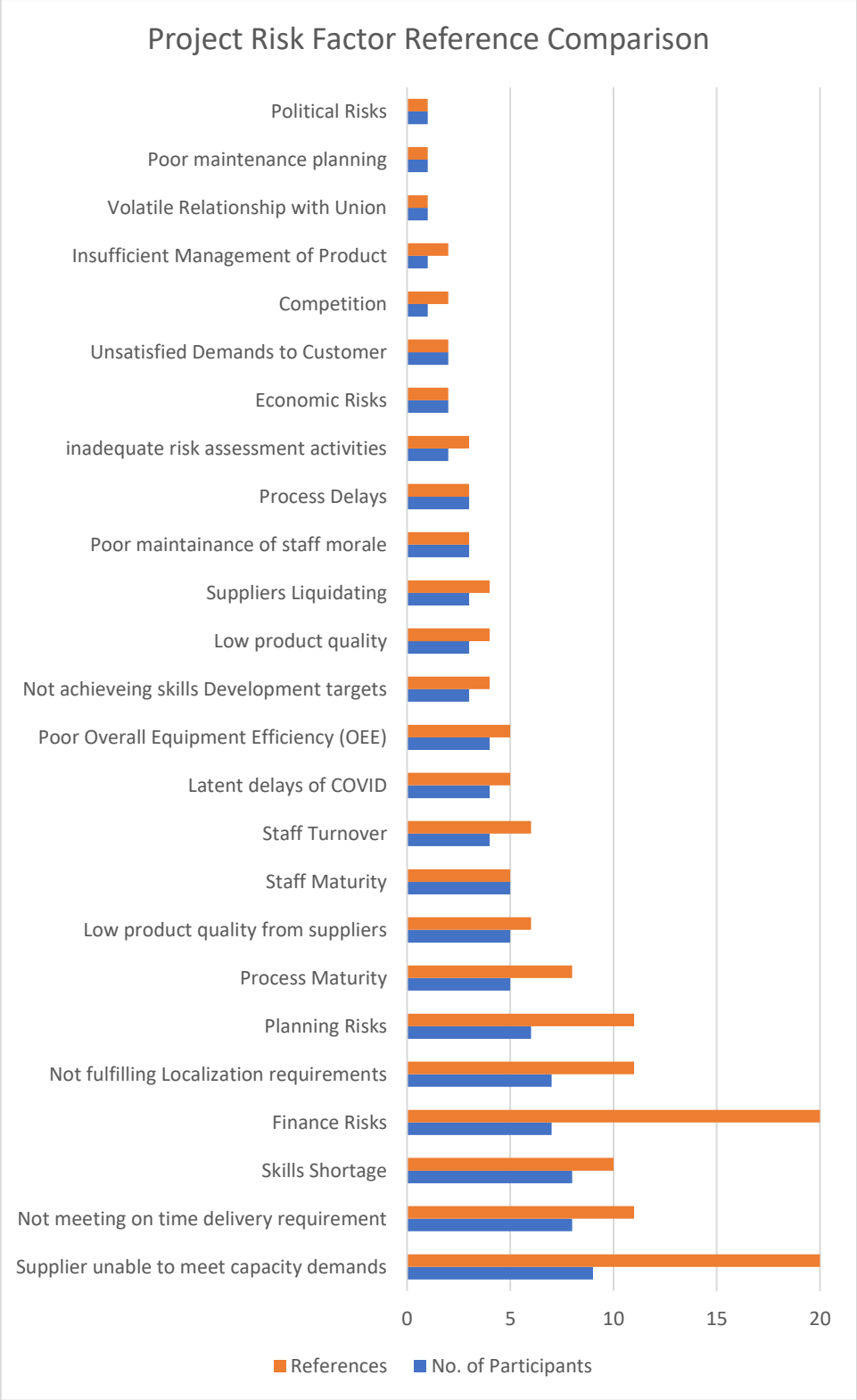

Figure 10 Project Risk Factor Reference Comparison

From Figure 10 it is evident that there is a correlation between the number of participant references and the total number of references for each risk factor. i.e., the risk factors with the higher number of participant references also have the higher total number of references. This correlation can be an

indication of risk significance, as the risks with the higher numbers of references were considered by more interview participants and therefore can be assumed to have been more prevalent or of more significance than those with fewer references.

Abiding by step 4 of the approach defined by Creswell (2014) for phenomenological research, the coding process is used to generate a description, in this case of the identified project risk factors. Therefore, a detailed discussion on the identified project risk factors based solely on the interview data will be presented below to convey the findings and present a richer description of the risk experiences of the participants. The discussion will focus on the top 9 risks identified and weighted based on the significance described above. The top 9 risks in order of perceived significance are as follows:

1. Supplier unable to meet capacity demands
2. Not meeting on time delivery requirement
3. Skills Shortage
4. Finance Risks
5. Not fulfilling Localization requirements
6. Planning Risks
7. Process Maturity
8. Low product quality from suppliers
9. Staff Maturity Level

4.3.1 Supplier Unable to Meet Capacity Demands

The project manufacturing team act as integrators of supplied parts and components, and therefore depend heavily on suppliers to produce train components and parts at the right quality, delivered on time. Suppliers however may face challenges such as financial constraints, capacity risks due to the immaturity of the value chain or the fact that they are not well established; challenges that affect their ability to deliver parts as per production demands. If the ability of the supplier is not at the level required to effectively support the project, production milestones will be missed, and the project on-time delivery performance would be hampered. Further to this, as the ramp up phase of production draws nearer, the material availability risk becomes more apparent, as suppliers are barely meeting the current production requirements.

Supplier delays are also becoming more apparent due to the impact of COVID19. Many of the strongest suppliers are struggling to keep up with project demands. The totality of this impact has however not yet been comprehended and contributes uncertainty to the project. The latent delays

and impact of COVID19 cannot be quantified and the project is unable to fully understand the extent of what may happen. The internal risk management process is assisting to identify and support vulnerable suppliers, but there may be blind spots that are overlooked. Further to this, the country is currently experiencing a carbon steel shortage. This shortage of a critical material may result in higher costs and further delays to the project if efforts are not directed to source the material elsewhere. The project currently has a very narrow value chain, which ultimately exposes it to major performance impacts on the event of the loss of a critical supplier.

Lastly, the project contract requires the homologation of certain key materials used for production. The phase-in phase-out plan of the project however did not cater to or consider the challenges local suppliers might have in starting up and taking over the supply, and there is no allowance for a fall back to old international suppliers. This may result in a break in supply if the local supplier fails to meet the capacity demand. If the international supplier is however employed due to production constraints, to cater to the break in supply, the localization/ local content requirements may not be met, which may cause the project to incur financial penalties. As part of the localization initiative, the contract also requires there to be a percentage of local content in certain supplier products. Some suppliers struggle to achieve this requirement, which affects the project overall local content.

4.3.2 Not Meeting On-Time Delivery Requirement

The project has committed contractually to deliver a specific number of trains per financial year according to a delivery schedule. The challenge becomes delivering on the contractual obligations by managing the risks and risk sources associated with this to ensure the on-time delivery of the expected trains. Not meeting this target can result in financial penalties. A large contributor towards the project not meeting the on-time delivery requirement is the maturity of the value chain, which is discussed in Section 4.3.1 above. If the value chain is not mature enough to deliver quality parts on time, the project in turn cannot deliver trains to the customer on time. Parts are procured in a timely manner to ensure business continuity is not impacted by a potential shortage of parts. However, many other factors can prevent the supply chain from delivering quality parts on time.

The competence of the staff also contributes to the punctual delivery of the trains. If the staff and production workers do not have the required level of competence to produce the agreed number of trains within the planned time frame, on-time delivery targets will not be met. The risk is ultimately in the rate of production, which is currently low, and is influenced by among other things the staff competency, process method times, Overall Equipment Efficiency (OEE), availability of parts etc. If the rate of production is lower than what is expected to meet the on-time delivery target, the target will be missed. Although the project has taken measures to ensure the achievement of objectives, such as

plans for overproduction to create a buffer; a backlog possibly caused by shortages of parts and materials, fitting and replacement of defective parts, employee strikes, and low production rates can deplete the existing buffer, putting the manufacturing process on the critical path.

4.3.3 Skills Shortage

According to one interview participant, the education system of South Africa is not comparable to the best in the world, as a result many South African companies are challenged for talent and to find people with the right level of skill for the jobs on offer, especially when experience is required. It is not always possible to recruit well educated experienced people; in some cases, the organization may find well educated people who are still gathering the required experience.

The project utilizes a variety of special processes during the manufacturing of the train which require operators to be specially trained and qualified. There are also several key pieces of equipment that were imported, which required the project to send operators abroad to gain specialized training and experience to use. Due to the special training, the project cannot afford to lose the trained people as the talents are vital for business continuity. The organization may try to set up systems to retain the talent, but there is still a risk that highly skilled employees may leave the project after being lured by external job offers. There is a limited number of people in South Africa who are skilled in making trains, so if one of these people were to leave their position, it could have a significant impact on the project's performance.

Transfer of Technology (TOT) programs, which involved bringing in expats to share their knowledge and experience with local employees, have not yielded the desired results as expats are still being hired. There also exists an opportunity (a positive risk) to upskill other employees using the existing project experts, but this is not being done effectively.

Multiskilling is being implemented in an effort to improve competence, and there has been a noticeable improvement in the people's skill development since the project's inception. Respondents however had mixed views on the current skill level of employees. The majority of participants agreed that there is a skills gap that needs to be filled on the project and that the employees' skill levels are below what is ideal. Some participants believe that the skill level is already adequate for the current project activities, and that initiatives like multiskilling will only serve to increase the skill level even more to support project ramp up. The main risk in this area is the risk of losing skilled workers and not being able to find replacements with comparable or better expertise, which could affect the continuity of the project.

4.3.4 Finance Risks

Since there are fines associated with the non-fulfilment of contractual obligations or targets, managing the project's financial risk is crucial to avoid the associated liquidating damages that may have an impact on the project. The project is currently in "time at large," where supply is driving demand and, if there is no improvement in production rate, the associated liquidating damages could eliminate the gross margin.

One of the main challenges with the project is time management, which has a significant financial impact. The project budget didn't anticipate that new tasks, processes, and changes would need to be made as the project progressed. To make the time budget feasible it needs to be adjusted catering to these changes. Also, without alignment with the customer on this issue, penalties may still be imposed for the delays.

If the projected cash flows do not materialize, there is a financial risk to the project. To ensure the project is financially viable, it is essential to manage the cash flow. The project's costs have increased each month, because of unforeseen costs, which means that the project's profitability may decline each month. The cost of the project is being impacted by the difficulties in tracking the cost of each train in terms of consumed equipment, man hours etc. Early indications suggest that the train's cost is higher than forecasted, and that there are inconsistencies in the recorded method times. This raises the risk of underbudgeting.

With South Africa having produced very few trains in many years, there is a risk associated with costing inefficiencies or costing gaps for suppliers. The new type of train requires suppliers to provide costing for unfamiliar products, which leads to delays and inaccuracies in budget. Pricing is a very important factor as it establishes the project expenses for the various products. If the sourcing team is unable to negotiate lower pricing, the project costs may be elevated. The project must also ensure it is able to anticipate market trends regarding material pricing to ensure it takes advantage of opportunities where material is priced low, to source and stock, to ensure it capitalizes on pricing opportunities. Additionally, it must make sure that it is constantly examining the product's design for opportunities to replace some materials with better ones at lower costs, drive product improvement, and provide the customer with a better product while cutting its own costs and lowering the project's financial risk.

Project delays, whether in delivery of products from the supplier, process delays, failure of key equipment, unavailability of staff due to illness, excessive overtime etc. all play a part towards increasing the financial risk of the project. Lost time often results in lost finances, which can lead the

project to operate from a cash negative position. The project also needs to be conscious of the financial position of its suppliers, as if any of its key suppliers go into bankruptcy it would have a direct impact on production and effectively on the financial riskiness of the project

Inefficiencies dealing with the customer in terms of contractual matters, correspondence, delayed processes, claim processing, outstanding invoices and delayed payments also impact the project financially. If the customer does not pay the project timeously, it impacts the project's cash flow and its ability to pay its suppliers. In cases where the supplier is a start-up or small organization that needs a lot of upfront cash injection to sustain itself, this inefficiency may lead to a cycle of suppliers closing, the project having missing parts, not delivering on time, and ultimately incurring penalties.

4.3.5 Not Fulfilling Localization Requirements

One of the biggest components of the project is the localization or local content scope, which requires the project to source local products from local suppliers. This scope is stipulated in the contract with associated targets that the project must commit to, high targets and high penalties. The main risk surrounding this is whether the project will be able to deliver on the local content obligations.

The train manufacturing value chain in South Africa has been barely existent due to there being very few train manufacturing projects over the last 40 years. There are technical competency and cost related risks associated with this. The project has to on-board many suppliers and support them toward being able to meet the delivery demands of the project. Many of the suppliers are not well established, influenced by among others, technical inexperience, financial challenges, capacity challenges etc. It is therefore very difficult to get suppliers on board who have the potential to meet project capacity demands; especially for big subsystems which involve new designs. Although South Africa is a low labour cost country, it does not necessarily mean that it will be cheap to manufacture the required components, especially since it does not have the latest industry technologies.

The project began with international suppliers who are well equipped and experienced in supplying the required products at the required capacities, however the localization requirements do not support maintaining the international suppliers. Once new suppliers have been phased in and old suppliers phased out, the expectation is that the new suppliers will deliver to the demand. However, an inefficient phase in/ phase out plan that does not consider the learning curve and possible challenges the local supplier might have may lead to a break in production. If the local supplier cannot produce what is expected due to capacity, financial, or quality issues, and begins to negatively impact production, the project is able to use the international suppliers as backup, however this negatively

impacts the localization targets, and the project may incur penalties associated with not achieving the target.

Beyond the project, the suppliers are also expected to maintain a certain local content level, which contributes towards the overall localization objectives of the project. Many suppliers are struggling to achieve the localization target, and if a supplier is unable to comply from a local content perspective it compromises the objectives of the project.

4.3.6 Planning Risks

The project is defined through a series of steps mapped out against a timeline, and if one does not have a clear view of the possible obstacles with clear mitigation plans it could seriously impact on the achievement of the timeline. The project plan is too optimistic and does not consider and integrate a clinical analysis of the project environment, looking at the supplier network, Capital Expenditure (CAPEX) items, the feasibility or achievability of certain planned objectives etc. The project is susceptible to delay, some unavoidable, that need to be accommodated in the project schedule without significant penalties. With the current tight schedule, the project cannot withstand major delays, and based on the ramp up plan, the project also cannot afford to stop the momentum it currently has. Strikes and slowed production negatively impact the project plan and require recovery plans to be initiated to recover the lost time.

The phase in/ phase out plan, that determines the hand over from one supplier to another as part of localization requirements, may also contribute to planning risks if it does not take into consideration the challenges that may be faced by new suppliers. Coupled with this is the planning for overseas backups in case the local suppliers are unable to meet the project demand. This has a direct impact on project supply chain.

There is also risk associated with the planning revisions which are tied to the project contract. Each time the project is not able to meet the manufacturing planning schedule, it has a negative impact on planning. The project commits to production volumes, and the suppliers commit to local content. These commitments are linked to planning, which in turn is linked to localization goals. If the project doesn't follow the planning, localization suffers, which in turn means it won't fulfil its commitment to the customer and will be penalized.

4.3.7 Process Maturity

As the project moves forward with the product's manufacturing, new processes and technologies are introduced to help reduce costs, improve production, and increase efficiency. Inefficient processes

have a negative impact on the project because they result in delays, mismanagement, inefficiencies, and waste. An example that has been used repeatedly in this research is the procurement strategy, which must be carefully managed because even a minor flaw can have a significant impact on the project. The following other project processes were identified as lacking in maturity and contributing to risk:

1. Warehouse management
2. System Configuration and Change Management
3. Risk Management

4.3.8 Low Product Quality from Suppliers

The project depends on suppliers to deliver good quality products. To ensure this quality is challenging as each supplier faces difficulties that could affect their capacity to produce at the expected quality and quantity levels to satisfy production demands; challenges which may not be under the project's control. A supplier may be forced to close some of its sites due to quality, sustainability, or financial issues, which results in the loss of trained workers and further challenges with production quality. The immaturity of the local value chain also contributes to the poor quality of produced parts. Low quality products received from the suppliers require either replacement or rework which impact the project both financially and in the delivery schedule.

4.3.9 Staff Maturity Level

The stringent Economic Development requirements require that the project have a young staff compliment, and as a result the larger percentage of employees is under the age of 40. There is no balance between the young and matured, and although this offers a good opportunity to improve the skill of the younger generation, the effect of the immaturity of the employees may have a significant impact on project performance. Some of the employees are very well educated however their lack of experience presents as immaturity. The lack of technical experience may lead to the production of poor-quality products. Beyond technical immaturity, the younger employees need more devoted management and supervision because they may not take responsibility for their actions or appreciate the significance of their roles and contributions to the project. They are not self-sustaining or self-motivating, which may impact project efficiency and productivity.

4.3.10 Risk Themes

As described in the methodology section, according to Creswell (2014), the coding process is also used to generate a small number of categories or themes for further analysis. For phenomenological

research, these can then be shaped into general descriptions presented as a narrative passage containing discussions about the themes.

The identified top 9 risk factors can be grouped into the following four broad themes:

1. Supplier capacity (competency) issues:

   This category includes all risk factors related to the capacity of the suppliers to effectively support the manufacturing process
2. Inability to fulfil obligations

   This category includes all risk factors related to the project's ability to achieve contractual targets and obligations
3. Employee competence issues

   This category includes all risk factors related to employee competence in fulfilling duties to the project
4. Finance Risk

   This category includes risk related to project finance

Where each theme is composed of the following risk factors:

1. Supplier capacity (competency) issues
   1.1. Supplier unable to meet capacity demands
   1.2. Low product quality from suppliers
2. Inability to fulfil obligations
   2.1. Not meeting on-time delivery requirement
   2.2. Not fulfilling localization requirements
3. Employee competence issues
   3.1. Skills shortage
   3.2. Planning risks
   3.3. Process maturity
   3.4. Staff maturity level
4. Finance Risk
   4.1. Finance Risk

From the above we can deduce that the top risks that the project is exposed to can be grouped into four main themes, these include risks related to the supplier capacity to support the project, risks related to the project's ability to fulfil contractual obligations and requirements, risks brought about by employee competence, and risks related to project finance.

The narrative passage below discusses the above themes and presents a high-level view of the risk profile of the project:

" At project initiation a contract was defined that stipulated all objectives, obligations, and requirements that the project must fulfil successfully. Failure to achieve these objectives would result in financial risk in the form of penalties. To fulfil these objectives, the project is required to manufacture and deliver trains on time and at the right quality, abiding by specified requirements. Any negative financial exposure to the project may prevent the project from fulfilling its objectives. For production to be successful, specific skills are required by employees to define, implement, and perform certain manufacturing, planning, finance, and quality processes. These processes are far reaching and impact all aspects of the project. As a result, a lack or inadequacy in these processes may result in financial exposure both to the project and its' suppliers and prevent fulfilment of obligations. To support the manufacturing process, suppliers are employed to produce and deliver components on time, in the right quantity, and at the right quality. A failure on the supplier side may lead to delays in production, exposing the project to financial risk. Suppliers are however also impacted by the project. Apart from the financial risk suppliers can be exposed to if the project does not pay on time, improper planning and requirements defined by the project may negatively affect the supplier's output. "

4.4 Influence of South African Environment

One of the additional objectives of this research was to identify which of the risk factors were as a result of the South African Environment, i.e., what influence does the South African environment have on the train manufacturing project. These findings do not eliminate the possibility of the identified risk factors appearing in projects in other countries, however their uniqueness in this case are the characteristics of the South African environment, whether political, social, economic, and the like, that influence the project in the manner they do.

With the aid of a questionnaire, the research participants were presented with a consolidated list of all the identified project risk factors and were asked to select as many of the listed risk factors that were as a result of the South African environment. The selections were tallied, tabulated in Table 10, and the resulting Pareto chart is presented below in Figure 11.

Table 10 Results of Questionnaire

Risk Factor	Frequency	Risk Factor	Frequency
Supplier unable to meet capacity demands	10	Poor Overall Equipment Efficiency (OEE)	5
Not fulfilling Localization requirements	9	Low product quality from suppliers	5
Political Risks	9	Inadequate risk assessment activities	5
Suppliers Liquidating	9	Staff Turnover	5
Economic Risks	8	Not achieving skills Development targets	4
Skills Shortage	8	Process Maturity	4
Finance Risks	7	Planning Risks	4
Latent delays of COVID	7	Process Delays	4
Volatile Relationship with Union	7	Unsatisfied Demands to Customer	3
Poor maintenance planning	7	Competition	2
Staff Maturity	7	Insufficient Management of Product	2
Poor maintenance of staff morale	6	Low product quality	2
Not meeting on time delivery requirement	6		

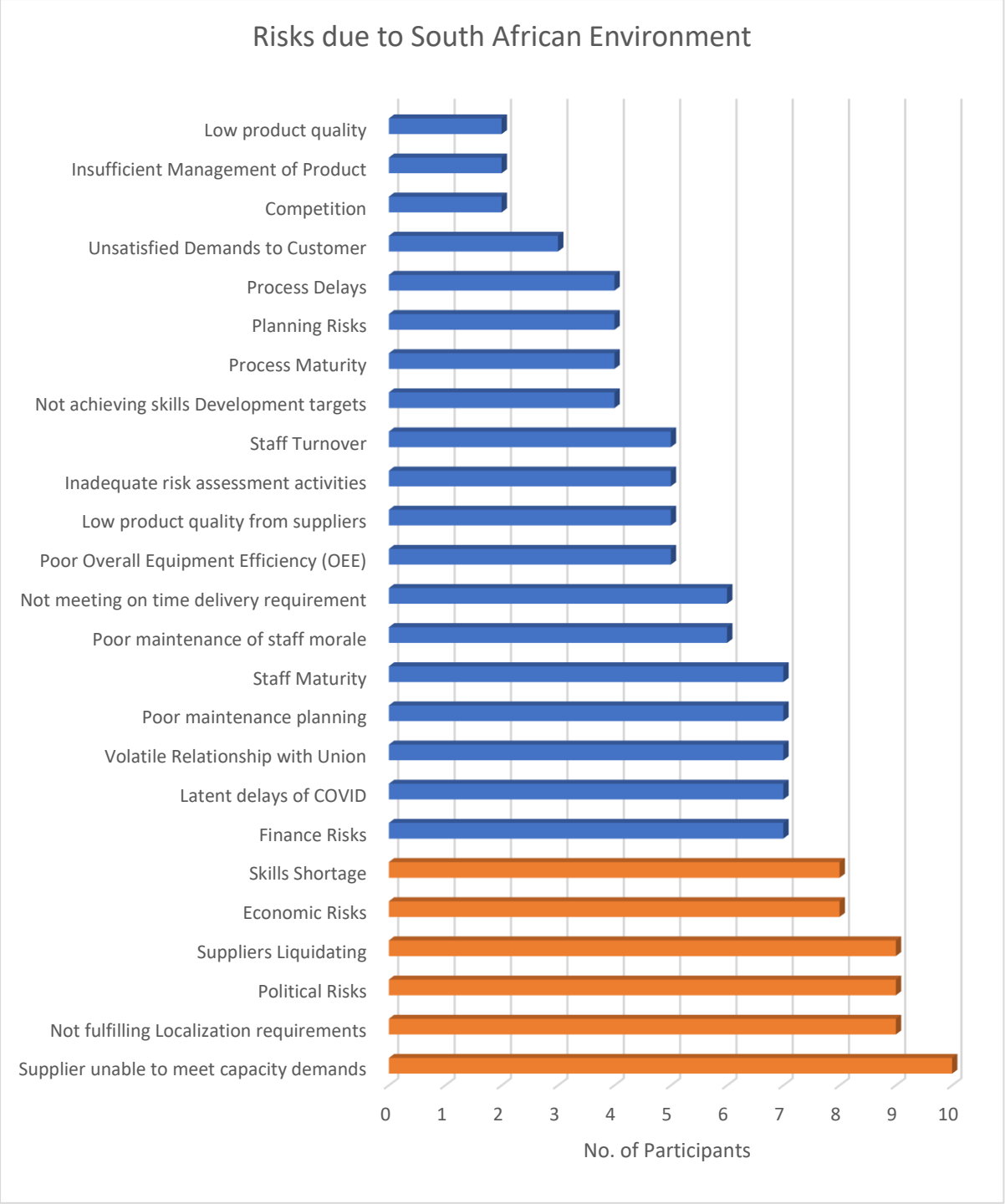

Figure 11 Risks Due to South African Environment

As described in the methodology section, analysis of the frequency counts of each risk factor can be used as a basis for deducing its importance or significance as being as a result of the South African environment. From Figure 11 above we see that all the identified risk factors were selected by at least two participants. This may be due to the subjectivity of risk and how it is highly dependent on individual perception. The variability in the participants, their different roles, experiences, backgrounds, and areas of function, means that they may have had different encounters or

experiences with the project risks, resulting in different perceptions of the sources of risk. This variability is however also a good source of interesting insights for the results of this research(Rowley, 2014). Notwithstanding the variability of the participants, there is uniformity in the selection of 6 risks as being as a result of the South African environment. At least 8 of the 11 participants selected the following risk factors:

1. Supplier unable to meet capacity demands (10/11)
2. Not fulfilling Localization requirements (9/11)
3. Political risks (9/11)
4. Suppliers Liquidating (9/11)
5. Economic Risks (8/11)
6. Skills Shortage (8/11)

The variability of the participants strengthens the acceptance (Rowley, 2014) of these 6 risk factors as the top risks that the project is experiencing as a result of the South African environment.

Three of the above identified risk factors that are brought about by the South African environment are also part of the top 9 project risk factors that were listed in Section 4.3 above, these are:

1. Supplier unable to meet capacity demands
2. Not fulfilling Localization requirements
3. Skills Shortage

It is also interesting to note that the top project risk factor "Supplier unable to meet capacity demands", is also identified by most participants (10/11) as being brought about by the South African environment.

4.5 Comparison of Research Findings to Literature Review

Table 11 below presents a comparison of the research findings to the literature review. It lists the risk factors and categories identified during the interviews as well as all the references to the reviewed literature that confirm and identify related factors as project risks or risk factors. Table 11 shows that most project risk factors identified through this research study are similar to risk factors that have been identified in other research studies. Some of the identified project risk factors however did not correspond to any of the risk factors identified in the literature review; this could be due to the following:

1. The scope of literature that was reviewed
2. Risks associated with the COVID19 pandemic only became apparent in 2019/2020

3. The research environment; some risks arise due to environment specific conditions e.g., labour and union relations, localization requirements, or competition where projects are not ringfenced.

Table 11 Comparison of Research Findings and Literature Review

Project Risks	Description
Competition	(Association, 2013; McKinsey&Company, 2016)
Economic Risks	(Hsieh and Shannon, 2005; Canbolat *et al.*, 2008; JICA, 2013; RDG, 2018; Andrić *et al.*, 2019; Rahmayana and Purba, 2019; Dewi *et al.*, 2020)
Finance Risks	(Suh, 2000; Authority, 2004; Canbolat *et al.*, 2008; Association, 2013; JICA, 2013; Ellis, 2016; McKinsey&Company, 2016; RDG, 2018; Andrić *et al.*, 2019; Rahmayana and Purba, 2019; Dewi *et al.*, 2020; Fartaj *et al.*, 2020)
Force Majeure	(Workgroup, 2017)
Latent delays of COVID	
Inefficient Labour Relations	(Andrić *et al.*, 2019)
Poor maintenance of staff morale	
Volatile Relationship with Union	
Insufficient Infrastructure Readiness	(Authority, 2004; JICA, 2013; Fartaj *et al.*, 2020)
Poor maintenance planning	(JICA, 2013; Andrić *et al.*, 2019)
Poor Overall Equipment Efficiency (OEE)	(Dewi *et al.*, 2020)
Insufficient Management of Product	(Hsieh and Shannon, 2005; Canbolat *et al.*, 2008; RDG, 2018; Andrić *et al.*, 2019)
Not meeting contractual obligations	(McKinsey&Company, 2016)
Economic Development	
Not achieving skills Development targets	

Not fulfilling Localization requirements	(Crompton *et al.*, 2017)
Supplier Immaturity	(Authority, 2004; Canbolat *et al.*, 2008; Berenji and Anantharaman, 2011; JICA, 2013; Mburu *et al.*, 2017; Dewi *et al.*, 2020)
Low product quality from suppliers	(Authority, 2004; Canbolat *et al.*, 2008; Ellis, 2016; Dewi *et al.*, 2020)
Supplier unable to meet capacity demands	(Suh, 2000; Authority, 2004; Canbolat *et al.*, 2008; Association, 2013; Mburu *et al.*, 2017; RDG, 2018; Dewi *et al.*, 2020; Fartaj *et al.*, 2020)
Low project performance	(Association, 2013)
Inadequate risk assessment activities	
Low product quality	(Authority, 2004; Canbolat *et al.*, 2008; Ellis, 2016; Lestyánszka-Škůrková, 2017; Workgroup, 2017; RDG, 2018; Andrić *et al.*, 2019; Dewi *et al.*, 2020)
Not meeting on time delivery requirement	(RDG, 2018; Fartaj *et al.*, 2020)
Process Maturity	(Canbolat *et al.*, 2008; Association, 2013; Lestyánszka-Škůrková, 2017; Rahmayana and Purba, 2019)
Planning Risks	(Authority, 2004; Ellis, 2016; Lestyánszka-Škůrková, 2017; RDG, 2018; Andrić *et al.*, 2019; Rahmayana and Purba, 2019; Dewi *et al.*, 2020)
Political Risks	(Suh, 2000; Canbolat *et al.*, 2008; Ellis, 2016; Andrić *et al.*, 2019)
Process Delays	(Authority, 2004; Association, 2013)
Skills Shortage	(Authority, 2004; JICA, 2013; Crompton *et al.*, 2017; Andrić *et al.*, 2019; Dewi *et al.*, 2020; Fartaj *et al.*, 2020)
Staff Maturity	(Authority, 2004; JICA, 2013)
Staff Turnover	(Andrić *et al.*, 2019)

Suppliers Liquidating	(Canbolat *et al.*, 2008)
Unsatisfied Demands to Customer	(Suh, 2000; Authority, 2004; Workgroup, 2017; RDG, 2018)

A comparison of the findings of this research study and the study compiled by JICA (2013) reveal the following:

1. JICA (2013) identifies the low scale of production, insufficient funds, handling of new technologies, the transfer of technology from one generation to another, and improvement in the skills of operators as huge challenges that affect localization. This corresponds to the findings of this research. In addition to this, the findings of this research identify challenges related to costing for procurement, high product manufacturing costs, and suppliers not being able to achieve the localization targets, as impacting localization objectives.
2. JICA (2013) also identifies a lack in the education level of South Africa, and the need to improve it to sustain upcoming train manufacturing projects; which corresponds to the views of some of the research participants

4.6 Trustworthiness Considerations

As defined in Section 3.7 the following strategies were used to ensure and demonstrate the trustworthiness, credibility, and internal validity of the research study:

1. Use a rich, thick description to convey the findings
2. Present negative or discrepant information
3. Spend prolonged time in the field
4. Clarify the bias the researcher brings to the study

To develop a thorough understanding of the research environment and phenomenon under study, time was spent on the manufacturing site with the interview participants, where the researcher was able to get a clearer understanding of the project, its objectives, and view of the role and involvement each participant had in the identification and management of project risk. This time also assisted to confirm the ability of the participant to provide meaningful information towards the research objectives.

Detailed descriptions were used to describe the research findings which were based on the perspectives and experiences of the interview participants, this can be seen is Sections 4.3.1 through

4.3.9. The interview audio was transcribed verbatim and used as is to develop codes and themes; this was to ensure that the information the interviewees shared was not truncated before analysis, allowing the richness, and meaning of conveyed information to be extracted and shared in the research findings.

Discrepant information that was uncovered during the data analysis stage was also presented in the research findings, in Section 4.3.3, to demonstrate the differing perspectives of the interview participants regarding the skill set of the project employees, which is a reality of life. People attribute different meanings to the same phenomenon based on their perception and past experiences.

The descriptions of project risk factors, in Table 9, were summarized descriptions presenting the combined perspectives of the participants based on the narratives and details captured during the interviews, rather than the general/accepted definitions of the terms. This is to ensure the internal validity of the data and to present the risk factors as they are experienced in the project.

4.6.1 Researcher Bias

Clarifying the bias that the researcher has, according to Creswell (2014), allows the researcher to reflect on any biases or influences their background may have that may shape the interpretation of the findings. For this study, the researcher has the following biases that may influence the outcomes of this study:

1. Familiarity bias: The researcher has a background in risk management, having worked in the project management office of the project under study. Being involved in the project risk management activities and having knowledge of the risks that the project is facing may influence the researchers' opinions about the risks identified in literature and may determine which risks from literature will be presented based on alignment with existing project risks or perceived criticality.
2. Screening bias: The researcher's background may also influence the data analysis process where risks identified by interview participants are captured. If an identified risk does not seem to align with the challenges the project may currently be facing, the risk may be excluded from the list.

Both biases presented above may seem similar in that they both see the researcher underplaying new or unfamiliar risks and emphasising familiar risks. The difference however is that they are applicable at different stages of the research process. To limit the influence of these biases on the interpretation of the findings, the researcher will endeavour to limit the use of personal opinion and rather centre the interpretation of findings on the explanations provided by the interview participants, e.g., defining

the identified risks in line with the accounts of the participants rather than by the commonly accepted definitions. Also, all risks identified during the interview process will be captured and analysed objectively; no risks will be excluded based on perceived relevance.

5 CONCLUSION AND RECOMMENDATIONS

This section presents an overall review of the research study, reflects on the study objectives and their achievements, and provides recommendations as to how the research findings can be used in the future as well as potential research areas that can be studied to strengthen the findings.

5.1 Review of Research Objectives and Findings

The Objectives of this research study were to:

1. Identify project risk factors associated with a train manufacturing project in South Africa
2. Identify which of the project risk factors are as a result of the South African environment
3. Determine how these risk factors compare to risk factors in other manufacturing projects?

To achieve the objectives of the research, a qualitative study making use of a phenomenological approach to research was undertaken. Aided by semi-structured interviews, a purposeful sample of 11 participants who are employed by the train manufacturing company were interviewed. All the participants were determined to be qualified to provide information for the research, by reason of their responses to a set of introductory interview questions, and none of them were disqualified during the interview process. In an analysis of the responses to the introductory interview questions, it was found that all the research participants have a positive perception of risk management, and they understand its importance and significance to project performance.

Following the introductory questions, the interview participants were asked, among other questions, to identify as many project-level risk factors they were aware of associated with the train manufacturing project. The interview data was then coded into themes and categories that represented the project risk factors. In a post interview questionnaire, the participants were presented with a consolidated list of the identified risk factors and were asked to indicate which of the identified risk factors were as a result of the South African environment within which the project exists. The responses were then tallied and ranked in order of frequency counts.

The following sections present a reflection on each research objective:

5.1.1 What are the project risk factors associated with train manufacturing?

A total of 25 project risk factors were identified through the interview process. A correlation between the number of participant references and the total number of references for each risk factor indicated that the identified risk factors with the higher numbers of participant references could be assumed to

have been more prevalent or of more significance than those with fewer references. The list below highlights the top 9 identified risk factors in order of perceived significance:

1. Supplier unable to meet capacity demands
2. Not meeting on time delivery requirement
3. Skills Shortage
4. Finance Risks
5. Not fulfilling Localization requirements
6. Planning Risks
7. Process Maturity
8. Low product quality from suppliers
9. Staff Maturity Level

The top risks that the project is exposed to were then grouped into four main themes to present a high-level view of the project's risk profile. The themes are: risks related to the supplier capacity to support the project, risks related to the project's ability to fulfil contractual obligations and requirements, risks brought about by employee competence, and risks related to project finance.

The supplier not being able to meet the project capacity demand was identified as the most significant project risk factor. It was also described to have direct impacts on project finance, production rates, and achievement of contractual obligations. Understandably so because late deliveries of equipment and parts is likely to cause project delays. With South Africa having produced very few trains over the past 40 years, the value chain for train manufacturing has not matured enough to the state that it can support a project of such magnitude without significant technical, quality, financial and competency challenges.

Further to this finding, the immaturity of the South African value chain was found to directly impact the ability of the project to achieve the contractual localization targets, that have associated penalties. The challenges with local suppliers: technical experience, financial capacity, skills maturity, poor product quality, production capacity etc. make it difficult to localize certain train components, as the local supply may be unreliable, requiring international backup suppliers. Sustainability issues make supplier bankruptcy a reality and a threat to project continuity.

In conclusion, the objective to identify project risk factors was successfully achieved as a list of 25 project risk factors was generated. Considering that data saturation was reached by the 11th interview, it demonstrates that the interview participants share common views on the project risk factors; especially focusing on the top 9 factors where each was identified by at least 37% of participants.

5.1.2 Which of the identified risk factors are as a result of the South African environment?

The findings of the questionnaire highlighted the subjectivity of the risk identification process as each risk was selected by at least two participants as being as a result of the South African environment. Due to this, we cannot completely exclude the possibility that each of the risk factors is in some way influenced by the South African environment. The participants have all had different encounters or experiences with the project risks in their various roles and would have differing perceptions of the influence of the South African environment on the risk factors. However, the methodology employed to identify risks that are as a result of the South African environment allowed for the use of the frequency counts of each risk factor as a basis for deducing its importance or significance as a response to the question. Making use of this methodology, the following 6 project risk factors were identified as being as a result of the South African environment, having been selected by at least 73% of participants:

1. Supplier unable to meet capacity demands
2. Not fulfilling Localization requirements
3. Political risks
4. Suppliers Liquidating
5. Economic Risks
6. Skills Shortage

Therefore, the objective to indicate which of the identified risk factors is as a result of the South African environment was successfully achieved in line with the methodology employed. The results are however highly subjective and based on the opinions and perceptions of the interview participants. Further studies of the South African environment with a more objective view can assist to validate the results. The variability of the participants however strengthens the acceptance of these 6 risk factors as the top risks that the project is experiencing as a result of the South African environment.

5.1.3 How do these risk factors compare to risk factors in other manufacturing projects?

Table 11 presented a comparison of the identified risk factors and the risk factors discussed in the literature review. Comparing the research findings to the data collected through literature review, it was found that 20 of the 25 identified risk factors were similar to risk factors that had been identified in other similar studies. The list below presents some possible reasons as to why some of the identified project risk factors did not correspond to any of the risk factors identified in the literature review:

1. The scope of literature that was reviewed
2. Risks associated with the COVID-19 pandemic only became apparent in 2019/2020

3. The research environment; some risks arise due to environment specific conditions e.g., labour and union relations, localization requirements, or competition where projects are not ringfenced.

Another goal of this research was to confirm and build upon the findings of JICA (2013) within the setting of a manufacturing project. The findings of this research were able to identify other challenges in train manufacturing projects that impact localization objectives over and above what was identifed by JICA (2013), such as costing for procurement, high product manufacturing costs, and suppliers not being able to achieve the localization targets.

Therefore, the objective to compare the risk factors identified in this reasearch study with factors identified in other research studies was successful.

5.2 Research Limitations

The limitations and constraints to the research were as follows:

1. The research was limited to convenience purposeful sampling facilitated by interviews. This implied that any intended participant who was unavailable for interview would not be able to contribute data to the research, and this may have limited the depth of acquired knowledge if that person held information that would be significant to the findings.
2. The research derives its findings on a single case, being the project undertaken by the train manufacturing company. Although the findings may be significant to make inference on similar projects in South Africa at present, changes to the industrial environment, economic development mandates, labour laws, the economy and the train manufacturing industry globally may influence the validity of the inference. Further research should consider the dynamic nature of the environment as well as project constraints.
3. The findings of the research are subjective and solely based on the responses of the sample of participants. An effort is made to select a group of people who will provide meaningful and truthful information that will give a true reflection of the project risks. However due to the constraints surrounding the interviews, peoples' availability, peoples' exposure to the project etc., data accuracy and completeness may be affected.

4. Although qualitative research is said to be emergent, the researcher may have unconsciously conveyed pre-conceived ideas to the participants prior to or during the interviews which may have affected their responses and tailored some of the findings of the research to the ideas of the researcher.

5.3 Recommendations for Future

5.3.1 Use of Research Findings

The South African train manufacturing industry is being revitalized after years of dormancy. The train manufacturing company's project is therefore very important for the country and continent. As the economy and industry grows in South Africa and other developing countries, more projects of this nature may arise. Research of this kind will assist these new projects to understand the nature of risks, the potential impact of external factors on project risks, their impact on project objectives and the importance of identifying and addressing them early. This research can be used as a reference to help with risk identification in similar projects; as data collected for risk identification processes can also be based on past project experiences (PMI, 2017).

The top 2 risk factors, "Supplier unable to meet capacity demands" and "Not meeting on-time delivery requirement" speak quite heavily toward project delay which has severe negative impacts on projects. Many of the top 9 risks can also be seen to cause project delay in one way or the other. In addition to having a keen focus on all the identified top 9 risk factors, new train manufacturing companies should focus their risk mitigation activities to ensure they significantly reduce the probability for project delay by wholistically treating the contributing factors.

The findings of this research are very particular to the South African environment as the study was performed within the environment. From the findings it is evident that in order to support the successful realization of future train manufacturing projects, the South African government needs to begin addressing the external project risk factors that impact the project; especially those mentioned in the list of top 9 risk factors, i.e. "Supplier unable to meet capacity demands", "Skills Shortage", Not fulfilling localization requirements, and "Low product quality from suppliers". This can be done, among other initiatives, by :

1. Increasing investments in rail related skills training that can focus on equipping youth and other interested parties in the fundamentals of rail manufacturing. This focus on the youth can also support towards achieving local content requirements related to employment of youth, as it improves their employability.
2. Developing suppliers to the rail manufacturing industry by setting up incubation hubs where potential suppliers can receive wholistic training and development on the production of train materials and components, allowing them to supply quality products to train manufacturing companies at capacities to match their demand.

3. Partnering with train manufacturing companies to ensure their localization targets are met. This involves setting attainable/ realistic targets, and supporting companies to achieve those targets through funding, professional guidance and incentive.

5.3.2 Further Research

The following areas are proposed for further research:

1. Analysing and assessing the identified risks to examine the relationships between them. In most cases risks cannot be viewed in isolation, they tend to form part of a cause-and-effect system, interacting with each other.
2. Analysing and assessing the impact of the risk factors on the project and assigning criticality or priority to them. This assists the project to deal with risks on a priority basis, addressing those of higher impact first.
3. Quantifying the impact of the South African environment on project risk. This will assist to verify the assertions of the interview participants, as well as to highlight areas that the South African government can address to improve the possibility of success for future projects of this nature.

6 APPENDIX

6.1 Interview Transcripts

Participant 1

1. 9/10
2. 10/10 it is important and necessary. Reason being, if you didnt do the risk management, you wont be able to assess the risk, you wont be able to have control measures, and you wont be able to identify if there is any risk
3. 10/10 the way i understand it , if you have identified risks, you can come up with strategies on how to mitigate it, either you transfer risks, or you take the risks, so it enables you to come up with a strategy
4. yes, i am involved in a lot of committees that came up from the company, e.g. quality ambassador, where we sit and identify risks and how do we go about in terms of making sure that the risks in terms of quality has been taken care of
5. the ones that I can think of listed in terms of weight :

- On time delivery, if we dont deliver on time due to shortages of parts.
  - Shortages of parts
  - Suppliers not supplying material on time
  - Incorrect BOM
  - Poor quality
- Force majure or acts of nature, rain (we cannot deliver on the expected day as testing should be in the dry season
- riots, community riots,
- skills and competency,
- teams maturity because that plays a major role. If you are using people who are not mature in terms of technical expertise you will be producing a product of poor quality

Participant 2

1. 9/10 (very confident) project risk manager, is experienced in the field
2. 10/10 It is very important. The project is focused on 2 elements, trains and economic development. The project received half of the allocation for its lifespan years. If it does not succeed In the first half, the second half of the project may not continue. Risk management in the context of the project looks at anticipating the future. When you do that you put in place mitigations, looking at risks related to delivering trains and ED. Well in advance and in anticipation you need clear mitigation actions to prevent tomorrows realities from happening, else you will always be in fire fighting mode and compromise the project in terms of performance.it is important to know what will impact you tomorrow and prevent it today from happening.
3. 9/10 A risk factor is a factor that could potentially impact you, e.g. in this project we are talking about ED, performance, on time delivery of trains. From there you do root cause analysis and find out why, then implement preventive actions. Project risk management can be cascaded down from project to process, skills, infrastructure, environment, all resources. So it covers many aspects
4. Yes
5. Focussing on the two key focus areas. External factors:
    a. Supplier maturity
        i. Capacity: them being able to supply parts or components on time
        ii. Supplier quality: the supplier can deliver good quality but not on time or vice versa. So supplier maturity impacts the project directly, if you don't have suppliers that can deliver parts/components/ material on time, you are critically impacted and cannot deliver trains
    b. Economic development, localization and skills development. If you have a supplier that cannot comply from a localization perspective you are also compromised. That means you have material bought elsewhere, and the supplier has clear targets from one financial year to the other. So if he does not comply to localization or buying components or material locally, you are also compromised. There is also the issue of skill, hiring local people, hiring young females etc. those are also ED components that are critical for the project
    c. The biggest risk at this point in time is the supply chain maturity or the value chain where suppliers are really not able to ramp up to our needs

    Internal

    a. We have the same issues as suppliers. We have committed contractually to deliver X number of trains for a specific financial year. We also need to do the same (deliver on the commitment).
    b. Competency of the staff, which we are mitigating through multiskilling
    c. Infrastructure readiness, we still have infrastructure that is specifically earmarked to improve our efficiency, but that specific infrastructure , some are not commissioned, and others are not reliable, overall equipment efficiency (OEE), that can also impact us based on time
    d. Staff morale. You need to maintain the social aspects of the business, making sure the staff is aligned with management, stakeholders and unions are aligned with the business priorities, and communicating the reality of the business in real time, if the business is not thriving financially, disclose to stakeholders, employees, etc. if you don't manage the transparency of communication it will impact you as there will be lack of trust, and once the relationship is broken it will be very difficult.

> But most important is to make sure value chain is matured enough to give you quality parts on time, and deliver trains, and secondly is ED component, localization and ensuring we hire as per the contractual agreement

This encompasses both components ED and train delivery. The mission of the project is to revitalize the whole rail industry, if there was a mature value chain, and mature supplier base, we would not have to go through this supplier development. The reason we are dealing with these suppliers is to address south African challenges specifically in the rail environment. For a very long time we have not been building trains, or had factories that could build good or high tech trains. Even the infrastructure is very old, so a large investment had to go into building the plant. IN the local south African environment we do not have good suppliers as compared to the automotive industry which is very mature, and has a very strong supplier development base. There has not been much focus on the rail industry . so this project is part of an initiative to address the risk factors linked to the status quo of this country

Participant 3

1. 7-8/10
2. 9-10/10. It is very important mainly to be able to have mitigation actions for all the identified risks for the project so that things run smoothly, and we have actions in place to manage those risks.
3. 7/10. It is to identify all risks that would impact the project performance
4. Yes
5. Externally:
    a. the south African situation with vandalism, we have trains idling, they are not generating money because they are not in service (because of the external environment).
    b. Contractual obligations with the customer, ie. Localization and ED targets. If we do not perform there, also on time delivery, there is a high risk that we can get penalties from the customer

INTERNALLY

    c. Configuration and change management
    d. Special processes, to have qualified people to ensure the skill level is up to standard for the special processes
    e. With the staff, we have a young team some not matured enough in terms of experience. We need to have a balance between young and matured to ensure things are under control
    f. Retention of people that were trained to be specialists. To lose those individuals is a cost to the company to send new people for training to try and catch up and maintain the skill level

Participant 4

1. 5/10
2. 9-10/10Yes, it is very important, as it might delay the project. The project has timelines to deliver to the customer, and there are heavy penalties attached to delays in the project. It is a priority, it needs to be done everyday. It is a project, it has timelines, so we need to be more aware of the risks, not only senior management, it needs to be cascaded down to operators. People do not understand their role in the project or how they add value to the bigger product we are trying to sell
3. 7/10 Our biggest bottlenecks. Anticipating and being more proactive. Seeing where bottlenecks are and addressing or unclogging them before they jeopardize the whole project.
4. Yes
5.
    a. Localization of certain key materials. The phase in phase out plan did not cater for any problems that local suppliers might have in starting up, as the localization focused on start-ups. (e.g. localized supplier is not running at 100% capacity or efficiency, there will be a learning curve) there is no fall back plan to old suppliers
    b. The processes to qualify local suppliers take long .
    c. The way we pay our contractors or suppliers , if it is a start-up they need a lot of cash injection, and we are not at the level where we are breaking even, and this has an impact on our smaller/local suppliers
    d. We have a very narrow sourcing /value chain. On some of the line stoppers, we may have entrusted it on one supplier and do not have a backup
    e. The sourcing strategy is shocking. We could get some products locally, however we are still importing them, they have not looked at the whole business, it does not make sense for us to be importing them, they can be manufactured locally. as they are not specialized parts
    f. The warehouse is outsourced to 3PL. the warehouse capacity is too small, it needs to be extended. The management of stock capacity is done properly, still causing delays in production when products are available at the outsourced warehouse. The warehouse process in not mature – there is no min/max management.
    g. Some equipment was bought off the shelf, not the latest technology. There should have been more research and investment in the quality of equipment that was bought, there are problems currently being experienced with the robots in CBS.
    h. The TOT and skilling from Brazilian counterparts did not produce the desired results as we are still bringing in experts/expats
    i. The system/ configuration management – it is as if we are still learning as we go, we need to setup the system properly.
    j. Stock accuracy issues, e.g. one component having 3 materials.

Participant 5

Missing parts, in sourcing it relates to financial risks associated with suppliers, which are the tools we are using, and what sort of mitigations do we have in place, e.g. increasing the safety stock levels, or a second source etc. from there you start quantifying it, or grouping risks under work packages such as localization, ramp up plan, costing. There are many risks. You classify bottom up based on tangible facts from daily operational activities.

1. 8/10
2. 10/10. Yes it is important, it is anticipation, so things don't hit you unexpectedly, it is very difficult to manage because you anticipate the unforeseen.
3. Risk is broad , it requires a bottom up approach in order to identify risk factors, then you can summarize at a higher level what type of risks you are facing or foreseeing.
4. Yes
5. Within sourcing there are capacity risks, where the suppliers need to be ramping up to 4/6 trains, localization risks, because we have committed to certain local content targets, and some suppliers are battling regarding localization, and we have high targets and high penalties regarding localization. Costing risks due to the rail sector, with South Africa not producing trains for many years, we are revitalizing the industry, and the type of train we have is complicated, it is not the same as the normal metrorail trains, the car body shell is complicated. The costing was complicated for many suppliers, the types of tools that they used etc. There is a risk associated with costing inefficiencies or costing gaps for suppliers. Some risks evolve on a yearly basis, they have to be constantly reviewed depending on imminent priority. COVID increased the risk related to bankruptcy. We had to increase the value/priority of the risk related to bankruptcy because through the risk analysis post covid, a great number of suppliers increased in terms of financial risk.

   All localization is south African related because it has to be a south African train, costing because we have not been producing trains for so long. The design authority for the car body shell is in lapa, it has never been done in South Africa hence the suppliers were struggling regarding the tools to be used to make all the CBS parts, in Brazil they did not have that issue. Ramp up, although it is across the board (not only in south Africa) it is linked to the project milestones or what is in the contract, if we had a different type of contract it wouldn't be specific to SA. Risks associated to the planning revisions, which is also tied to the contract, because each time we are not able to meet the MPS because the commitments with the suppliers are linked to the planning, the planning is linked to the localization. Everything is linked. (you commit volumes and they commit the local content). If we do not deliver on the planning, we affect localization, and in turn do not meet the commitment with the customer and face the penalties that are anticipated in the risks. E.g. if we transfer knowledge (e.g. cabin structure transfer from REI) we should be investing in the CAPEX for the transfer

Participant 6

1. 7/10
2. 10/10 We have to manage the risk because of the associated liquidating damages. We have associated penalties, we have a contractual date to deliver X amount of trains by a certain time which is the demand, and the program is at "time at large" (we are late), we are so late that the supply is driving the demand. The liquidating damages can take away our gross margin. The short comings in the project to day relate to Time management, finance, supply network.
3. 7/10
4. Yes
5. Latent delays from covid, the hidden delays from covid that we cannot quantify. We don't fully understand the extent of what will happen, covid and the unseen impact of covid is the major impact, (impact on suppliers etc.). congestion behind T&C since customer does not collect their trains. Production may have to stop (we don't have a plan B in place) – financial and administrative issues with the supplier. Our plan is way too optimistic without clinical analysis in the environment, and considering and integrating it into the plan (supplier network, CAPEX related items – are they achievable) , we do not use the REX to forecast where we can go. Covid has introduced a new way of working, there are new things to do that we have not accounted for in the budgeted available time for production. We need to re-adjust the time budget, making I feasible to consider covid -shift time is impacted and we have not taken it into consideration.

   The inefficiencies dealing with a parastatal in terms of contractual matters, correspondence, delayed processes and claim processing, this is the frustration dealing with the South African environment, political associations etc. it has become the culture for things to be done extremely slowly, outstanding invoices, delayed payments.. organizational and parastatal culture, and it impacts the cash flow. We cannot pay suppliers because of peoples inability to manage the project. inefficiencies are both external and internal- the environment determines the behaviour

Participant 7

1. 7-8/10
2. 9-10/10. It is very very important given the magnitude of the project. Both financially and in terms of the scope. This is because we as a business would like to ensure that we fulfil our customers expectations as that will almost certainly bring new business to our company. The contract is 10 years, for the production of trains, we have made a significant investment in our operation and would like to achieve reasonable longevity out of the plant. Through timeous delivery and quality, this should open up opportunities on the country and over the continent
3. The business obtains clarity on all factors which are likely to impact on achievement of meeting the contract with the client
4. Yes. On site we rely heavily on electricity. In south Africa the supply of electricity is unreliable , so if we have unreliable electrical supply we need to ensure business continuity at all times, so we come up with a backup electricity source. In operations, we have various pieces of equipment, and there could be equipment sensitive to lightening spikes or electrical surges, and for such equipment we need to incorporate the necessary surge protection, and to make sure there are onsite backup equipment (especially for long delivery items) to ensure business continuity. If it takes one week for a long delivery item to be delivered, our business could lose 165Million. From a financial perspective its loss of time and loss of money. The cost to keep the spare item on site vs benefit. The cost is insignificant vs business continuity
5.
    a. In the south African context we work in a volatile labour environment, one of the key risk factors is the people risk factor. Our business makes sure to maintain good labour relations with the unions and the people, and have to be committed to people development. To ensure people are being trained to meet company future requirements and are being presented with opportunities to learn and grow
    b. Machine factor: we need to ensure we have very robust maintenance plans in place. We have invested a significant amount of money in the factory, and to support the equipment over at least 10 years, there should be a maintenance plan to address short, medium and long term replacement of parts, at the basic level it should encompass inspection, lubrication, condition monitoring etc. but there are wear parts that need to be replaced at different service level intervals and major repairs at annual or bi-annual basis. So we need to anticipate all that to ensure plans are in place and parts are procured on time to ensure we don't have a catastrophic failure and impact business continuity
    c. Technology is progressing at a fast rate. We need to keep abreast of latest technologies so we are not left behind by the competition. Although we have some advanced technologies in our operation, the risk that our competitor can get the next contract is real, the market is very competitive, so we have to make sure we are at the forefront of technology.
    d. The product is comprised of various materials. There is the sourcing factor that includes pricing with good negotiations. Pricing is a very important factor. We need to ensure we are able to anticipate market trends regarding material pricing to ensure we take advantage of opportunities where material is proceed low, to source and stock, to ensure we capitalize on pricing opportunities. We also need to ensure we are continuously looking at the design aspect of the product to find opportunities to replace materials with better materials at better prices,

and drive the improvement of the product, thereby offering the customer a better product. These help to drive costs and improve customer satisfaction.

e. Methods/processes: the factory is launched with certain methods and processes, but as we embark upon the manufacturing of the product, new methods and new technologies come into play to help to drive down costs, either via headcount reduction or using same headcount and increasing speed. If you are able to continuously improve through labour cost saving or throughput on the line you maintain a competitive advantage. Your competitors are also looking at ways to optimise costs and get to market faster, from that perspective if we understand the reality of that risk, it helps up do better than our competitors.

Labour and plant reliability. One of the challenges that south African companies face is the education system, it I s not comparable to the best in the world, so we are challenged in our country for talent. We have strived to bring on board well educated experienced people, but it is not always possible. There are some well educated but still gathering experience. And to ensure we retain the young talent we need to make sure we have sustainability/ succession/ reward and recognition plans because if we don't we would be grooming people for someone else's business.

Maintenance/machine front: it is interrelated to the people factor. A number of pieces of key equipment are imported. We had to ensure we groom people b y sending them abroad to gain specialized training and experience on these systems, and we cannot afford to lose these people, the talents are crucial to business continuity. There is a very important link between man an machine in the south African context. Places like Switzerland or Germany, have these advanced technologies, but they also have skills in abundance, so their retention and succession plans do not have to be so robust

Participant 8

1. 7-8/10
2. 10/10. Risk management is very important . with this project being so big and complex involving so many different stakeholders, so many different variables and so many different unknown and changing variables, it is very important for us to take a step back to forecast some of the things that can go wrong, and then to proactively put things in place so that we can prevent either these things from happening or prevent the probability of them happening or if they do happen, prevent the impact that they have on the business.
3. 7-8/10. People have different definitions for risk. People often confuse risks, hazards and consequences
4. Yes
5. Risks
   a. Ability to produce the expected number of trains: the risk is in the rate of production, which is very low, it has to ramp up and we don't know if we can do that
   b. Financial viability of the project. There is a cash flow issue that we have to manage. There is a financial risk to the project if the forecasted cash flows do not materialize
   c. Political risk, the current political environment is unstable, combined with the unstable economic environment, compounded by COVID, could put some risks on the project because the project is funded by treasury, so if treasury decides that the project is no longer a priority that will be a risk for us on the project
   d. Our customer and their ability to accept the trains, whether they are able to absorb the trains in, able to run the trains, maintain the trains. Also their ability to maintain their infrastructure to the standard which is required in order for our trains to run in the network
   e. Customer in terms of their top management. You need to have stability in the top management to when doing big negotiations. When management is changing all the time it makes it impossible to do such
   f. Whether we are going to be able to deliver on our local content obligations, which is very heavy, it requires a lot of work and effort from our side. We have some suppliers who are not honest about their local content situation. We may think they are correct but fins in audits that they were not 100% honest, and this affects the project local content
   g. There are a few parts of the train that we need to localize, according to the contract, but we are finding it very difficult to do that
   h. The duration of the project: should be 10 years for the manufacture, but there are lots of delays happening, some are because of things the customer is doing, and some for things we are doing. We need to find a way to accommodate these delays into the project schedule without significant penalties. Because if there are significant penalties they will add further to the financial risk of the project
   i. Staff turnover, we need people to be stable and ensure continuity of the plant. We suspect it could get problematic
   j. Finance risk: multicurrency payments. We have a lot of equipment coming from Europe and have to pay our European suppliers in Euros, but the local customer wants to pay us in rands
   k. Equipment and the reliability of our equipment. We use lots of machines for our manufacturing and some of them haven't been very reliable and they break down quite often even though they are still quite new, it's a big risk since we cant produce if we have that

l. Ability of customer to take delivery of the trains. We are not able to produce trains because we do not have place to put them

m. Supply chain. We are just the integrator but we depend very heavily on lots of suppliers to produce us the right part at the right time and quality. To ensure this is done is very difficult as we have quite a few suppliers and they each have their own individual challenges and we need them all to work with us. So making sure they all work correctly and synchronised is a big challenge. We have seen lots of suppliers not able to meet our production demands and this causes delays in trains

n. Suppliers that are liquidating: We have established suppliers that are producing equipment for us. For some We have paid significantly to assist them in terms of their capital investments to produce, and supported them from a supplier development point of view, and they have come to the point where they want to liquidate for some or other reason. It is a big risk for us because it takes a long time to get other suppliers on board, especially for big sub systems where you have a new design you have to do, and is not a simple part, which takes very long. We could go overseas but that affects our local content (localization)

o. Cost containment. We have forecast a cost for building the trains. the duration of the trains so far has not been consistent. It is proving difficult to track the cost of each train in terms of equipment, hours. Early indications is that the cost of the train is higher than we forceasted.

p. Some suppliers overescalate their process over the years. Way over market prices, which is affecting our cost baseline.

q. We don't know what the future of AU will be. The customer is not happy that we are using AU, as its like "giving work to brother" so there is pressure to outsource the work of AU to other south african companies , that is a risk because we don't know if we will be able to do that or what the cost will be for that

r. Some costs were not forecast, we don't have a view of those costs, so we have to put them in, meaning every month we have an increased cost, which means the profitability of the project is decreasing on a monthly basis.

s. COIVD, but its not a risk, it is an event/ issue

South African environment is contributing a lot to the risks. The economy which is uncertain and depressed, and all indications are that it will get worse. The fact that this project is being funded by the government, although it is ring fenced, and although government is prioritising infrastructure projects, we know infrastructure is a key to job creation and growth; and our project is key to that. There is always a risk that priorities can change at some point in time. Our project is dependent on other sectors of the economy, and other suppliers. Even though we have a single customer who is backed by the government, a lot of our suppliers are not in that fortunate position and are open to market forces, competition, fluctuations in the economy. And for a majority of them the business we are giving them is not sufficient to keep them afloat. So even though we have given them work, if they do not have sustainable business form other customers they will not be able to survive which is a big risk for us. Skills shortage in south Africa which makes it very difficult for any company to retain skills because good people are in high demand everywhere in south Africa and a lot of companies are willing to pay good prices for good resources and that is a problem for us because we want to retain people as well. So it is becoming difficult to retain people with the current situation in south Africa. Succession planning, retention of staff, skills development

Customer and the fact that the passenger rail network in south Africa was built under the apartheid regime, and was built to bring the poor people from townships to work in the city centres, it was strategically built for that purpose. Because the infrastructure footprint was put in, it keeps that purpose today, and the customer cannot break from that. Therefore keep servicing clients from a low economic grouping, low income base, cannot afford high process for tickets, forcing customer to keep prices low, constraining their revenues, and continuing to be a loss making entity, and requiring assistance from the government every year. so their ability to maintain the trains will be difficult
Customer does not have many resources , weak in technical, management, project management skill, operation ability, maintenance ability, ability to execute mega capital project is very weak. They have to execute the project as part of a portfolio, including modernising track, signalling, depo, sub stations, and that is a big risk for us.

Participant 9

1. 9
2. 10; without risk management in this project we have the potential to fail the project and close our doors, as there are risks that can stop the whole project, so it is important to put things in place to identify the risks so that we are able to work on the mitigations and avoid catastrophic events
3. 8; The main reason is so you are able to put containments or contingencies in order to be able to address the risk before it becomes a complete failure so if you spend time identifying the risk in advance it becomes easier to prevent the risk before it becomes an actual impact.

4. Yes
5.

a. Supplier failure, the material availability risk. Potential of suppliers not being able to supply
b. Loss of skills, if we don't have a proper succession planning on this kind of project there is always a potential that we might lose very important skills or very limited skills in the project
c. This goes back to the supply chain - Most of our processes , one pf the biggest scopes of our project is the local content part of the project. We have a lot of suppliers and some of them are not well established suppliers. If any one of them goes bankrupt at the wrong time during this project, o0ur project would fail badly
d. Volatility of the unions (union involvement in the project and the amount of impact/influence they have on our project and business) with the very tight schedule we currently have, the project cannot withstand major delays, and based on the current experience in manufacturing ,we have had situations where we have slowed down or there have been stoppages due to strikes and unhappiness in the company, those are internal risks that need to be managed (peoples involvement and people management) making sure employees are always happy , which is not easy. At the current expected ramp up plan, we cannot afford to stop the momentum, and that is one of the major risks when it comes to people- strikes and losing key people from key positions. But the main one is supply chain and sourcing of material
e. The whole procurement strategy needs to be very well managed as one small failure in this project unfortunately has a huge impact
f. Current skills and competencies are very good and there has been a huge improvement from the beginning of the project till now. There has been a lot of evolution, for a brand new factory built from scratch ad commissioned. So in a period of 2-3 years we have had people who have not built trains before to being able to build and deliver, it tells a lot about the evolution and skills improvement of the people. What is still lacking is the maturity, we are still not on the right level. The people still need to be managed very well, they are not self sustaining or motivating. For the project to be successful people should know their role and responsibility and the impact on the project, and know what to do. That is what we need to strive for: people understand their responsibility and take ownership of their actions. If the supervisor is there the work flows , but people need to mature. This will improve efficiency and productivity

   Losing skills. Some of the skills we have, since there are not many companies making trains. There are a limited number of people who are able to do certain things. If you lose such a person from a key role, the impact can be huge

Supply chain, most south African businesses, since the market is so small, in South Africa, there aren't many other customers who are building trains, we are their only source of income, so many of them cannot survive for long – they are dependant on us. Unlike in Europe where there are many sites building trains and the supplier can supply many places. In south Africa there are very few companies building trains, so in a very specialized environment for our market, the risk factor becomes bigger because we have an instant impact on the suppliers, and some of them are not able to react fast enough to any financial impact we can have on them. The consequence is that our project is at risk. We have supplier development on our side, but many are very poor, so due to covid etc, they struggle to pay employees, so they laid off people, but due to ramp up they are unable to supply to our demand

Later in the project it wont be a big problem, but now most of the companies producing and supplying for us are living cheque to cheque, and due to ED requirements we have to give them business, but they cannot sustain themselves. But the risk for localization and ED is that of they are unable to supply or fail at the wrong time we will have to buy from overseas suppliers which means we start impacting our local content measures .European counterparts are always ready to jump in and have financial muscle to supply. As the project continues, if the locals cannot supply we will be forced to go outside. Due to the projects slow ramp up, the suppliers ramp up wasn't aligned to ours, and due to that most of them will fail and die. During the second phase some suppliers will be able to sustain themselves, but most will require big investments to catch up to where we are.

Participant 10

1. 8
2. 10, risk management enables you to look at your project, to assess where are the potential road blocks that may impact your ability to execute well, and gives an opportunity to put in place actions to mitigate those risks. Whether those actions are borne solely by the company, or to look for other stakeholders to assist like we have with PRASA, department of trade and industry, IDF, risk management is something you have to look at, not once a year. We do it on a biweekly basis with suppliers so we don't fall into a blind spot or trap, we cant afford to learn from hindsight on this project. We need to make sure we have as a clear a foresight with the data available
3. 8, it is not necessarily trying to identify what will go wrong tomorrow, but rather what could go wrong in 2/3 years. Some actions cannot be implemented in 6 months, some may take 18/24 months depending on the complexity. When looking at risk factors you look at mechanisms that exist to mitigate the risks today, which may be different from mechanisms to mitigate risk in 2/3 years because the market could change, the challenges may be different, the project could take a different direction. A lot of the risk factors are informed by the commitment to the customer and contract, regarding localization, development of local industry, homologation of localized solutions instead of relying on imports etc. identifying the factors looks at what are our obligations and what are the things that can impact our ability to deliver on the obligations
4. Yes
5.

a. Cash exposure
b. Limited ability of suppliers to deliver to enable us to deliver to our customers
c. Localization constraints->, technical competency risk, cost related risk. Since we are in a low labour cost country, it doesn't mean it is cheap to manufacture in SA since we do not have the latest technologies
d. Evolution of products/obsolescence- we have a long term project. We need to interface with suppliers to manage the product evolution with the suppliers
e. Socio economic impact – strikes during construction because local communities wanted opportunities – it impact our ability to deliver to the customer
f. Cost
g. Design
h. Supplier delays, it is more realistic post covid. Strongest suppliers are not able to keep up with the demand. Although we support them to expedite but we could not foresee everything, though we were able to identify the very risky ones and support. There is bound to be a blind spot but we are ready to mitigate and manage the issues
i. Carbon steel shortage in the country, working with major steel merchants in the country for possible containment and permanent solutions. Looking at flexibility
j. TOT – we are missing an opportunity to take the learning and see where we can improve to create efficiency.
k. Stringent ED requirements, so we have a young staff compliment – we have the opportunity to use the people who have some expertise. Its not being done across the board. We need to adopt a culture of continuous improvement
l. Not that the risk management process hasn't been implemented, but there is an aspect of the mitigation plan that is still not there, hence all the reorganizations of ops team etc.

Financial status of our suppliers. Many are small engineering companies which were thriving when the government had many tenders in the rail space. When those subsided over the past few years, some are solely dependent on Gibela
Technological gap. We train many e.g. mechanical engineers but we never use design, we are very lazy on design. Not that we should blame the government. We miss an opportunity to develop solutions in SA, not because engineers are lazy but we are not deeply rooted in pure design engineering. The trainings and learnings are there but the ..its a broad industry issue. Its not a public sector issue, the biggest role should be played by the private sector

Participant 11

1. 8
2. 10, Risk management is very important. If we don't manage the risks, we don't anticipate the risks, which has the potential to collapse the project, in all ends. Risk management is there for us to identify things that can hinder the project and treat them before they become actual risks. Risk management is at the heart of the business in terms of anticipating short, long or medium term in terms of project stability. If you really need project stability we need to have a robust risk management in place.
3. 6, So that we can categorize the factors in terms of priority, severity and their impact on the business. When we identify them we understand the risk factors in our process and eliminate them. Other factors, when identified, can serve as opportunities. So categorize the risks, understand the level of impact on the business, because we need to know all the factors that are attached to the risks
4. Yes
5.
    a. Parts coverage/ parts shortage. We are beginning to miss our deadlines (PC9, PC2) and milestone because of parts coverage/shortage
    b. Poor Quality of supplied parts, we have parts that are forever failing during testing etc.
    c. Competency of our employees
    d. Excessive overtime, it has a financial impact on the project. Cost is a risk, having an overrun of the budget
    e. COVID 19, from time to time we have to stop operations when people are infected or quarantined, we don't have people on the line to do the job. Even though it is a risk that just came up and caught us by surprise

    Parts coverage and quality of the products. Locally produced parts, with our South African suppliers, the maturity is not at the right level. The maturity in quality and keeping up with the parts demand are not at the right level

6.2 Questionnaire Responses

QUESTIONNAIRE -PARTICIPANT 1

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☒
Economic Risks	☒
Finance Risks	☐
Force Majeure	☒
Latent delays of COVID	☐
Inefficient Labour Relations	☒
Poor maintenance of staff morale	☒
Volatile Relationship with Union	☒
Insufficient Infrastructure Readiness	☒
Poor maintenance planning	☐
Poor Overall Equipment Efficiency (OEE)	☐
Insufficient Management of Product	☐
Not meeting contractual obligations	☒
Economic Development	☐
Not achieving skills Development targets	☐
Not fulfilling Localization requirements	☒
Supplier Immaturity	☒
Low product quality from suppliers	☒
Supplier unable to meet capacity demands	☒
Low project performance	☐
Inadequate risk assessment activities	☐
Low product quality	☐
Not meeting on time delivery requirement	☒
Process Maturity	☐
Planning Risks	☐
Political Risks	☒
Process Delays	☐
Skills Shortage	☒
Staff Maturity	☐
Staff Turnover	☒
Suppliers Liquidating	☒
Unsatisfied Demands to Customer	☐

QUESTIONNAIRE – PARTICIPANT 2

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☐
Economic Risks	☒
Finance Risks	☒
Force Majeure	☐
Latent delays of COVID	☐
Inefficient Labour Relations	☐
Poor maintenance of staff morale	☐
Volatile Relationship with Union	☒
Insufficient Infrastructure Readiness	☐
Poor maintenance planning	☐
Poor Overall Equipment Efficiency (OEE)	☒
Insufficient Management of Product	☐
Not meeting contractual obligations	☐
Economic Development	☐
Not achieving skills Development targets	☐
Not fulfilling Localization requirements	☐
Supplier Immaturity	☒
Low product quality from suppliers	☐
Supplier unable to meet capacity demands	☒
Low project performance	☐
Inadequate risk assessment activities	☒
Low product quality	☐
Not meeting on time delivery requirement	☐
Process Maturity	☒
Planning Risks	☐
Political Risks	☒
Process Delays	☐
Skills Shortage	☐
Staff Maturity	☐
Staff Turnover	☐
Suppliers Liquidating	☐
Unsatisfied Demands to Customer	☐

QUESTIONNAIRE – PARTICIPANT 3

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☐
Economic Risks	☐
Finance Risks	☐
Force Majeure	☐
Latent delays of COVID	☐
Inefficient Labour Relations	☐
Poor maintenance of staff morale	☐
Volatile Relationship with Union	☒
Insufficient Infrastructure Readiness	☒
Poor maintenance planning	☒
Poor Overall Equipment Efficiency (OEE)	☐
Insufficient Management of Product	☒
Not meeting contractual obligations	☐
Economic Development	☒
Not achieving skills Development targets	☐
Not fulfilling Localization requirements	☐
Supplier Immaturity	☒
Low product quality from suppliers	☐
Supplier unable to meet capacity demands	☐
Low project performance	☐
Inadequate risk assessment activities	☐
Low product quality	☐
Not meeting on time delivery requirement	☐
Process Maturity	☐
Planning Risks	☐
Political Risks	☒
Process Delays	☐
Skills Shortage	☐
Staff Maturity	☒
Staff Turnover	☐
Suppliers Liquidating	☒
Unsatisfied Demands to Customer	☐

QUESTIONNAIRE – PARTICIPANT 4

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☐
Economic Risks	☐
Finance Risks	☒
Force Majeure	☒
Latent delays of COVID	☒
Inefficient Labour Relations	☐
Poor maintenance of staff morale	☐
Volatile Relationship with Union	☐
Insufficient Infrastructure Readiness	☐
Poor maintenance planning	☒
Poor Overall Equipment Efficiency (OEE)	☒
Insufficient Management of Product	☐
Not meeting contractual obligations	☐
Economic Development	☐
Not achieving skills Development targets	☐
Not fulfilling Localization requirements	☒
Supplier Immaturity	☒
Low product quality from suppliers	☐
Supplier unable to meet capacity demands	☒
Low project performance	☐
Inadequate risk assessment activities	☐
Low product quality	☐
Not meeting on time delivery requirement	☒
Process Maturity	☐
Planning Risks	☒
Political Risks	☐
Process Delays	☐
Skills Shortage	☒
Staff Maturity	☒
Staff Turnover	☐
Suppliers Liquidating	☒
Unsatisfied Demands to Customer	☐

QUESTIONNAIRE – PARTICIPANT 5

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☐
Economic Risks	☒
Finance Risks	☐
Force Majeure	☐
Latent delays of COVID	☒
Inefficient Labour Relations	☐
Poor maintenance of staff morale	☒
Volatile Relationship with Union	☐
Insufficient Infrastructure Readiness	☒
Poor maintenance planning	☐
Poor Overall Equipment Efficiency (OEE)	☐
Insufficient Management of Product	☐
Not meeting contractual obligations	☒
Economic Development	☐
Not achieving skills Development targets	☐
Not fulfilling Localization requirements	☒
Supplier Immaturity	☐
Low product quality from suppliers	☐
Supplier unable to meet capacity demands	☒
Low project performance	☐
Inadequate risk assessment activities	☒
Low product quality	☐
Not meeting on time delivery requirement	☒
Process Maturity	☐
Planning Risks	☐
Political Risks	☒
Process Delays	☐
Skills Shortage	☒
Staff Maturity	☐
Staff Turnover	☒
Suppliers Liquidating	☐
Unsatisfied Demands to Customer	☐

QUESTIONNAIRE – PARTICIPANT 6

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☐
Economic Risks	☒
Finance Risks	☒
Force Majeure	☒
Latent delays of COVID	☒
Inefficient Labour Relations	☐
Poor maintenance of staff morale	☐
Volatile Relationship with Union	☒
Insufficient Infrastructure Readiness	☒
Poor maintenance planning	☒
Poor Overall Equipment Efficiency (OEE)	☒
Insufficient Management of Product	☐
Not meeting contractual obligations	☒
Economic Development	☒
Not achieving skills Development targets	☒
Not fulfilling Localization requirements	☒
Supplier Immaturity	☒
Low product quality from suppliers	☒
Supplier unable to meet capacity demands	☒
Low project performance	☒
Inadequate risk assessment activities	☒
Low product quality	☐
Not meeting on time delivery requirement	☒
Process Maturity	☒
Planning Risks	☒
Political Risks	☒
Process Delays	☒
Skills Shortage	☒
Staff Maturity	☒
Staff Turnover	☐
Suppliers Liquidating	☒
Unsatisfied Demands to Customer	☒

QUESTIONNAIRE – PARTICIPANT 7

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☐
Economic Risks	☒
Finance Risks	☒
Force Majeure	☒
Latent delays of COVID	☒
Inefficient Labour Relations	☐
Poor maintenance of staff morale	☒
Volatile Relationship with Union	☒
Insufficient Infrastructure Readiness	☐
Poor maintenance planning	☒
Poor Overall Equipment Efficiency (OEE)	☒
Insufficient Management of Product	☐
Not meeting contractual obligations	☒
Economic Development	☐
Not achieving skills Development targets	☒
Not fulfilling Localization requirements	☒
Supplier Immaturity	☒
Low product quality from suppliers	☐
Supplier unable to meet capacity demands	☒
Low project performance	☐
Inadequate risk assessment activities	☒
Low product quality	☐
Not meeting on time delivery requirement	☐
Process Maturity	☐
Planning Risks	☒
Political Risks	☒
Process Delays	☒
Skills Shortage	☒
Staff Maturity	☒
Staff Turnover	☒
Suppliers Liquidating	☒
Unsatisfied Demands to Customer	☒

QUESTIONNAIRE -PARTICIPANT 8

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☐
Economic Risks	☒
Finance Risks	☒
Force Majeure	☒
Latent delays of COVID	☐
Inefficient Labour Relations	☒
Poor maintenance of staff morale	☒
Volatile Relationship with Union	☒
Insufficient Infrastructure Readiness	☐
Poor maintenance planning	☐
Poor Overall Equipment Efficiency (OEE)	☐
Insufficient Management of Product	☐
Not meeting contractual obligations	☐
Economic Development	☒
Not achieving skills Development targets	☒
Not fulfilling Localization requirements	☒
Supplier Immaturity	☒
Low product quality from suppliers	☒
Supplier unable to meet capacity demands	☒
Low project performance	☐
Inadequate risk assessment activities	☐
Low product quality	☐
Not meeting on time delivery requirement	☐
Process Maturity	☐
Planning Risks	☐
Political Risks	☒
Process Delays	☐
Skills Shortage	☒
Staff Maturity	☒
Staff Turnover	☒
Suppliers Liquidating	☒
Unsatisfied Demands to Customer	☐

QUESTIONNAIRE – PARTICIPANT 9

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☐
Economic Risks	☒
Finance Risks	☒
Force Majeure	☒
Latent delays of COVID	☒
Inefficient Labour Relations	☐
Poor maintenance of staff morale	☐
Volatile Relationship with Union	☐
Insufficient Infrastructure Readiness	☐
Poor maintenance planning	☒
Poor Overall Equipment Efficiency (OEE)	☒
Insufficient Management of Product	☐
Not meeting contractual obligations	☒
Economic Development	☐
Not achieving skills Development targets	☐
Not fulfilling Localization requirements	☒
Supplier Immaturity	☒
Low product quality from suppliers	☒
Supplier unable to meet capacity demands	☒
Low project performance	☒
Inadequate risk assessment activities	☐
Low product quality	☒
Not meeting on time delivery requirement	☒
Process Maturity	☐
Planning Risks	☐
Political Risks	☐
Process Delays	☒
Skills Shortage	☐
Staff Maturity	☒
Staff Turnover	☐
Suppliers Liquidating	☒
Unsatisfied Demands to Customer	☐

QUESTIONNAIRE Participant - 10

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☐
Economic Risks	☒
Finance Risks	☐
Force Majeure	☐
Latent delays of COVID	☒
Inefficient Labour Relations	☐
Poor maintenance of staff morale	☒
Volatile Relationship with Union	☐
Insufficient Infrastructure Readiness	☒
Poor maintenance planning	☐
Poor Overall Equipment Efficiency (OEE)	☐
Insufficient Management of Product	☐
Not meeting contractual obligations	☒
Economic Development	☐
Not achieving skills Development targets	☐
Not fulfilling Localization requirements	☒
Supplier Immaturity	☐
Low product quality from suppliers	☐
Supplier unable to meet capacity demands	☒
Low project performance	☐
Inadequate risk assessment activities	☒
Low product quality	☐
Not meeting on time delivery requirement	☒
Process Maturity	☐
Planning Risks	☐
Political Risks	☒
Process Delays	☐
Skills Shortage	☒
Staff Maturity	☐
Staff Turnover	☒
Suppliers Liquidating	☐
Unsatisfied Demands to Customer	☐

QUESTIONNAIRE – PARTICIPANT 11

Identification of Project Risk Factors in a South African Train Manufacturing Project

Which of the following train manufacturing project risk factors are brought about or are as a result of the South African environment within which the project exists?

RISK FACTOR	RESULT OF SOUTH AFRICAN ENVIRONMENT? (tick)
Competition	☐
Economic Risks	☒
Finance Risks	☒
Force Majeure	☐
Latent delays of COVID	☒
Inefficient Labour Relations	☐
Poor maintenance of staff morale	☒
Volatile Relationship with Union	☐
Insufficient Infrastructure Readiness	☒
Poor maintenance planning	☒
Poor Overall Equipment Efficiency (OEE)	☐
Insufficient Management of Product	☒
Not meeting contractual obligations	☒
Economic Development	☒
Not achieving skills Development targets	☒
Not fulfilling Localization requirements	☒
Supplier Immaturity	☒
Low product quality from suppliers	☒
Supplier unable to meet capacity demands	☒
Low project performance	☒
Inadequate risk assessment activities	☒
Low product quality	☒
Not meeting on time delivery requirement	☒
Process Maturity	☒
Planning Risks	☒
Political Risks	☒
Process Delays	☒
Skills Shortage	☒
Staff Maturity	☒
Staff Turnover	☒
Suppliers Liquidating	☒
Unsatisfied Demands to Customer	☒

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