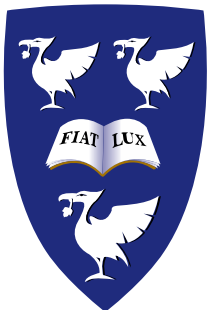


UNIVERSITY OF LIVERPOOL

Lessons that can be learnt using Action Research strategies within TfL

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor of Business Administration

By
Christos Savva

June 2023

Abstract

London Underground has a persistent and increasing level of incidents over the last five years. The TfL PITTA project is a programme of works that installs media assets within the Transport of London (TfL) railway environment. Key safety risks on the TfL PITTA project are addressed using an action-research (AR) based approach. The action research team includes various delivery stakeholders. We know little about what has been learnt using this approach. This study explores what lessons can be learnt about the perceived effectiveness, implementation challenges and the institutionalisation of the AR based strategies with the aim to produce actionable knowledge.

This study explores what strategies have been implemented in reducing safety risks, where improvements could be made, what challenges have been encountered and how they have been addressed. Furthermore, this study explores how these strategies have been institutionalised, and uses actionable knowledge to develop implications for practice within a wider organisational context. This study uses a stakeholder theory to gain a broader view by using all the perspectives of the delivery stakeholders.

Specific safety risks to do with manual handling and working at height are addressed using the AR approach. Innovative solutions are found through this process that minimise the risk associated with manual handing and working at hight, especially within escalator environments. This study uses an action research method, and it is rooted in a practice-based problem, it aims to produce actionable knowledge and travels through cycles of reflective action. Interviews are used to collate data from the AR team. Post analysis feedback and action research cycles draw out how AR has been effective, and how the surrounding safety culture has enabled the new solutions to become normative everyday practice. It explores how safety leadership plays a significant part in enabling successful safety outcomes. It explores how AR can be institutionalised within TfL.

The key findings suggest that AR can be effective in solving very specific safety risks. Aside from the TfL governance requirements that are prescribed in addressing safety risks, AR is shown to offer practical and effective solutions for complex safety risks. In addition, the collective stakeholder engagement through AR based approaches suggest that it promotes a better safety culture and safety environment. Post analysis feedback also suggests that a framework where key safety risks are identified, vetted, and senior leadership is engaged through an AR based approach, is a viable safety proposition to institutionalise.

Future research opportunities may explore more stakeholders to widen the research. In addition, a quantitative or mixed methods approach could be applied for a more generalisable outcome.

Keywords: Action Research, Transport, Construction Projects, Safety management systems, Safety Culture, Safety Leadership, Stakeholder Theory

Declaration of own work

I declare that his thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where states otherwise by reference or acknowledgment, the work presented is entirely my own.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES 7

ABBREVIATIONS 8

INTRODUCTION 9

BACKGROUND 9
THE PRACTICE-BASED PROBLEM 10
RESEARCH QUESTION, OBJECTIVES AND AIMS 13
RESEARCH APPROACH 15
SIGNIFICANCE OF THIS STUDY 16
CLOSING INTRODUCTORY COMMENTS 16

LITERATURE REVIEW 18

INTRODUCTION 18
KEY CONCEPTS AND DEFINITIONS OF SAFETY MANAGEMENT SYSTEMS 20
KEY PERSPECTIVES IN SAFETY MANAGEMENT SYSTEMS 22
SAFETY LEADERSHIP 25
KEY CONCEPTS AND DEFINITIONS OF SAFETY CULTURE 28
MANAGING RISKS ON CONSTRUCTION PROJECTS 32
PROBABILISTIC APPROACH 32
SYSTEMATIC APPROACH 32
AR BASED TYPE APPROACH 33
SAFETY RISK INTERVENTIONS 34
Educational Interventions 34
Legislative Interventions 35
Informational Interventions 36
Facilitative Interventions 36
Multifaceted Interventions 37
SAFETY MANAGEMENT MODELS FOR UK RAIL PROJECTS 38
CURRENT MANAGEMENT OF TFL PROJECT RISKS 40
A THEORETICAL PERSPECTIVE - STAKEHOLDER THEORY 41
WHERE FURTHER RESEARCH AND DATA IS NEEDED 43
ANALYSIS OF EXTANT LITERATURE USED IN LITERATURE REVIEW 44

METHODOLOGY 47

INTRODUCTION 47
PHILOSOPHY 49
METHODOLOGY 51
DESIGN OF THIS RESEARCH 52
ACTION RESEARCH 53
DATA COLLECTION 56
PRIMARY DATA COLLECTION – INTERVIEWS 56
SECONDARY DATA COLLECTION – ORGANISATIONAL SAFETY DATA 57
SECONDARY DATA - EXTANT DATA 57
SECONDARY DATA - ACTION RESEARCH DATA FROM TFL PROJECT 57
PARTICIPANTS 57
DATA COLLECTION 61
DATA ANALYSIS 64

Insider Bias / Role Duality Issues 65
Limitations of This Study 67
Ethical Issues 68

FINDINGS 69

Introduction 69
Research Question and Objectives 70
Explore what strategies were implemented 70
Landlord strategies that were implemented 71
Client strategies that were implemented 72
Principal Contractor strategies that were implemented 73
Which strategies effective, needed refinement or improvement? 75
Landlord Perspectives on efficacy 75
Client Perspectives on efficacy 75
Principal Contractor Perspectives on efficacy 77
What challenges were faced and how were they addressed? 80
General challenges 80
Pre-Construction Phase challenges 81
Construction Phase challenges 82
Explore how well these strategies have been institutionalised 85
Institutionalised Strategies 85
Stakeholder Recommended Strategies 86
Stakeholder Ease of Adoption Strategies 87

DISCUSSION 91

Discuss findings and the link to literature theory 91
Stakeholder Perspectives 91
Safety Management Systems 93
Safety Leadership 93
Safety Culture 94
Managing Safety Risk 96
Safety Risk Interventions 97
Research Question 98
Actionable knowledge 100
Strategies Used 101
Efficacy of Strategies Used 104
Challenges Experienced on Strategies Used 108
Institutionalising of Strategies Used 111
Implications for practice 119
First Round of Action Research for ISR 127
Second Round of Action Research for ISR 127
Subsequent Rounds of Action Research for ISR 129

LIMITATIONS AND RESEARCH DIRECTIONS 129

CONCLUSIONS 131

RESEARCHER'S REFLECTIONS FROM PRACTICE OF AR APPROACH 132

REFERENCES 134

APPENDICES 142

APPENDIX A – Interview Questions 143
APPENDIX B – Ethics Approval Letter 144

APPENDIX C – PARTICIPANT CONSENT FORM 145
APPENDIX D – PARTICIPANT INFORMATION SHEET 147
APPENDIX E – EXISTING SAFETY REPORTS (EXTRACT ONLY OF P13_2018 AND P7_2019) 150
APPENDIX F – TOTAL WORD COUNT 161

List of Tables and Figures

Tables

Table 1 - Participant Profile 60
Table 2 - Participant Interview Questions And Categories 62
Table 3 – *Extract* of Landlord Stakeholders Data Collection Method Mapped Against 2nd Order Categories and Aggregate Theoretical Themes (similar tables exist for other Stakeholder groups) 63
Table 4 - 1st Order Codes, 2nd Order Themes and Aggregate Theoretical Dimensions 65
Table 5 - Researchers' Responses to Interview Questions 67
Table 6- Stakeholder Strategies and Methods Used 75
Table 7-Stakeholders' Perceptions of Strategy Effectiveness 80
Table 8 - Stakeholder Challenges In Implementing Strategies 85
Table 9 - Stakeholders and Institutionalising Strategies 90
Table 10 - Summary of Stakeholder Perspectives 118
Table 11 - Implications for Practice 123
Table 12 - Implications for Practice for TfL ISR Project 126

Figures

Figure 1 - Relationship between Events, barriers, and safety management systems 21
Figure 2 - Safety management systems Relative to Theoretical, practical and standards Levels 22
Figure 3- Generic SMS framework (Hale, 2005) 24
Figure 4 – Bandura (1977a, b, 1986) model of reciprocal determinism 28
Figure 5 - Cooper and Phillips (1995) model of Safety Culture 29
Figure 6 - Safety Culture Model (Bisbey et al., 2021) 31
Figure 7 - Extant Literature Analysis by Industry Sector, Theoretical approach and Year of Publication 46
Figure 8 - TfL Pathway Lifecycle Diagram 48
Figure 9 - Safety Management Systems - General 102
Figure 10 - Safety Management Systems - Pre-Construction Phase 103
Figure 11 - Safety Management Systems - Construction Phase 104
Figure 12 - Stakeholders' Efficacious Strategies - Pre-Construction Phase 105
Figure 13 – Stakeholders' Efficacious Strategies – Construction Phase 106
Figure 14 – Stakeholders' Perspectives on Strategy Improvement 108
Figure 15 - Stakeholders' Perspectives on General Challenges 109
Figure 16 - Stakeholders' Perspectives on Challenges During Pre-Construction Phase 110
Figure 17 - Stakeholders' Perspectives on Challenges During The Construction Phase 111
Figure 18 - Institutionalised Strategies 112
Figure 19 - Recommended Elements for Institutionalising 113
Figure 20 - Ease of Strategic Adoption into Organisations 114
Figure 21 - Institutional Blockers 115

ABBREVIATIONS

AR	-	Action Research
CDM	-	Construction Design and Management Regulations
CPP	-	Construction Phase Plan
DBA	-	Doctorate in Business Administration
DRA	-	Designers Risk Assessment
H&S	-	Health and Safety
ISR	-	In-Station Retail (TfL)
LBP	-	Lower Back Pain
LCD	-	Liquid Crystal Display
LDS	-	Lumbar Disc Surgery
LU	-	London Underground
ORR	-	Office of Rail and Road
PC	-	Principal Contractor
PCI	-	Pre-Construction Information
PCIP	-	Pre-Construction Information Pack
PD	-	Principal Designer
PITTA	-	Programme for the Investment & Transformation of TfL Advertising
PLF	-	Programme Leadership Forum
PM	-	Project Manager
QUENSH	-	Quality, Environmental, Safety and Health (London Underground)
RAMS	-	Risk Assessment Method Statement
RIDDOR	-	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations
RM3	-	Risk Management Model
ROGS	-	Railway and other guided systems
SHE	-	Safety Health and Environment
SLT	-	Safety Leadership Team
SMS	-	Safety Management System
SPM	-	Senior Project Manager
SSOW	-	Safe System of Work
TfL	-	Transport for London
TTLP	-	Transport Trading Limited Properties
UK	-	United Kingdom

INTRODUCTION

BACKGROUND

Transport for London (TfL) is a local government body responsible for most of the transport network in London, England. It manages transport networks including the London Underground, London's buses, taxis, principal road routes, cycling provisions, trams, and river services. TfL is scheduled to separate itself from central government funding by 2023, though this deadline has been postponed due to the Covid pandemic. TfL aims to eventually become financially autonomous from the government which entails increasing its ability to generate revenue streams. Becoming financially autonomous inevitably requires providing customers with a valued and safe service, in addition to investing in major capital projects that preserve a modern railway system and futureproof it for a growing population. Improving health and safety within TfL also improves revenue generation as it provides increased confidence and reputational gain.

TfL currently has two main revenue income streams. Its primary revenue stream comes from transport ticket sales, which is managed by a TfL operational department. Its secondary revenue stream involves income from property-related activities and advertising on the TfL-owned land and assets. Relative to its primary revenue stream, TfL's secondary revenue stream is underexploited and therefore offers a great potential to increase future revenues. TfL's secondary revenue stream is managed by TfL's Commercial Development department. Commercial Development manages retail, property development and advertising. The TfL advertising department works in partnership with an advertising company. This partnership is called *Programme for the Investment & Transformation of TfL Advertising* (PITTA). Safety within TfL is driven by safety policy and is linked to safeguarding our revenue generation.

PITTA works jointly as a client and landlord to manage a delivery partner, who is responsible for the installation of advertising assets. PITTA'S delivery partner acts both as a Principal Designer (PD) and a Principal Contractor (PC) as per the Construction and Design Management (CDM) 2015 definitions. The CDM 2015 is a UK legal framework setting out the responsibilities and duties of the client, the principal designer and the principal contractor for all UK construction projects. PITTA works in collaboration with the client and the principal contractor to install advertising assets across the TfL estate. Nine separate programmes divide the total PITTA project, namely Programme 1-9 (P1-P9). The different programme numbers allocate different types of advertising media to be installed and in addition clusters of specific station types. The total number of media assets to be fixed is currently about six thousand assets. These installations span over four hundred and twenty-seven stations. This project is a sophisticated programme of works given the large numbers of assets and multiple locations. Safety is at the centre of everything we install and is inextricably linked to our protecting and enhancing our revenue generation from property and transportation revenues. Naoum et al. (2011)

correlate safety performance and profit margin and highlight the direct link to increased profits on safety performance and vice versa.

I am both a practitioner and a researcher within TfL Commercial Development. Being involved within the project team as a construction lead, project manager and member of an AR team gives me an insider view of the issues, solutions and the organisation. Within the AR action groups I undertook the lead on three specific safety risk elements so am familiar with the AR project and its actions and outcomes. Being a TfL construction lead, also exposes me to the TfL risk-management methods we have applied to our project. AR has a diagnostic element which identified workplace injuries as a risk that needed to be addressed and reduced. Being a researcher and a practitioner introduces challenges such as objectivity and conflict of interest. For this study, the researcher's objectivity shall supersede professional practice, but only where there is a conflict. The practice of a professional practitioner and the objectivity of a researcher are mostly compatible.

More recently, and since January 2020 I have also been involved with another programme within TfL Commercial Development that delivers retails units within our stations, namely In-Station Retail (ISR). Currently we have approximately eight hundred retail units that fall within the station footprints of the TFL estate, with the view to maintain, enhance and create new retail spaces over the next five to ten years. The programme is ambitious and hopes to enhance our revenue generating capacity as a landlord transport company. Again, the challenges we face on this programme of works is a multi-geographical and a multi-nodal one as with the PITTA advertising programme of works. The relevance of this new role becomes more apparent later in this study, when the question of how to apply actionable knowledge from this study could become institutionalised within TfL.

A specific area of collaboration on the PITTA programme is in the management of safety risks. A Safety Leadership Team (SLT) collectively seeks out to identify the specific safety risks, and Programme Leadership Forum (PLF) vets these risks and helps to prioritise them from a safety and overall business perspective. Both groups consist of a diverse group of delivery stakeholders that have an overall collective interest in the PITTA works. The primary stakeholders are the landlord, the client and the principal contractor.

THE PRACTICE-BASED PROBLEM

TfL is increasingly experiencing health and safety incidents. London Underground infrastructure workers have experienced a rising number of cases over the last five years. Our advertising assets within PITTA installations are predominantly within the London Underground (LU) environment. LU is a subsidiary of TfL. The number of total workforce incidents that were reported to the Office of Rail and Road (ORR) for London Underground (LU) as a whole and over the last few years (financial year) are as follows: (sourced from ORR _ 5210 workforce injuries LU annual data extract from 2014-15 to 2019-20)

- 2014/15 264 incidents
- 2015/16 268 incidents

- 2016/17 320 incidents
- 2017/18 283 incidents
- 2018/19 335 incidents
- 2019/2020 422 incidents

The incident numbers demonstrate a significant increase in the number of incidents on infrastructure workers from within LU over a five-year period.

The Health and Safety Executive (HSE) annually publishes safety related construction statistics. The latest edition of Construction statistics in Great Britain, (2022) the report highlights the economic cost impact of injuries to the construction sector from injuries and ill health. Economic costs are comprised of financial costs and non-financial valuations which are reduced to a monetary unit. In 2019-2020 in the UK the economic impact of work-related injuries in construction alone amounted to £883 million. Ill health economic impact amounted to £515 million. Together the economic impact of injuries and ill-health amounts to £1.4 billion for construction. This equates to 7% of the total cost of works undertaken in that year. This is a significant impact. Comparing the total economic impact of injuries and ill-health for all sectors in 2019 to 2020, which includes agriculture, manufacturing, mining, wholesale, transportation, defence, education, and recreational services amongst other sectors, the total costs amount to £18,67 billion. Work related injury and ill health contribute a considerable burden to individuals, organisations, and the UK government. The individual burden alone in the 2019/2020 period amounts to £11.5 billion. Organisations bear the cost of £3,5 billion and the remaining £3,67 billion is borne by the UK taxpayer and UK government. In order of economic impact, Ill-health contributes £11,1 billion, non-fatal injuries contribute £7.36 billion and fatalities contribute approximately £210 million.

From a European perspective however, the UK fairs well. In 2021, the HSE Summary of Statistics shows the UK to the be second lowest in terms of fatality incidence rates. Germany rates are lower. The UK is also significantly lower in comparison to the average European (twenty-eight European countries) rates. In terms of self-reported ill health and injury rates, the UK places second lowest and lowest respectively. Thus, from a wider context, the UK accident and incidents rates are well below the European averages. Incidents and ill health are a major disruption to revenue generation and London Underground is no exception to this problem.

The rise in incident levels on LU workforce noted above causes concern and especially to the vital revenue generation within London Underground. Evidently there is a practice-based problem that needs to be solved. Solving this problem requires a collection of delivery stakeholders, so that tacit knowledge can be extracted and co-constructed in a meaningful and explicit way so that action can be taken towards reducing the safety risks and reducing the number of incidents. It is these specific considerations that provides the initial platform for action research to be considered as a possible method to reduce the specific safety risks on the PITTA project. The PITTA risks are also live, and the installation works are already in progress. Understanding how to solve a problem as we go along is a strong companion for AR approaches (Nonaka, 1994).

The Action Team is an AR (Action Research) based group that was created and led by myself in response to the critical safety risks, identified by the safety leadership team, within the PITTA programme of works. The action team was embedded within the safety leadership team and was tasked with addressing very specific problems that were live, during the construction phase of the PITTA project. All the action team members were also stakeholders of the safety leadership team. The AR approach to addressing a specific safety risk, proposed to diagnose a specific problem and develop a selection of actions that were assessed and some, subsequently actioned.
As an example, manual handling was identified as one of several, high-level, construction safety risks within the safety leadership team. An action research (AR) group was formed a week after the first safety leadership meeting to tackle the problem. Manual handling was identified as a top safety risk because persons involved in manually handling assets were at risk of injury. In the construction industry, musculoskeletal injuries contribute towards 65% of all work-related ill-health in 2017 (Health and Safety Statistics for the Construction Sector in Great Britain, 2017). It was also recognised as a top programme risk as one of the larger media assets was identified as not having a vertical transportation solution, therefore posing a serious risk in time delays, and subsequent detrimental effect to revenues. This specific asset was identified as the 98-inch asset, a ninety-eight-inch, liquid crystal display (LCD) screen that weighs approximately 300kgs in total. It can be separated into three parts, with the front screen weighing 200kg. The action group consisted of stakeholders from the client, landlord, contractor, and subcontractor teams that were involved in installing the media screens. Solutions were proposed, trialled, and tested several times, before finally proposing a comprehensive overall solution to solving this specific problem and minimising the threat of manual-handing injuries.

The problem we have is that TfL PITTA does not know if these strategies were effective, and what can be learnt from this experience, and how these strategies can be implemented. The AR team members act as a repository of knowledge and experience. There is a need to learn from these repositories to make improvements in the future. This necessitates an exploratory study to draw out these experiences and the challenges faced and subsequently refine existing strategies, if required, and extend successful strategies.

Safety culture, safety leadership and safety management systems surround the AR process that AR is applied, and it is important to understand how these facets support the AR mechanisms that create the TfL PITTA project safety outcomes. Li & Guldenmund (2018) provide a model where safety management systems (SMS) can be viewed from three perspectives, namely, theoretical, practical and compliance perspectives. This model as per figure 2 in the following chapter helps to formulate the AR approach within this study, in terms of these perspectives. AR is supported by critical theory, and in practice it is an action-based research approach, and it is applied in such a way that it addresses safety compliance issues. Thus, AR fits in well into what is defined as a safety management system. However, SMSs do not exist in isolation, they are influenced and affected by the surrounding safety culture and also by safety leadership within TfL. Bisbey

et al., (2021) provides a conceptual model of safety culture, which helps this study identify elements and mechanisms that surround the AR-based approach. Enabling factors and enacting behaviours enable safety management systems to thrive, if fully realised. This study explores these enabling factors and enacting behaviours that contributed towards the AR-based approach achieving the safety outcomes it aimed to accomplish. The enacting behaviours are also related to safety leadership concepts, where attitudes as per Stiles, Ryan, & Golightly (2018) note, that compliance alone is not enough, visible behaviours play a significant contributory role in safety outcomes. Safety climate defines the safety context of the surrounding safety management systems and contributes considerably towards safety consequences (Hoffmeister *et al*., 2014). The AR based approach is applied within a TfL safety climate, and this study explores the mechanisms that helps to support this approach. TfL site supervisors' engagement (Conchie, Moon, & Duncan, 2013) and supervisors' behaviours influence safety climate in a profound way that reduces safety risks in a sustainable way. This study explores these aspects of supervisors' engagement and behaviours and explore what lessons can be learnt within the TfL context.

Extant literature is limited specifically when it applies an AR based approach within a railway environment and during a construction phase. Within the literature review chapter, more detail is provided. This study uses stakeholder theory to offer specific perspectives on the problem and the effectiveness of AR based approach to solve a workplace problem, and as such there is no such study that concretely contributes towards this, that can be used with the TfL context. The last section of the literature review chapter depicts the graphical view of literature used within this study and it is evident that AR based approaches, using a stakeholder perspective within a railway environment are limited. Extant knowledge lacks a study, which could be used well in this study's context.

RESEARCH QUESTION, OBJECTIVES AND AIMS

The purpose of this study is to explore the effectiveness of the AR based strategies, that PITTA has implemented, to reduce incidents to the workforce. This study explores what lessons can be learnt about the perceived effectiveness, implementation challenges and the institutionalisation of the AR based strategies.

The research question is "what lessons can be learnt about the perceived effectiveness, implementation challenges and the institutionalisation of the AR based safety strategies in the TfL PITTA project."

Thus, the research has the following four objectives:

The objectives of this research are:

1. To explore what strategies were implemented.
2. Which strategies were perceived to be effective, needed refinement or improvement?

3. What challenges were faced and how were they addressed?
4. To explore how these strategies have been institutionalised.

The aim of this study is to develop an AR-based strategic framework which can be applied in the future to reduce workplace incidents at London Underground and TfL. The word *strategic* is defined within this thesis as a plan of action for the purpose of achieving a long-term or overall goal. Thus, strategic frameworks can be organisational or operational methods or approaches. In addition, the effectiveness of an AR based strategy is provided through the interviewee, stakeholders' perspectives, who are experts in the fields of health and safety, project management and construction management within TfL. Effectiveness of an AR-based solution can also be demonstrated through a risk assessment process, before the AR based solution has been implemented. The risk assessment approach demonstrates the evaluation of safety risk before an AR mitigation is applied and after it is applied and the subsequent safety risk reduction. The measure of TfL incidents are undertaken by periodic safety reports. However, unless specific safety resources have been tasked and committed to measure the AR based solution in implementation, the safety reports cannot be correlated to successful reduction in incidents, unless specific variables have been isolated for the specific purpose of measuring effectiveness. Nonetheless, the safety reports do provide useful information to indicate if specific risks that the AR based approach had sought to improve do not flag up in a near-miss or an incident or an accident. Safety reports can also provide useful situational context at a specific point in time. For example, one of the AR based solutions within the TfL PITTA project was to solve a specific manual handing issue. If the safety reports do not expose incidents that have to do with manual handling or musculoskeletal issues during the period of AR-based implementation, then there may be grounds to argue the case that significant incidents would have flagged up if the solutions were ineffective. In summary, the expert stakeholder perspectives, the relevant risk assessments, and the TfL periodic safety reports all contribute towards assessing the effectiveness of a strategy.

The AR based approach applied during the PITTA project relates to reducing health and safety risks, such as manual handling risks and reducing them through mechanisation methods. It is also important to highlight the financial implications should the AR based solution not have been solved for manual handling. The 98-inch advertising screens could only have been transported though the station escalator environment and as such the manual handling method was aborted due to the intolerable safety risk to the workforce. A solution needed to be found to achieve the safety requirements and to meet our ultimate financial requirements. No installed advertising screens equates to zero revenue for TfL though advertising revenue. My personal motives for reducing safety risks as a senior manager relate to the value I place in my duty of care for the workforce. I am accountable to them, and I am also accountable to the TfL programme requirements, which is to safely install advertising assets so that advertising revenue may be achieved for TfL. Safety in this instance is inextricably linked to financial implications within the AR based solutions that were sought within the PITTA project. They were also directly linked to my obligations as a manager, to my personal values and duty of care to the workers.

RESEARCH APPROACH

For this study we are using an AR approach and presenting the report as a qualitative case study. AR is based on a diagnostic, evaluative, and action-based approach and when applied, it has a learning capability too (Azhar, Ahmad, and Sein, 2010) A qualitative approach is required because data is gathered from members involved with the TfL AR project through interviews, and the value of the data held through the induvial perceptions of the interviewees. This data is qualitative.

The TfL PITTA action research data is available to me, being a member of the AR team within the TfL Commercial Development department. In addition, the interviewees are stakeholders within the project; I have access to them by being a stakeholder myself. The objectivity of the research shall aspire to take precedence where there is a conflict of interest between researcher and employee responsibilities. However, being in a position of both researcher and employee imports an element of risk of bias and judgment. Bazerman *et al.* (2008) categorises three biases, namely, availability biases, representativeness biases and confirmation biases. One of the risks in being both practitioner and researcher are biases and being cognisant of these will contribute towards identifying these when they occur and then putting mitigations in place to alleviate them.

Significant consideration was given to the ethical element of this research. The University of Liverpool Ethics Committee granted an ethics approval for data collection specifically for this research. How data is collated and protected is a key consideration for this research. No data could be collected until the ethics approval had been granted. Given the recent Covid19 pandemic, it has been necessary to gain ethics approval to collect interview data remotely. Another part of the ethical consideration is how and when to notify interviewees about the research, to gain their consent, and to explain how they will be protected through anonymisation.

In addition, the ethical considerations have to do with conflict of interest of the researcher. Being an insider and knowing the political landscape, the formal and informal organisational structures within our project offers both advantages and disadvantages (Baskerville, 1997). The advantage is that knowing the organisation from the inside would take years to gain from the outside, yet there is also the disadvantage or risk of losing objectivity by being closely linked with the project. Critical thinking, collective, and open discussions by introducing opposing views will help to mitigate some of these risks.

TfL, the advertising partner, and the principal contractor are regarded as delivery stakeholders within the AR project and its outcomes. Freeman (2010) defines a stakeholder as someone who can influence or is influenced by the accomplishments of a company's objectives. The data which will be sought in this study will reflect the stakeholder's perspectives through interviews. Stakeholder theory (Freeman, 1984) recognises that stakeholders of an organisation contribute towards value creation. Thus, this study will apply stakeholder theory in its approach. The interviewees fall into three stakeholder categories and as such will provide stakeholder perspectives and stakeholder theory fits well with this approach.

SIGNIFICANCE OF THIS STUDY

Actionable knowledge that fits within the context of this study does not exist and an aim of this study is co-create such knowledge for the TfL context.

Within TfL projects, risk management during the construction phase has applied approaches that have been in use for some time. However, the data collated from the Office of Rail and Road, as previously noted above, indicate a significant rise in incidents within London Underground. A very specific area of concern is manging construction risks while the projects are live. Action research is one such strategy that has the potential to work well within this environment. The need for research to be effective in practice is emphasised in Azhar, Ahmad, and Sein's (2010) report in using action research. The research paper addresses a live practical problem which creates theoretical and conceptual knowledge. The paper presents the validity of action research as an applied method to solve problems in practice within the construction engineering and management field. AR used within the construction discipline can be an effective method for solving live issues and in creating new academic knowledge. In addition, it has the potential to build strong relationships between practice and academia, by using academic theoretical advancements to inform AR-based approaches and solutions. Generating actionable knowledge from AR based projects within the construction area is important knowledge gap to fill, and this study aims to contribute to this area. Safety leadership styles play important roles in safety outcomes (Conchie, 2013).

Having had applied this AR approach to TfL PITTA project, the next logical step is to determine its effectiveness as a strategy to reduce workplace incidents. This study proposes to use stakeholder theory to gain a varied perspective about this effectiveness with a view to institutionalise this strategy within the TfL Commercial Development department and potentially to the wider TfL organisation. Actionable knowledge is to be developed and co-created within this study from our practice-based experience in using AR for managing live construction risks.

CLOSING INTRODUCTORY COMMENTS

The increasing number of incidents within London Underground over the last five years is of concern. Despite the controls currently in place and the recent RM3 intervention method in TfL as supported by the Office of Rail and Road (ORR), the increase of incidents is worrying. Within the TfL PITTA project, a concerted effort was made to apply an AR based approach towards addressing this issue. AR was used to solve workplace problems by identifying specific safety risks, and collaboratively seeking to explore innovative solutions to eliminate or reduce the safety risk to TfL infrastructure workers. We have applied this AR approach, but what we do not know yet, is whether this approach was effective in reducing workplace incidents. This study aims to explore existing strategies that are used in reducing safety risks, whether these strategies are effective, and whether refinement or improvements are needed. In addition, this study will identify challenges

and how these were addressed and investigate how well these strategies have been institutionalised.

The experiences of individuals, who are experts in the health, safety, project management and construction fields and who were involved with the AR based approach, will be collated within interviews. This study will investigate how effective the AR based approach has been within the PITTA project, with the intention to contribute towards solving a specific organisational problem within TfL as well as to the learning of other similar organisations. Actionable knowledge will be co-created, from the experience of the first iteration of AR based solutions within the TFL PITTA project and this new actionable knowledge can be used to implement the second iteration of AR based approaches within a new TfL department in the TfL retail space, where I am currently based. The second iteration of AR is the institutionalising of an AR based approach within TfL. The value of actionable knowledge is important for TfL because it is co-created with experts within the TfL project areas and applied to solve very specific and complex TfL problems.

LITERATURE REVIEW

INTRODUCTION

The UK construction sector has a high injury ratio of two and a half times more than other industries (Atique 2012, Bentley 2006, Haslam 2005). Injuries in the construction sector is a problem, and it is intensified by the lack of solid evidence that clearly demonstrates by how much safety management strategies and interventions reduce safety incident rates.

The Health and Safety Executives' (HSE) publication (Historical Picture Statistics Great Britain, 2022) provides the current injury ratios within the UK context. Workplace injuries over the long-term, since the 1990s, the number of fatal and non-fatal injuries has substantially reduced. However, the more recent five-year period there is general downward trend, and this has been affected by the coronavirus pandemic. Work-related illness particularly the musculoskeletal disorders has declined since the 1990s. However, reported stress, depression and anxiety is on the rise. Consequently, work related ill-health is on the rise and this amounts to 30.8 million workdays lost due to ill health in 2021-2022. In 2020 the UK lost £11.2 billion in new cases of work-related ill health and excluding long latency illness (www.hse.gov.uk/statistics/tables/ - Accessed May 2023). As noted in the Introduction Chapter of this study, the specific London Underground injury ratios over the last five years and excluding ratios since March 2020, when the coronavirus pandemic impacted the UK, the injury rates have been on the increase. It is within context that safety and safety related strategies within TfL and the PITTA project were considered. Safety is an important issue to address within TfL in terms for not causing harm or injury to our workforce and in terms of financial loss to TfL.

The Cochrane Research Centre undertakes extensive evaluations on healthcare interventions, and some recent work undertaken by the research centre in 2018 and 2019 evaluates interventions specifically applied to reduce construction injuries. (The Cochrane Research Centre, 2020). The report demonstrates that more work is needed to link safety interventions to evidence that supports a reduction in safety incident rates.

The central theme of the research question is about safety, and as such safety management is identified as a predominant literature subject. Safety, however, does not exist in isolation, it overlaps with and/or is in tension with other themes of safety. Within this infrastructure construction context, safety culture is one such topic for literature review. In addition, safety leadership is another important factor for review. AR is also included in this literature review because the research question specifically explores an AR based approach as a safety strategy.

Considering the aims of this research, I explore what strategies were used during the PITTA project and the challenges and benefits of applying these strategies. It is possible to form a complete view of safety strategies when all the stakeholders' perspectives are included. The interviews were designed to include all the delivery stakeholders within the PITTA project. Stakeholder theory is thus reviewed for this purpose within this chapter.

Searches were conducted using the works "safety management" and then filtering for AR based and stakeholder theory. The same was done for "safety culture". In both searches I reviewed the list of literature and selected those that had a relation to construction, management, or infrastructure projects. In addition, I reduced the literature list, where possible, to literature dating back to 2000.

Safety leadership was proposed later, and recommended literature was proposed by the viva examiners. It is considered an important introduction to this research paper as it plays a vital part in how safety is influenced and managed. The literature is synthesised in common themes as set out in this chapter, with an analysis section at the end of the chapter.

One aim of this study is to review the existing safety risk strategies that TfL applies. The Office of Rail and Road (ORR), the UK governing body that oversees railway safety performance, examines the safety-risk reducing methods used within TfL. Safety risk management is an approach that is applied within the construction industry to control safety risks. There are two parts of an approach that are used in the intervention for reducing injuries; the actual safety measure and the strategy used to operationalise the measure (Haslam *et al*., 2005). There are five areas that safety measures specifically target; the worker or workforce, the workplace, materials used, equipment to be used and the organisation.

I also examine intervention approaches used in other industry sectors. Safety reducing measures and strategies to reduce incidents used on other construction sectors will be assembled in this review. This study will also explore AR based strategies that contribute towards reduction of workplace injuries.

There are two main reasons why safety risk management is required. One is for control of safety risks and the second is for compliance reasons. Controlling safety risks is essential to the control of loss, incidents, and hazards. Compliance reasons relate to industry standards, laws, and regulations. Our investigation will focus on the control of incidents and how these are affected though the application of AR based strategies. AR based solutions are by nature, action based, and action is developed, planned, and applied in practice by the co-creation of knowledge with a group of stakeholders that are experts in the TfL environment. Action is assessed and adjusted to be applied in the next cycle of action, and this cycle is repeated to generate actionable knowledge and learning loops for TfL.

The literature that is assembled further in this chapter ranges from medical research (Fouquet *et al.*, 2018), specific transportation sectors such as high-speed trains (Bena *et al.*, 2009) and aviation (Lowery *et al.*, 1998). Specific construction sectors are also included, consisting of high-rise building construction (Goh *et al.,* 2016) and the masonry discipline (Kincl *et al.,* 2016). There are additional studies included on a training programme approach for Latino labourers (Williams *et al.,* 2010), a virtual reality approach

for prefabricated construction company (Inyang *et al.*, 2012), a drug-testing programme approach (Altayeb, 1992) and a legislative approach (Aires *et al.*, 2010).
This chapter sets out the types of interventions that exist within the construction industry ranging from legislative, educational, informational, persuasive, facilitative and multifaceted interventions. This chapter addresses the successes and failures with each type and an explication of why some of these measures provide the specific outcomes that they do.

Safety measures target specific construction areas, and strategies are used to implement these measures. There are numerous strategies that operationalise safety measures (Haslam *et al.*, 2005). These include legislative, educational, informational, persuasive, facilitative and multifaceted strategies, where two or more of the strategies are applied. Interventions contribute towards the methods and techniques that support an overall safety management system, and legislative interventions provide a legislative framework (See fig. 2 below). Interventions can also be regarded as barrier mechanisms as shown in figure 1 below.

This literature review follows concepts of safety management systems because this offers a framework for TfL to consider safety as something operating within a wider system. Safety culture is also defined and a framework for this is proposed. Safety culture is included within safety systems because it helps us understand the overarching enabling and enacting organisational behaviours that contribute towards an overall safety culture, which motivates employees to act and take action that leads to successful safety outcomes. Stakeholder theory has also been selected as the theoretical perspective in this study and the design of the research questions was developed using this theoretical perspective. Also, the three different sets of stakeholders that were involved in the AR based approach provide an overall picture and this could not have been developed unless I included the perspectives of all the stakeholders.

KEY CONCEPTS AND DEFINITIONS OF SAFETY MANAGEMENT SYSTEMS

Safety is a concept that is defined as a state free from something that could cause adverse effect, loss, or damage (Li and Guldenmund, 2018). In TfL terms this is a condition where incidents and accidents are avoided. For infrastructure projects, a zero-risk situation does not exist. TfL as with other transportation organisations, seek to reach zero accidents, but that is by no means a zero-risk state. Risk is the product of probability and consequence of a future event (Yoe, 2011, p.1), thus, organisational safety is determined by the level of acceptable risk (ORR, 2017, p.4).

Safety management is a process that is managed by an organisation. The purpose of safety management is to create a state of safety, to protect people, machinery, and assets from unacceptable risk (Li and Guldenmund, 2018). Ivan *et al.*, (2003) define a safety management system as a "systematic process designed to assist decision makers in selecting effective strategies to improve the efficiency and safety of the transportation system." A safety management system as a collection of "necessary actions to discharge

responsibilities under the new age of the delegated responsibility and self-regulation." (Thomas, 2011, p. 3). The UK Health and Safety Act 1974, underpins its philosophy with self-regulation, so to encourage better safety systems, more management involvement, and more participation from employees.

Safety management systems sometimes give rise to two other concepts, namely risk management systems and control systems. Risk management systems are a component of safety management systems but are not the complete safety system. Risk management, however, is a critical component of a safety management system. Control systems are like risk management systems in that they identify risks and assess them. Control systems are typically used to achieve a certain reliability or safety levels. Loss control systems were developed for insurance organisations to minimise personal injuries (Bird, 1974).

As per Figure 1, safety management systems are modelled on three key components, namely, events, barriers, and management elements. Thus, safety management systems should comprise of these three elements. Events are typically modelled on accident models where inputs are captured as hazards and the output is a risk register. Events and barriers are a further addition of accident models where the inputs are risks and the outputs are obstructions to risk. Events, barriers, and management are modelled on management models, where the inputs are barriers and the output is safety performance (Li and Guldenmund, 2018). The relationship of events, barriers and management is depicted in figure 1 below (Li and Guldenmund, 2018, p. 103).

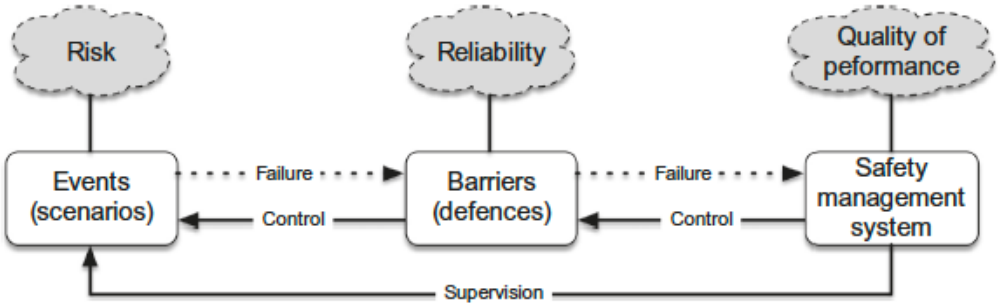


FIGURE 1 - RELATIONSHIP BETWEEN EVENTS, BARRIERS, AND SAFETY MANAGEMENT SYSTEMS
(Li and Guldenmund, 2018, p. 103)

The period between 1970-1990 saw the accident theories as the predominant driver for the development of safety management systems (Haddon, 1973; Smillie and Ayoub, 1976; Nielsen, 1974; Bird, 1974). Adam (1976) proposed accident prevention as a safety management system with the viewpoint that the root cause of an accident is embedded in the management structure.

Since the 1990's, safety management systems adopted a more multi-disciplinary approach. As theoretical models developed, so too did the safety management systems that were underpinned by them. Complex systems were beginning to shape the new thinking about safety management systems. Reason (1990) developed control models that included human factors and information feedback loops. Organisational factors also

began to appear at about this period too, which also informed safety management systems of new methods and techniques. Standards and legislation added to the compliance of safety management systems. Standards also contribute towards the global applied levels of what is acceptable. As per Figure 2, the safety management systems (SMS) are underpinned by theory, supported by methods and techniques, comply with industry specific standards, and checked against audit tools. This is depicted in figure 2 below (Li and Guldenmund, 2018, p. 100).

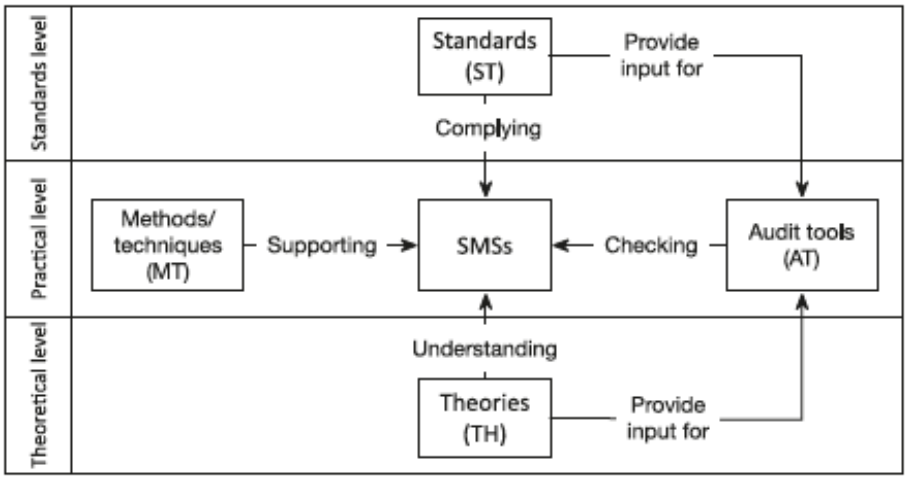


FIGURE 2 - SAFETY MANAGEMENT SYSTEMS RELATIVE TO THEORETICAL, PRACTICAL AND STANDARDS LEVELS
(LI AND GULDENMUND, 2018, P. 100)

Safety management systems are linked directly to this study's research problem. At TfL many methods and techniques are applied to manage safety risks, and specifically for this study we are exploring what lessons can be learnt from applying AR to mitigate safety risks. AR has a theoretical premise, namely, critical theory, and AR is practical applied method. Safety audits are undertaken to collate safety data and the methods promote safety compliance and safety standards as per Figure 2 above (Li and Guldenmund, 2018). The whole system includes a theoretical perspective, a practical application and a compliance to safety standards which defines the TfL safety management system.

KEY PERSPECTIVES IN SAFETY MANAGEMENT SYSTEMS

Safety management systems are developed from accidents and incidents models and how to prevent them. The purpose of developing safety management systems is for control and compliance purposes. Controlling loss, accidents, incidents, and risks are critical to safety management. Control processes typically follow a plan-do-check-act (PDCA) method developed by Deming (1950). The control process is separated into the PDCA components and subsequent processes support the overall control process. Therefore, for planning control, a policy and plan system are developed in connection with information reporting. For the doing phase, operation and risk management processes are developed. For the checking phase, a monitoring system is required and for

the acting phase, a maintenance and learning systems are required. Compliance is an important aspect of safety management systems too. Legislation and standards define safety norms within specific industries, and these can be applied globally and help to benchmark safety performance.

Safety management systems may be seen through a legal perspective. For railway and other guided systems (ROGS). The legislation specific to this area is ROGS (2006) and it defines the legal requirements that railway companies should comply with. ROGS (2006) determines the legal obligations of rail operators. It specifically lists risk assessments which must be undertaken in the pursuit to plan, manage, monitor, and control the works associated with railway operations. If the rail construction work falls outside of the legal frameworks of ROGS (2006) regulations, then the statutory requirements are determined by other legislative mechanisms such as the Health and Safety at Works Act (1974). Thus, there is a legislative compliance perspective associated with safety management systems.

As noted above, safety management systems, can be cultivated from accident and incident models. More specifically, accident and incident data to do with medical perspectives exist. Thus, safety management systems can have a medical perspective. A study undertaken by Fouquet *et al.*, (2018) specifically looks at lumbar-disc surgery (LDS) numbers. The study focuses on a French region and provides data on actual injury numbers and the industry sector of causality. Remarkably for men, the construction sector surpasses other industries and for women, the retail, wholesale, accommodation, and food services sectors are the primary industry sectors. The report explores preventative models. The limitation with the report is that it includes only surgery numbers, which is useful, but does not complete the picture in incident levels. Manual handling incidents within construction in the UK causes significant lost time from injury that does not extend into surgery. Musculoskeletal injuries in the UK construction sector contribute towards sixty five percent of all work-related ill-health in 2017 (Health and Safety Statistics for the Construction Sector in Great Britain, 2017). Nonetheless, Fouquet *et al.*, (2018) study does offer an important medical perspective for safety management systems.

There are several perspectives in safety management systems. One wider set of perspectives can be seen from the three elements that create a safety management system, namely, safety, management, and systems perspectives. A broader set of perspectives of safety management systems can provide valuable perspectives in how safety management systems integrate with rail organisations and the wider framework that they share. Therefore, taking three wider perspectives of a theoretical, practical and a standards perspective as depicted in figure 2, is valuable for this study. AR based approaches relating to this study, contribute to the methods and techniques that we have applied at TfL and the underpinning theory that supports this approach is critical theory (Habermas,1974). These AR based approaches are integrated into an overall safety management system within TfL and this study is concerned with how effective these methods have been in reducing incidents and how we can institutionalise them into TfL.

The theoretical perspective in safety management models typically fall into the three categories of events, barriers, and safety management systems as shown in Figure 1. For this research study, critical theory as developed by Horkheimer (1937), support the notion of critical action research, of which AR based approaches are developed from. This is partly through the contributions of Greenwood & Levin (2007) who combined general system theory and pragmatism to form action research. Greenwood & Levin (2007) argued that action research was about solving real life problems in a way that was collaborative and democratic. This is relevant for this study as a variety of stakeholders were used in the AR based approach to solve real-life organisational problems for TfL.

From a practical perspective, the safety management system needs to incorporate methods or techniques to control risks and have audit tools to ensure the controls are working to prevent accidents and incidents. Hale (2005) developed a generic safety management system framework model that is useful in understanding the logic behind the control systems, see figure 3 below.

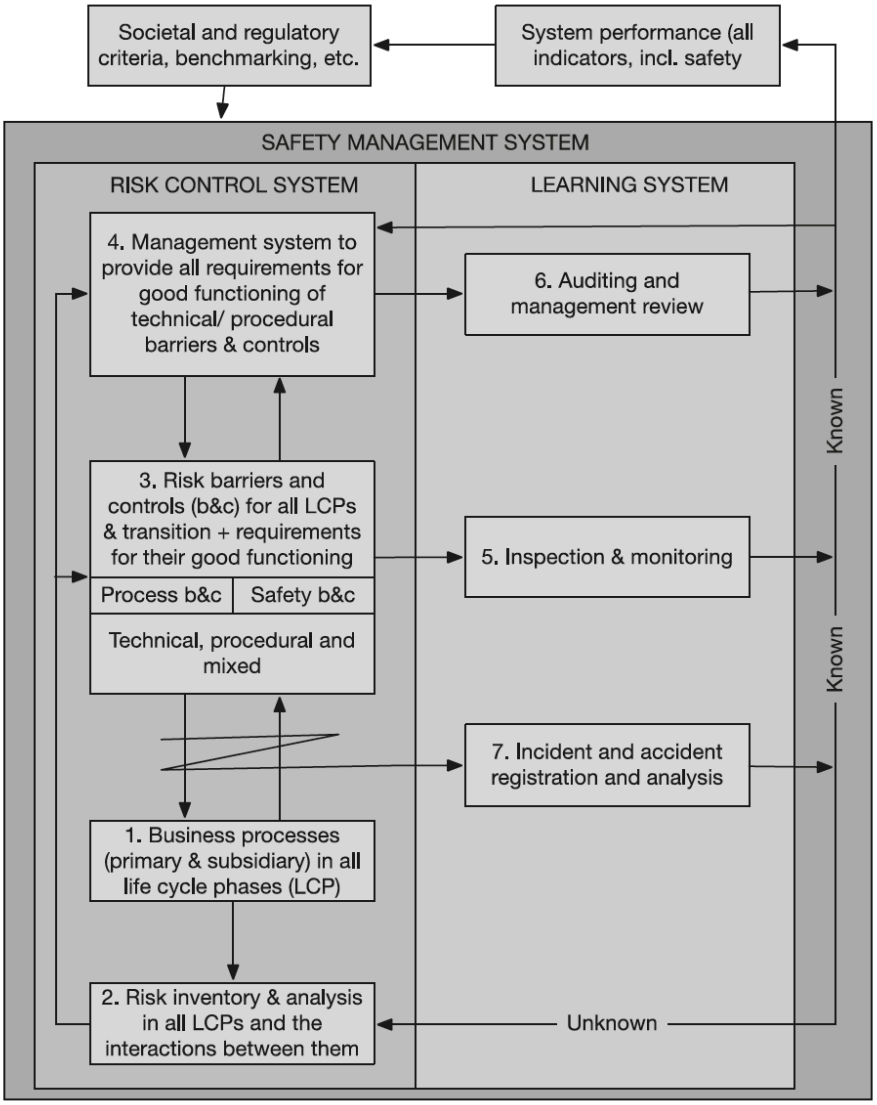


FIGURE 3- GENERIC SMS FRAMEWORK (HALE, 2005)

This study is positioned from a methods and techniques perspective that sits within a practical perspective as depicted in figure 2 above. AR is a practical tool that in our case managed safety risks on a practical level and contributed towards finding solutions that fitted within the overall TFL safety management system. AR based methods also incorporated a learning mechanism. There is limited literature from a practical perspective of AR approaches in controlling and managing safety risks on construction and even more specifically on railway environments. From the extant literature there are couple of research papers that fill the AR knowledge gap within the construction sector; one is by Azhar, Ahmad, and Sein (2010), AR is applied to a data warehouse problem case study and another by Davies *et al.* (2014) where an innovation strategy is developed for the Crossrail project using AR. Only Azhar, Ahmad, and Sein (2010) go as far as evaluating the effectiveness of the AR solutions. Therefore, this study is positioned to contribute towards this area of research.

SAFETY LEADERSHIP

Attitudes towards safety is important in generating the intrinsic motivations and safety culture that sustain any safety aspiration. Five premises influence safety leadership interventions, namely, context, preparation, communication, leadership behaviour and style and action. Safety compliance through standards, processes and advanced management systems can provide an adequate level of safety. Stiles, Ryan, & Golightly (2018) argue that for an advanced safety level, more is needed and suggest improving behaviours and safety culture. Safety compliance alone is not enough, and particularly within the rail construction sector, raising awareness of what good safety leadership looks like is especially important. Stiles, Ryan, & Golightly (2018) specify increasing visibility around safety, involving workforce, recognising good safety performance and effective communications.

Leadership style and method has a direct effect on safety. Employee safety behaviour depends on the level of trust in their leader (Conchie, 2013). The level of trust facilitates the intrinsic motivations that influences the relationship between safety-specific transformational leadership and employee safety behaviours. Intrinsic motivation argues Conchie (2013), through employees' safety behaviours is affected by safety-specific transformational leadership. This style of leadership is related to citizenship behaviours and safety compliance behaviours. Shaping safety attitudes and behaviours is most influenced by the trust in leadership. Hoffmeister *et al*., (2014) further distinguishes leadership types in relation to safety outcomes. Transactional and transformational leadership is linked with positive safety outcomes. Transactional leadership is characterised by three aspects, namely contingent reward, active and passive management. Active management is proactive and focuses on prevention and passive management is reactive and focuses on correction after the fact. Transformational leadership has four distinct facets, namely, idealised influence, inspirational motivation, intellectual stimulation, and individualised considerations.

Safety climate is encouraged through aspirational attributes and behaviours, inspirational motivation, intellectual stimulation, individual considerations, and respective rewards. Hoffmeister *et al*., (2014) research discovers that the most significant safety-climate contributors are idealised attributes and behaviours. Interestingly, active management does not seem to contribute significantly towards safety climate within Hoffmeister *et al*., (2014) findings. Safety participation and compliance is influenced by idealised behaviours and attributes, inspirational motivation, and contingent reward. With regards to leadership attributes that contribute towards injury and pain, Hoffmeister *et al*., (2014) finds that all leadership facets contribute a small amount. A proposed hypothesis that active management will predict injury is not supported within the research inquiry. All facets of transactional and transformational leadership relate to at least one safety outcome except active management. All facets make contributions to safety climate, however only some facets predict safety compliance and participation, and no facets predict injury or pain. In contrast to Hoffmeister *et al*., (2014) research findings, Grill et al., (2017) find that active transactional, rule orientated and participative leadership in conjunction with transformational leadership does predict positive safety outcomes. Grill et al., (2017) use a comparison between Sweden and Denmark to establish these findings. Occupational accident rates are significantly lower in Sweden than in Denmark and the research uses surveys to establish these findings, over eighty-five sites. A laissez-faire leadership approach was found to be detrimental towards safety outcomes. Rule-orientated leadership is found to be positively associated with worker behaviour only in conjunction with participative leadership. In order to increase safety behaviour amongst construction workers, organisational enforcement of rules by site managers is best served with the collaboration of construction workers.

Supervisor engagement in safety leadership is crucial in relation to safety outcomes. This is an area that has been underexplored (Conchie, Moon, & Duncan, 2013). Identifying contextual influences on supervisors' safety leadership behaviours, Conchie, Moon, & Duncan (2013) find that role overload, production demands, formal procedures and workforce characteristics can hinder supervisors' commitment to safety leadership. Role overload negatively affects the supervisors' ability to engage in safety leadership. It is associated with reducing the time spent on site to observe what is really going on. Production pressure due to poor planning, adverse weather can cause pressure to complete the work, and spend less time in mentoring and coaching and more time on completing the work. Workforce characteristics and specifically subcontractor safety attitudes, language barriers and inadequately skilled workforce will appear in behaviours such as resistance to safety. Supervisors are more likely to become frustrated and adopt a more directive approach as opposed to a consultative, leadership one. In contrast social support and autonomy promote safety leadership. Social support is an important moderator of role demands (Törner & Pousette, 2009). Social support includes helpful safety resources. Three reasons explain supervisors' engagement in safety leadership. Firstly, it conveys the message that safety is a top priority and something that is expected from supervisors and part of their role. Second, the support equips the supervisors with necessary skills and knowledge to lead on safety. Thirdly, the support increases employee's safety awareness and attitudes and consequently their receptiveness to supervisors' safety leadership behaviours. Conchie, Moon, & Duncan (2013) also find that

work demands negatively affect leadership behaviours when they are interpreted as a hinderance, but also positively affected these behaviours when they were perceived as a challenge and when they improved personal growth. Fang, Wu, & Wu (2015) find that the impact of the supervisors on worker safety behaviours in construction projects is most profound as they have the most interaction with workers and all levels of management.

Supervisory behaviour is regarded as having two dimensions, namely, training and preventative action and secondly, reactive and supportive action. Conchie, Moon, & Duncan (2013) study finds that reactive and supporting action has a direct impact on worker safety behaviour but not on safety climate. However, training and preventative action can influence element of safety climate, thus, improve safety conditions in a more sustainable and profound way than reactive and supporting action. Training and preventative actions of the supervisor has indirect effects on worker safety in workmate influence, supervisor environment and worker influence. Workmate's influence directly effects worker safety behaviour as it enhances safety behaviour. Caring for workmates and oneself is an important factor in safety behaviour.

Safety is inextricably linked to risk so reducing safety risk improves the overall safety outcomes on a project. Xia et al., (2018) provides a unique perspective in linking and integrating construction risk management with stakeholder management in a way that promotes the effectiveness of both. Risk management in construction is dominated by the multiplication of probability and severity. This output provides a measure of risk, however there is a missed opportunity to find the positive aspects of risk in terms of both stakeholder and construction perspectives (Xia et al., 2018).

There are two broad approaches in stakeholder management, a broad, all-inclusive approach (Freeman, 1984) and a narrow approach (Clarkson, 1995). Within the construction sector a broad stakeholder approach best fits according to Yang *et al.*, (2014) and Xia *et al.*, (2017). They argue that neglecting certain stakeholders can have detrimental effects on construction projects where there is typically a large diverse group involved. Furthermore, Xia et al., (2018), nominate four modes where risk and stakeholders could make links. The first link is management of risk, based on stakeholder identification. This link describes how management of project stakeholders, especially relevant stakeholders and potential threats can formulate risk response strategies. The second link is internal stakeholders' responsibility and ability in the RM process. This mode explores how internal stakeholders can find ways to manage risks. The third mode links management of stakeholder differences concerning risk. This mode concerns itself with risk perception and risk-based decisions. Discrepancies can occur within internal stakeholders and in addition, within internal and external stakeholders. The fourth mode connects the interrelatedness between risk and stakeholder management. This mode is concerned with the effects of risk management processes on stakeholder management outcomes and the combined processes of both on project performance. Xia et al., (2018) study proposes a new way to enhance the reduction and management of project risks by integrating stakeholder management and risk management.

Safety leadership is important for addressing the research problem of this study. AR is applied during the TfL PITTA project, and we are collating the lessons that can be learnt for this AR approach. SLT, PLF and AR action teams are directly influenced of the type of leadership that is applied through these mechanisms that provide safety outcomes. Moreover, supervisors on site play a significant role on how effective the AR solutions are in application. Understanding the mechanisms that enable the AR solutions to produce sought-after safety outcomes is linked to how leadership and safety are connected and applied.

KEY CONCEPTS AND DEFINITIONS OF SAFETY CULTURE

Safety culture is not easily defined and explained, because there are many definition variations and perceptions of safety culture. There are perspectives that offer a learning situation where employees are faced with resolving safety problems and evading negative outcomes (Schein, 1974) and then there are the top-down perspectives where safety culture is formed by the overarching organisational strategy and the existing system for managing safety within an organisation (Glendon and Stanton, 2000). Both offer valuable descriptions, but they fall short of explication how employees become engaged and stay motivated in adopting assumptions, values and norms warn Bisbey *et al.* (2021).

Cooper (2000) pushes towards a model of safety culture and by drawing from Bandura (1986) reciprocal determinism model. This concept is further supported by Davis and Powell (1992) whereby they note that people exist in a state of mutual determinism with their environments and where their environments impact one another in a perpetual and dynamic way. See Figure 4 below:

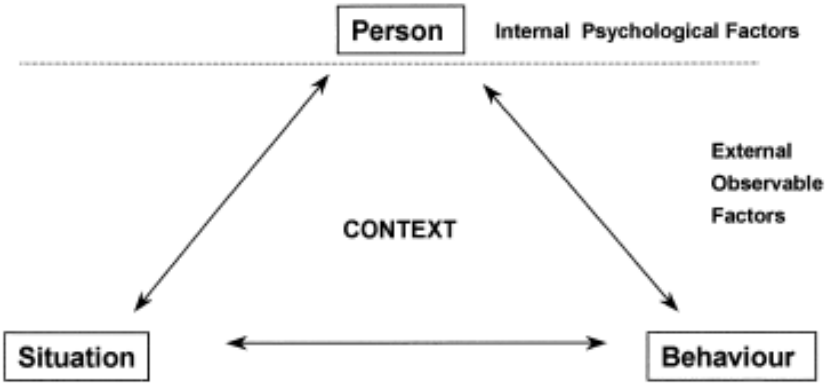


FIGURE 4 – BANDURA (1977A, B, 1986) MODEL OF RECIPROCAL DETERMINISM

The model above offers a basis for a framework for analysing safety culture as adapted by Cooper and Phillips (1995) in figure 5, below. The models contain three elements, namely, psychological factors, observable safety-related behaviours, and objective situational context. In the model below, internal psychological factors can be assessed through safety climate surveys, which relate to perceptions and attitudes. Behaviours are measured through behavioural safety initiatives and situational elements can be assessed through safety audits and inspections. Thus, safety culture can be quantified in a way that

is meaningful and useful. In addition, a triangulated group of measurements provide measurements that are not solely dependent on incident and accident data, and multi-level analysis can be undertaken to establish where cause and effect links exist.

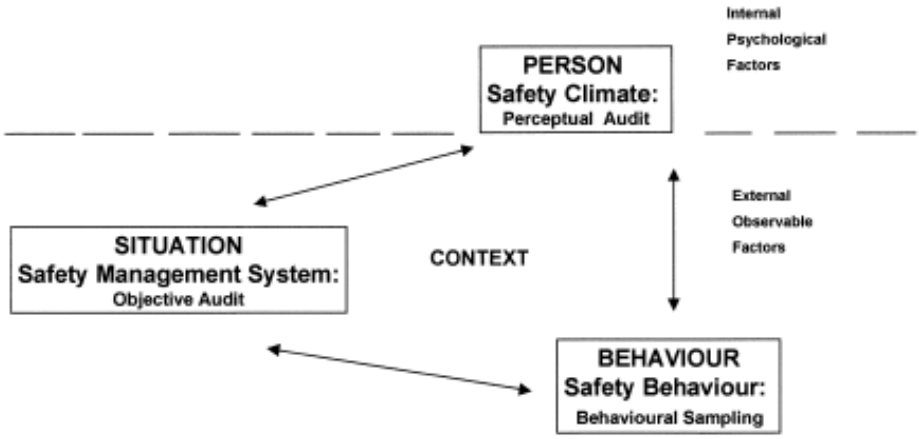


FIGURE 5 - COOPER AND PHILLIPS (1995) MODEL OF SAFETY CULTURE

Another model of safety culture developed by Schein (1992) depicts three layers comprising of core underlying assumptions, espoused beliefs and values and behaviours and artefacts. Similarly, Guldenmund (1998), depicts a model consisting of assumptions, declared beliefs and values that are operationalised as attitudes and behaviours and artefacts. Both the models above offer some validity to safety culture but fall short in capturing the dynamic nature of culture. This is because of the linear sequence that they follow. Assumptions dictate peoples' beliefs and values and in turn affect peoples' behaviour and artefacts that in turn, reflect, core assumptions. Cause and effect models have been shown to be inadequate, and Bandura (1986) demonstrates above that changing behaviour can and often does change people's attitudes and perceptions. Reason (1997) proposes a safety subculture based on organisational culture. A unit of safety culture should include all three aspects of culture, namely psychological, behavioural, and situational variables.

Cabrera and Isla (1998) examined reciprocal influences between methods, where safety climate versus ongoing safety related behaviours were examined. They found that bias such as social desirability responses skew the results. To combat this problem, they argue, a longitudinal research design is required. Doing so would highlight whether it would be better to change attitudes or focus on safety related initiatives.

More recent research undertaken by Bisbey *et al.* (2021) undertake a review of safety culture models and propose seven enabling factors that create conditions to adopt safety culture and four behaviours to enact them. Bisbey *et al.* (2021) report emphasises the point that recent theoretical models are poorly connected to the traditional organisational models and offer that safety culture is composed of three layers. A top, superficial layer is composed of norms and artifacts. Signage, collective behavioural norms, practices, and procedures developed over time from learning from experiences. A middle subsurface layer relating to values and the value of safety and engaging in safety performance. Guldenmund (2000) notes that values are implicit in nature but become

explicit when being expressed on attitudes and perceptions. Attitudes and perceptions collectively can be regarded as safety climate. Within the centre is the core layer, where assumptions about the basic realty at work are held.

Bisbey *et al.* (2021) note research undertaken by Schein (1984) and Glendon and Stanton (2000) on safety culture. Schein (1984) postulates that culture is developed through learning situations, and Glendon and Stanton (2000) suggest that safety culture is shaped by the business strategy and the existing system in place for managing safety. Although both offer valuable perspectives, they do not explain how employees become engaged in adopting assumptions, values, and norms.

People make sense of their realities by categorising and creating rules for social groupings (Turner, 1999). Social identity theory (Tajfel and Turner, 1986) suggest that when individuals perceive that they belong to a group they reduce the uncertainty around how to feel and act by developing and refining assumptions. Through self-identification, employees define their self-concept to be based more on group characteristics than on personal ones. The notion of self-concept exists on a subconscious level, and it determines what a person should think, feel, and do. Social identify is a part of self-concept where assumptions and expectations are held and facilitated by consistent feedback. Shared experiences are further enhanced by organisational strategy and safety management systems, which influence safety culture (Glendon and Stanton, 2000). Enabling factors allow employees to assume appropriate norms, values and assumptions and create conditions for safety culture to develop over time (Vogus *et al.*, 2010).

Enabling factors fall into three categories, namely, organisational, group and individual factors. Organisational enabling factors consist of leader commitment and prioritising safety and policies, in addition to resources for safety. Group enablers comprise of interpersonal and social factors. These factors influence norms, values, and assumptions. Specific group enabling factors include cohesion and psychological safety. Cohesion is defined by the individual commitment to the team and its goals, in addition to valuing the teams' values (Beal *et al.*, 2003). Cohesion is central to positive relationships and the support of one another in a team. Psychological safety allows members to take interpersonal risks (Edmondson, 1999), by freely speaking about errors and a non-punishing approach to reporting. This in turn encourages an open and transparent approach to changing safety culture. Individual factors include safety related knowledge, a sense of control and an individual commitment to safety. Safety related competence is linked to being able to identify safety threats and the ability to be able to deal with them. Safety knowledge is also related to defining the role of a safety manager and knowing what to expect (Reiman *et al.*, 2010). Employees have a greater tendency to act if their actions relate and connect to safe outcomes, and this provides a sense of autonomy and empowerment. Promoting a positive safety attitude is underpinned by the commitment of employees towards safe working practices and the priority of safety goals over other goals. Guldenmund (2007) highlights that this employee commitment encourages engagement in safety related matters. Please note figure 6 below, depicting the enabling factors.

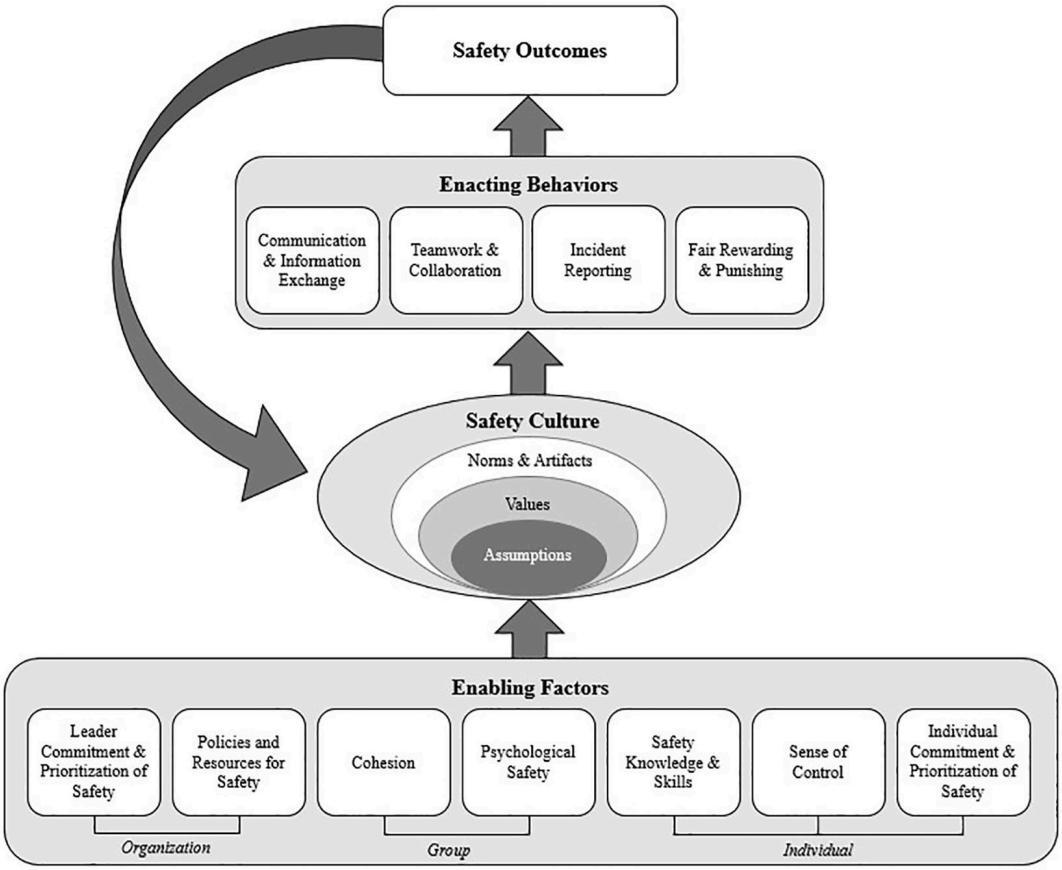


FIGURE 6 - SAFETY CULTURE MODEL (BISBEY ET AL., 2021)

Enacting behaviours run concurrently to enabling factors to ensure that safety culture is turned onto actions. According to Bisbey *et al.,* (2021), there are four enacting behaviours in safety culture. Communication and information exchange enables learning and growth, which is critical to safety culture (Argyris, 1994). In addition, sharing safety issues and involving employees in discussion on how safety issues are resolved enhances psychological safety. Teamwork and collaboration generate positive results on safety outcomes (Hughes *et al.,* 2016). Teamwork processes are the observable behaviours that teams enact whilst collaborating towards task goals (Marks *et al.,* 2001) and safety culture is delivered through teamwork and collaboration. Incident reporting refers to the notification of others when an error or near miss occurs that has safety related consequences. Incident reporting is also important for organisational learning (Reason, 1997). Risk factors that threaten safety can only be identified by employees with critical safety skills who appreciate the importance of safety. Bandura (1986) emphasises the importance of rewarding and punishing in relation to learning effective behaviour, which is turn is modelled by others in an organisational context. Bisbey *et al.,* (2021) stress the significance of enacting behaviours because they create normative behaviours over time which in turn supports safety culture. Safety culture is constructed and reinforced through individual employees and enabling factors contribute towards the development of assumptions, values, and norms over time. Enacting behaviours result in safety outcomes which reinforce collective assumptions, values, and norms in relation to safety.

MANAGING RISKS ON CONSTRUCTION PROJECTS

In this section, I review safety risk management and how AR may be applied on construction projects. I shall also review how safety risks are handled within other construction sectors. Since this research is exploring strategies that may have been used to reduce workplace injuries on construction projects, we could learn from other construction areas that have approached this problem previously.

PROBABILISTIC APPROACH

Large engineering projects and construction sites typically deal with risks in a probabilistic and statistical way. In order to establish risk profiles, managers consider work activities in uncertainty terms. Miller and Lessard (2001) and Mills (2001) develop this notion of uncertainty in terms of outcomes and causal effects. If outcomes and causal effects are not fully understood, then there is a measure of uncertainty. It is not uncommon to have uncertainty on engineering construction projects, in addition, the construction site is an ever evolving and complex system (Mills and Lessard, 2001). The literature points out two distinct methods for managing risk. The probabilistic approach and the risk management approach. If the risks are endogenous, Mills and Lessard (2001) prescribe a decision theoretic approach. If the risks are emerging or turbulent then a risk management approach that manages risk drivers is nominated by Mills and Lessard (2001).

Within TfL, probabilistic approaches have been used and are being used. Given the data shown in the introduction section there is a rising increase of incidents over the last five years within London Underground infrastructure projects. This leads one to question the effectiveness of current methods and the possibility of applying new strategies to reduce safety incidents. Risk assessments are a legal requirement when undertaking construction projects and there is validity in identifying key risks that are risk profiled. Thus, it is likely that a synergistic strategy is sought, where AR could be a strong contender.

SYSTEMATIC APPROACH

Mills (2001) proposes a systematic approach for emerging risks. Mills (2001) promotes a more controlled and structured way to addressing emerging risks. The systematic approach starts off by identifying the major risks associated with the project, then makes provisions for adversity with controls and mitigations in place, formalises the roles and responsibilities of stakeholders and explores any potential opportunities that may arise from specific risks. A specific area of concern (Mills, 2001) with regards to project risks are those risks that cannot be covered by insurance. Risks such as investigations, fines, legal costs, production delays and loss of expertise might not be covered by insurance. For this research, these uninsured risks are an area of concern because a loss in expertise, for example, may lead to workplace injuries. Thus, the question arises as to how to manage these types of risks on construction projects so that workplace injuries are reduced.

Dougherty (2016) promotes the management of emerging risks through collective deliberation. Complex systems exhibit a characteristic of emerging risks, so Dougherty's (2016) approach is applicable. There is a comparison to this notion as with the AR

approach because both approaches offer a collective deliberation and a diagnostic element.
Systematic approaches are used within TfL. The data shown in the introductory section above demonstrates that over the last five years incident levels have been on the increase. One may question the effectiveness of systematic approaches within TfL. Thus far, whatever approaches have been used there are still increases of safety incidents within the last five years within London Underground infrastructure projects. In addition, the safety management system noted in the previous chapter (figure 3.) incorporates several elements that come together to form the management system, namely, the risk control system and the learning system. This research is limited in that it does not aim to redesign the entire safety system, it is the aim of this study to find ways to improve the system with strategies that integrate well within the existing safety and risk management systems. Working on a live operational transportation can be detrimental to the overall system if change is not controlled well, and it is the aim of this study to explore how diagnostic, collaborative approaches, with purposeful planned actions and learned outcomes can offer effective solutions in reducing safety risks and subsequently, reduce incidents. Thus, action research is positioned well within this framework, in that it has diagnostic and collaborative aspects, that lead to planned actions and followed by learning loops to further advance solutions to this end.

AR BASED TYPE APPROACH

Complex infrastructure projects exhibit emerging risks that need to be managed, thus, AR becomes an appealing approach in managing these risks. In conjunction with Azhar, Ahmad, and Sein (2010) ideas in solving workplace problems in a practical way, AR becomes a strong contender in providing a strategy for identify emerging-risks and especially those that have a workplace injury potential to workers. Dougherty (2016) develops further the proposal that may help organisations in developing and enhancing innovation. Namely, abductive reasoning, the process of proposing that something may be, underpins the approach. In complex systems, where knowledge is fragmented, organisations should embrace emerging themes with collective learning to produce innovative solutions to solve complex problems, Dougherty (2016) argues.
Azhar, Ahmad, and Sein's (2010) highlight some challenges that AR may pose, such as collaboration. Collaboration initially, may be perceived as a positive trait, but it also introduces an element of risk in that the research can potentially lose its initial intended course and it would be difficult to control. In addition, collaboration comes with a risk of conflict. Azhar, Ahmad, and Sein (2010) provide specific pitfalls within AR, and that is the formation of evaluation criteria. The evaluation criteria are vital to the validity of AR approaches. There are five principles that AR should be evaluated on, namely the principle of researcher-client agreement (RCA). The RCA should provide mutual commitment and role expectations. The purpose of cyclical process model (CMP), where the process of diagnoses, action planning, action taking, evaluating and being specific about learning are demonstrated. Thirdly, the principle of theory, where the theory should play a central role in the research. Fourthly, the principle of change through action, there AR must demonstrate change through action. Finally, the principle of learning through reflection, where AR allows theoretical and practical contributions to be made (adaptation from Davison *et al*. (2004)).

"AR allows researchers to perform systematic investigations to seek solution of problems experienced by practitioners or to examine the effectiveness of proposed frameworks. For example, based on theoretical concepts, Ahmad and Sein (1997) developed a framework to implement Total Quality Management in construction project teams. The only way to validate their framework is through AR. In short, AR is particularly relevant in solving construction industry problems that require innovative and untried solutions. Such solutions are inherently risky and thus go against the grain of the construction industry that assiduously seeks to avoid risk." (Azhar, Ahmad, and Sein, 2010, p. 97)

As Azhar, Ahmad, and Sein's (2010) note above, that untried or untested solutions is part of the inherent design of AR. A great deal of skill and experience is required in in mitigating risks during testing new ideas. Trial and testing, untested solutions on railway environments and construction sites is risky and offers a specialism of its own. Even though AR offers possible solutions, one must be cognisant of the inherent risks of testing untried solutions.

Many risks within TfL infrastructure projects can be defined as emerging risks. This is due the risks being identified and profiled prior to the construction phase. Safety experts must make assumptions as to how the construction sites will be constructed and at what stage these activities will occur. Therefore, there is always an inherent risk that the assumptions will be different than initially envisaged thus changing the potentials for risk. There are methods that deal specifically with this potential shift, namely, dynamic risk assessments and point-of-work risk assessments. However, the point about emerging risks, in my view is important because AR based approaches deal with this element well (Azhar, Ahmad, and Sein, 2010).

SAFETY RISK INTERVENTIONS

Within the construction industry and specifically related to safety, the way risks are mitigated broadly fall into five categories of intervention according to van der Molen *et al.* (2018). Namely, legislative, educational, informational, facilitative, and multifaceted interventions.

EDUCATIONAL INTERVENTIONS

Educational training methods and how this approach reduces workplace safety incidents as explored in as Bena *et al.* (2009) study. Their research context is set within a European high-speed train, railway-construction environment. Post, initial basic-safety training the workplace incidents reduced by sixteen percent, and a twenty-five percent post a further specific-safety training. However, these results were not corrected for a time series model initially and once this correction was applied, a six percent reduction was produced (van der Molen *et al.*, 2018). This is not a significant reduction in workplace injuries. Nonetheless, there is a small indication that training may have potential benefits in safety incident reduction. Goh *et al.* (2016) also provide literature on a training and an awareness approach for operatives involved in high-rise construction projects in Malaysia. Their report is successful in detecting causality of accidents, predominant accident types and

the dominant methods of prevention used. Where the research fails, claim the authors, is linking the effectiveness of the prevention method to actual incident numbers and if there is any effect in reducing these safety numbers at all.

The Italian high-speed rail project (Bena *et al.*, 2009) undertook an educational intervention in Italy that consisted of a two-hour safety briefing session targeted at the organisational and worker level. Bena *et al.* (2009) concluded that the educational intervention had a modest positive effect in decreasing injuries using ITS analytical methods. This contrasts with van der Molen's *et al.*, (2018) own analysis of the data and adjustments made for bias. Their findings concluded that there was no significant initial or sustained reduction to injury rates. Sowah *et al.*, (2018) corroborate this finding in research that seeks to measure the effectiveness of educational intervention in the reduction of lower back pain (LBP) incidents. Their findings suggest that physical and exercise interventions with or without educational interventions are effective. The report claims that educational interventions fail to consistently provide effective reductions in LBP incidents. Educational interventions alone provide an inconclusive result in the reduction of workplace injuries.

A study undertaken in 2018 from a medical perspective that specifically looked at lumbar-disc surgery (LDS) numbers within a French region. The report undertaken by Fouquet *et al.*, (2018) provided data on actual injury numbers and the industry sector of causality. For men, the construction sector trumps over other industry sectors; for women, the retail, wholesale, accommodation, and food service sectors came first. Although the research includes surgery numbers and omits non-surgical injuries it is a useful to note that the research considers the injury numbers significant and pinpoints to the construction sector as a high-risk area for men. The report also looked at a preventative efficiency index using hypothetical models of which work-centred and personal and work-centred interventions as prevention methods were explored. For the construction sector the prevention intervention methods using these models reduced the LDS numbers slightly.

LEGISLATIVE INTERVENTIONS

Aires et al. (2010) evaluate the legislative effects on organisations within a European construction context on non-fatal injuries. Ten European countries collected data and analysed the data using an interrupted time series (ITS) method. It may be the case that legal interventions could reduce injuries and Aires et al. (2010) state that there was an overall ten percent reduction in incident rates. In contrast, van der Molen *et al.*, (2018) is critical of this finding having undertaken a meta-analysis of the data collated in Aires' *et al.* (2010) report and adjusted for bias. Their findings were that there was an insignificant reduction in fatal and non-fatal injuries. Therefore, there seems to be mixed results relating to legislative interventions and in reducing workplace injuries.

Specifically, for all UK construction projects, Construction Design and Management (CDM) 2015 regulations apply to all construction type activities. Several iterations of CDM have been developed since 1994, when these regulations were first introduced. In addition to CDM 2015, the Health and Safety Act 1974 and the Management of Health and safety at Work Regulations 1999, provide the legislative framework that UK construction work must comply with. Beal (2007) disagrees that CDM regulations have been effective in reducing accidents or major injuries but provides a contrasting view on the Health and

Safety Act of 1974. The author argues that designers, as defined within the CDM regulations are not best placed to reduce workplace accidents and proposes that contractors are better positioned for this purpose as they are the ones who send the operatives to sites to undertake construction work.
Effectiveness of legislative intervention is complex to measure. CDM 2015, for example, legislates that the contractor shall produce a risk assessment, which is a process of identifying risks and applying site controls and mitigations to lower the risk profile of specific activities. Thus, unless a multi-variate analysis of the legislature, is undertaken, isolating risk assessments over a time period and over multiple projects how would one actually measure the contribution made by this specific aspect of legislation. That should not deter researchers to search for methods and strategies to reduce workplace injuries. Haslam *et al.* (2005) determine that significant contributory factors in construction accidents have to do with deficiencies in risk management. Risk assessments is one specific tool used to manage risk. The point that in the UK it is a legislative requirement may deter contractors to not undertake risk assessments, however, measuring how much legislation contributes towards reducing accidents is difficult to prove.

INFORMATIONAL INTERVENTIONS

Informational and persuasive interventions introduce new knowledge into the workplace. With new knowledge comes the potential to cause changes that may contribute towards reducing injury rates. Haslam *et al.* (2005) highlight a point about safe systems of work (SSOW) and risk assessments (RA). Assessing risks and ensuring mitigations are implemented on worksites ensures the risk profile for risky activities is reduced and controlled. Van der Molen *et al.*, (2005) studies the implementation of an ergonomic intervention for bricklayers, where there were no statistical correlations in injury reduction, even though productivity had increased. Van der Molen *et al.* (2018) found no acceptable level of quality data to analyse for these specific interventions. This does not prove that these interventions have no effect, and Haslam *et al.* (2005) goes some way to explicate that risk assessments undertaken as a paper exercise result in poor control of risks which can impact work activities. Moreover, Haslam *et al.* (2005) note that poor RA contributes to a significant root cause of construction accidents. In my twenty-five years of being involved as practitioner of construction engineering projects, the proper undertaking of a safe system of works and a risk assessment is critical in managing safety risks. In my view, if the mitigations and work practices are pragmatic and are executed as per the controls prescribed within these documents (SSOW and RA), this method is effective, in practice. What would add validity to this argument is to corroborate this notion with observational data.

FACILITATIVE INTERVENTIONS

Van der Molen *et al.* (2018) provide some interesting results on facilitative interventions where (Wickizer, 2004) offered a reduction in workplace injuries through a drug-free workplace programme. The statistical analysis showed a significant reduction in injury rates, both in the initial implementation and in sustaining these injury reduction rates. Altayeb, (1992) also provides a study that implements a drug-testing programme. The

research showed no statistically significant reduction in this intervention. Rubio-Romero *et al*., (2015) evaluate a facilitative intervention, which provided subsidies for construction companies in Andalusia, Spain. The subsidies encouraged the purchase of new scaffolds. The analysis demonstrated a reduction in accidents over the period of 2009-2011. Van der Molen *et al.* (2018) interrogated these findings and although the initial findings showed a reduction in accidents, a follow-up on the companies studied did not reveal a sustained reduction in accidents. The findings on facilitative interventions seem to reduce workplace injuries but more research is required to determine the sustained reduction of accidents from these types of interventions.

MULTIFACETED INTERVENTIONS

Interventions that seek to utilise two or more methods are classified as multifaceted interventions. Van der Molen *et al.* (2018) study three independent, multifaceted-approach research papers. Both, the initial and sustained findings in reducing injuries showed mixed results. Some studies found an initial reduction but no sustained, whilst others showed no significant statistical reduction to injury. Van der Molen *et al.* (2018) also interrogated the availability of secondary data such as lost workdays, however, this data was not available for analysis. The authors confirm that facilitative and multifaceted interventions might offer some improvements in the reduction of injuries, but the quality of data needs to improve through further research.

We know that injuries, both fatal and non-fatal, within the construction industry are a major problem (Atique 2012, Bentley 2006, Haslam 2005 cited in van der Molen *et al*., 2018). We also have a framework to work from that sets target areas within the construction sector (Haslam *et al.*, 2005). In addition, we have a framework of application that includes safety measures which work in combination with strategies that are used to implement these measures. These strategies are the mechanism for implementation. We also know from the literature that based on the theory and models it becomes essential to define the indicators that are designed for assessing the function of the intervention to establish the effectiveness of the intervention. Van der Molen *et al*., (2018) stress the importance of measuring worker's behaviours in conjunction with injury data as this strengthens the evidence case for interventions. The literature also underscores the importance of the quality of data in the pursuit of evaluating the effectiveness of an intervention. Repeatedly, we see interventions beginning to show some potential for being effective but lack the quality of statistical evidence. Van der Molen *et al*., (2018) confirms that further research is required to define indicators to evaluate interventions, include behavioural indicators for the interventions, develop the variables to evaluate effectiveness of interventions and testing the connection to behaviour with changes to the main outcomes from interventions.

This research study explored how an Action Research approach can be applied as one such strategy with the aspirations to reduce workplace injuries. The potential with AR based strategies is that the method can also seek to discover and test measures and define target areas for intervention, and indeed determine which intervention is most suitable for the specific problem. As such AR encompasses an overarching strategy in interventions because the action undertaken is designed in a way that informs and

educates the participants in the best next steps to take for further action, whilst setting from the outset the primary aspiration to reduce injury rates.

SAFETY MANAGEMENT MODELS FOR UK RAIL PROJECTS

The ORR (the UK's Office for Road and Rail) is a government body whose role is to regulate the economic and safety elements on UK railways. The legislation applied to UK railways falls under statutory instruments defined as ROGS (The Railways and Other Guided Transport Systems (Safety) Regulations 2006). The ORR is responsible for sustaining the health and safety efficiency and performance of the rail industry. This is done by encouraging the rail businesses to manage health and safety well by identifying and assessing risks properly, by controlling the risks effectively and by complying with legislature. ORR encourages rail businesses through enabling the appropriate culture, management of health and safety, and risk controls. (RM3, 2019).
ROGS (2006) points out the legislative requirements that railway companies should adhere to. ROGS (2006) part 3, general duties, details out the duty of operators in undertaking risk assessments and moreover to plan, monitor, implement, control, and review arrangements developed out of these assessments. If the construction work falls outside of these regulations, and there are some exceptions, then the risk assessment legislative requirement is covered by other statutory instruments such as Health and Safety at Works Act (1974).

The ORR and RM3 (2019) risk management model uses maturity risk models, starting with an ad-hoc approach, through to excellence. In between these extremes we have managed, standardised and predictable maturity levels. The model looks at five broad safety areas and then further divided into twenty-six specific areas of business. Organisations will have a variety of maturity levels within the twenty-six areas of their businesses. The HSE (Health and Safety Executive), another governing safety body, works alongside the ORR. HSE published a risk management model in 2013, of which the RM3 risk management model is based. Namely, the PDCA model, which is an acronym for plan, do, check, and act model (HSE_HSG 65, 2013)

The risk management model (RM3) develops maturity through the collection of evidence. Consistency, quality, and time of evidence collection is assessed when data is sourced. An average is sought so that maturity levels can be established for all twenty-six categories within the business. The "here and now" is compared to "what excellent looks like" and improvement plans are drawn up for each part of the business to improve performance in managing risk. The twenty-six categories are divided more broadly into five sections, namely, safety policy, organisational control, competence, and co-operation, planning and implementing and monitoring.

Safety policy has to do with how the business is led and governed. It should make explicit the expectations from top level management and exactly how it expects to achieve these

aspirations. The leadership should act in a consistent way that reinforces the safety policies of the organisation. Organisational control set out roles and responsibilities for personnel to achieve the business' safety objectives. Having controls in place are a mechanism for managing risk. This control is achieved through defining roles for management and supervision and setting up an organisational structure that aligns with responsibilities, accountabilities and ensures that there are no control gaps.

Competence and co-operation aspects within a business ensures that there are the correct competencies within the organisation. The purpose of this is to ensure that the controls and activities within the organisation are achievable. Through worker engagement, rail safety policies are more effectively achieved.

Planning and implementing risk controls is critical in risk management within rail environment projects. Controls measures are put into place as a practical way of managing site risks. Risk controls provide a structured, and controlled method of achieving legal compliance. In practical terms, risk controls are determined though several methods, namely, the risk assessment method, planning, safe systems of work, change management, supplier control and management and emergency planning.

Risk assessments are undertaken prior to any work activities being undertaken. Hazards are identified and a risk profile for each hazard is developed, leading to a proposed mitigation control and a subsequent residual risk profile developed with the controls in place. Safe systems of work are developed to make explicit the methodology to be applied in undertaking specific tasks safely. In addition, emergency planning and preparedness is important, and it ensures that foreseeable emergencies have a plan of recovery.

Finally, risk management is effective when there is appropriate monitoring and audit involved. Monitoring ensures that risk controls are in place and working correctly. Monitoring and audits also provide a feedback loop to the organisation to learn from existing conditions and make appropriate adjustments and improvements. Aside from risk controls, monitoring seeks to interrogate whether the prescribed safe system of work is being followed. Monitoring is a vital aspect of safety and risk management. Improvements are made through corrective action reports, safety investigation reports and planned safety inspections.

Given that this RM3 model has been implemented for several years now, one could argue that change takes time to form. Thus, the findings of the RM3 assessments would take time to make changes to the organisation and indeed to provide evidence that incident levels are decreasing. To date this has not been the case within London underground infrastructure worker incidents (see chapter 1). RM3 could be perceived as a safety management system, as depicted in figure 2. above, where the theoretical framework is the based on the PDCA (plan, do, check and act) model (HSE_HSG 65, 2013), and the methods and techniques are fleshed out within the twenty-six sections of the RM3 model. It is also governed by safety standards and legislation. RM3 is the safety management system, and this study does not intend to unravel the system. It would be too risky to do

so. The aim of this study is to explore how AR based approach can complement the existing RM3 system, and to highlight challenges that could be improved. AR based approaches are diagnostic and take action to solve specific problems within organisations and teams, so the auditing methods of the RM3 model could indeed be used to provide initial information to highlight areas within the organisation that need to be enhanced, and AR based approaches, can provide a method to yield practical solutions, that are tested, implemented, and improved over time. This study did not use RM3 information as the data was not available at the time to do so, but as a practitioner, I can gauge that this is a strong synergistic possibility. This does not discount the value that AR based approaches can offer organisations such as TfL, and this study aims to explore how effective AR based approaches have been in reducing incident levels.

CURRENT MANAGEMENT OF TFL PROJECT RISKS

Within TfL, projects apply a project management model framework, developed for all TfL projects. This framework is called Pathway. The Pathway process is initiated by a tool that ascertains complexity, value, and novelty amongst other project elements to determine a suite of documents that should be applied. These documents are created and developed over time, to meet the safety and legal requirements of working within a rail environment. Pathway is underpinned by the legal framework of CDM 2015, and standards that govern our environment as set from the ORR (Office of Rail Regulation). Part of this Pathway process deals with how project risks should be managed and controlled. Essentially, the project progresses through peer gate-reviews. These gates are numbered from gate 1 to gate 6, namely gate 1 is outcome definition, gate 2 is feasibility, gate 3 is conceptual design, gate 4 is detailed design, gate 5 is delivery and gate 6 is close out and handover. The TfL business realises organisational benefits after gate 6. This includes the benefits to TfL passengers and/or the TfL organisation (TfL Process and Guidance Pathway Product H068, 2018). Key organisational risks are identified by the project team and managed through a software programme called ARM (Active Risk Manager). The ARM method ascertains probability and impact scenarios throughout the project lifecycle. Thus, project budgets are defined though a combination of base costs and an allocation of risk which is determined through ARM (TfL Pathway Guidance Product R0473, 2019).

During the design stage, risks are captured through a process called designer's risk assessments (DRA). The DRA is part of the design management plan (DMP) as noted within TfL Process and Guidance Pathway Product H064 (2017). Designers may opt to design out specific risks, reduce their impact or transfer them, but ultimately, our designs will be left with a residual risk that must be managed, throughout the installation and maintenance phase of any asset.
During the installation phase, risks are specifically captured through the Risk Assessment and Method Statement (RAMS) method, where a safe system of work is defined, capturing all the relevant risks, and providing mitigations to ensure the system of work is safe enough to execute.

In addition, a programme of work is defined, listing all activities in a defined sequence. Probabilities of occurrence are allocated to each activity so risk areas can be points of focus for managers to ensure that programmes of work are met in the agreed contractual time. Over and above the programme and RAMS we have an assumptions and issues register, which keeps track of our assumptions and issues which need to be monitored constantly to ensure they don't impact on cost, time, or quality (TfL Pathway Health and Safety Special Interest Group Product PD0225, 2017).

A THEORETICAL PERSPECTIVE - STAKEHOLDER THEORY

Consideration is given to several theoretical perspectives, namely, stakeholder theory, agency theory, network theory, institutional theory, and resource-based view. Agency theory primarily focuses on the relationship between principals and agents, such as the relationship between shareholders and managers. It may examine the conflict of interest between them and explores the mechanisms such as contracts, incentives and monitoring to align their needs. It focuses on managerial behaviour, executive compensation, and corporate governance (Jensen & Meckling, 1976; Jensen, 1993). The aim of this study is to explore what safety strategies have been applied and how effective these were for each stakeholder and as such does not satisfy the aims of this research.

Network theory focuses on the relationships and connections between organisations, and how they interact and collaborate within these networks to achieve theory goals (Granovetter, 1973; Valente, 1996). Network theory does not satisfy the aims of this research as the focus is not to analyse the inter-organisational relationships, network structures or collaboration dynamics (Meyer & Rowan, 1977; Zucker, 1983). Thus, this theory was discounted. Institutional theory is also considered. Institutional theory examines how organisations conform to and are shaped by social, cultural, and regulatory institutions. It explores the pressures that organisations face to adopt certain practices and structures to gain credibility. If the aims of this study were to focus on organisational change, institutional entrepreneurship or the role of norms and values in shaping organisational behaviour then institutional theory is a valuable perspective, however, this study does not aim to focus on these aspects, thus it is discounted. Resource-based view focuses on the internal resources and capabilities of organisations as sources of competitive advantage. It explores how organisations develop and leverage resources to achieve superior outcomes (Barney, 1991; Teece, Pisano & Shuen, 1997). The aims of this study, however, focuses on the collective approach of stakeholders that have applied safety strategies and especially the AR based strategy used within the TfL context.

Stakeholder theory emphasis is on relationships between organisations and stakeholders. It provides a framework for understanding how different stakeholders can influence the organisation. Stakeholder theory uses a holistic perspective and includes ethical considerations. There are also practical implications for managerial decision-making and strategic planning. It identifies the interests and expectations and uses an interdisciplinary approach for researchers to explore complex phenomena by using business, sociology, psychology, and ethics (Freeman, 1984; Phillips & Freeman, 2003; Donaldson, & Preston, 1995; Mitchell, Agle, & Wood, 1997). Stakeholder theory best

satisfies the aims of this research as it adopts a holistic approach, and the emphasis of this theory on relationships between stakeholders.

Thus, I have chosen to use stakeholder theory as a theoretical perspective. The AR group that was embedded in the TfL PITTA project consisted of three distinct stakeholder groups, namely the landlord, the client, and the contractor groups. The design of the research questions is based on stakeholder theory and an overall picture could not have been developed without all the perspectives of the stakeholders.

Stakeholders, by definition, are groups or individuals that have a valid interest in the activities and results of a firm and on whom the organisation relies on to achieve its objectives (Freeman, 1984). Stakeholder perspective developed as a method of considering how organisations and people generate value. The theory addressed three issues, namely, how to create value in an uncertain environment, the ethics of capitalism and the educational focus of how business should be conducted.

Stakeholder theory is underpinned by seven concepts. A managerial emphasis where executive managers engage with stakeholders, in a way that influences the value of the organisation. The focus here is on how to determine the best way to manage stakeholders to lead to the most favourable value-creating outcomes. The second concept is a moral perspective, where the respect for human rights, integrity, honesty loyalty and fairness support this notion (Phillips, 2003). A moral approach helps to enhance the feelings of self-worth with managers and executives that practice it. The third concept is enterprise strategy where the purpose of the organisation is defined. The organisation asks why it does the things it does and develops a purpose around this concept. The fourth concept is the creation of economic and non-economic value of the organisation. The value organisations develop goes beyond economic value, where factors such as personal development, esteem, and happiness contribute towards this idea. The fifth concept is reciprocity where the idea that humans respond positively when they are treated well and negatively when they are treated badly. Thus, organisations contribute towards their communities to gain reciprocity from them. Reputation is the sixth concept of stakeholder theory, where reputation can influence how attractive a firm is to both existing and future stakeholders (Freeman *et al*., 2007). The seventh concept is stakeholder interests and the issue of trade-offs. Decisions are often made when all stakeholders will benefit, such as launching of a new product. However, there are times where more difficult decisions need to be made that affect some stakeholders adversely, so for example the closing of a plant with employee loss. Shareholders would accept these decisions more readily, but employees who have lost their jobs will accept it less so.

A stakeholder approach relevant to this study because it contributes towards four valuable organisational elements. Creating value, innovation, dealing with various groups and stakeholders in an integrated way and the ethical significance that is generated. Creating value is a central theme for any organisation. For TfL, aside from the value of offering transport facilities to the public, we also want to create an environment that is safe to work in and where infrastructure workers do not face the potential threat of injury. Essentially the workers that undertake most of our construction works are external

suppliers, so creating this safe space is valuable to both the organisation and the external stakeholders such as suppliers. Innovation that is harnessed by a variety of stakeholders that are embedded within projects can be particularly valuable to the organisation (Dougherty, 1992). For this specific study, this is especially relevant as the repository of information sits within the stakeholders that have been engaged with the AR based approach within TfL and its stakeholders. New innovative ways were developed to address specific organisational problems and AR based approach supported the notion of stakeholder engagement. Thus, interviews within this study will glean the rich information gathered throughout the AR process. The third organisational element relating to this theory is the integration of stakeholders. This idea supports the organisation to search for value that benefits all stakeholders in an integrated and interconnected way. The fourth element business ethics and how organisations have a duty to fulfil moral and ethical obligations.

There are opposing views to stakeholder theory, whereby one such view focuses on the shareholders perspective only, and how to maximise profits without concern for ethical grounds. Capitalism and shareholder perspectives are seen as necessarily connected. In contrast, stakeholder theorists embrace market economy while abandoning shareholder perspectives. Shareholder's perspective has some validity, especially when the transaction cost theory (Williamson, 1975) leans towards the residual risk of an organisation is accommodated by the shareholders and as such, the governance of such organisation should be responsible to those who carry the risk. Employees do not bear the same risk and thus should have minimal say on the governance of a company.

WHERE FURTHER RESEARCH AND DATA IS NEEDED

Action research offers a specific opportunity for dealing with emerging, unforeseen risks. Dougherty (2016) texts go into much detail about emerging risks in complex systems, and AR may offer a potential strategy that can address these types of risk. Given that construction engineering projects by their very nature, evoke physical changes to the environment they occupy, risks that may seem predictable on the outset of a project have the potential to evolve, change and emerge into other types of risks later in a project, and sometimes catastrophic. Plans frequently change, sequencing of work shifts with time, assumptions evolve, and therefore so do risks. The AR strategy offers a methodology that can assess risks nearer the time of respective activities, and take account of the most recent environments, include current stakeholders and research, plan and execute strategies and interventions that could prevent injuries and save lives. The assumptions and issues register, together with the programme and action research approach (AR), we have an opportunity to approach the issue of emerging risk with an AR based approach, which helps to solve construction problems and reduce workplace injuries on the hoof.

Emergent risks are complex and unpredictable, and we need an adaptive system that can be diagnostic and dynamic. AR may fulfil this requirement. The notion of the application of AR to emerging risks in construction Projects is validated by Davies *et al.* (2014).

As noted previously Azhar, Ahmad, and Sein (2010), and Davies *et al.* (2014), make contributions to fill the AR knowledge gap in construction. However only Azhar, Ahmad, and Sein (2010) go as far as evaluating the effectiveness of the AR solutions. The extant literature falls short in filling the knowledge gap of AR in construction and more specifically within the railway sector by using a stakeholder theory approach. This research aims to position itself within that knowledge gap.
Semi-structured interviews will attempt to explore the current TfL safety management approaches and issues. AR has been applied on our specific TfL programme of works that offered solutions that were directly linked to safety risks. This study will seek to establish safety strategies used by practitioners and assess the effectiveness of AR towards contributing towards reducing safety related incidents.

There is no relevant extant literature assessing the effectiveness of AR on construction safety risks using a stakeholder perspective. As such, this paper aims to contribute towards that end. Davies *et al.* (2014) use AR to develop a strategy for innovation on Crossrail, by involving stakeholders but falls short of evaluating the effectiveness of such developments. Azhar, Ahmad, and Sein (2010) use AR to solve a construction related problem and do evaluate the effectiveness of solutions developed by AR do not apply stakeholder theory. The value of stakeholder theory evaluation is that the perspectives of stakeholders contribute vital information towards the understanding of how effectiveness is perceived from different parties that are affected by the AR solutions.

ANALYSIS OF EXTANT LITERATURE USED IN LITERATURE REVIEW

I have provided a visual display of the most relevant extant literature below, figure 7. Each circle depicted represents a research paper with the year of publication shown. The different colours relate to an industry field, which is defined at the bottom "Industry field" of figure 7. The size of circle depicts the number of research papers within the nominated year of publication, typically there are three sizes, from small, medium to large depicting one, two or three papers respectively. The three columns and three rows differentiate whether AR or stakeholder theory have been applied within the research paper. Where it is shown as "null" it is non-applicable as the literature mostly has to do with theory development or do with management or management of safety risk methods, thus not relevant to the AR or stakeholder theory perspective.

At the bottom right-hand corner on the table below, we have one article from Davies (2014) that includes an action research project and uses a stakeholder approach. However, this report does not go far enough in assessing the effectiveness of the innovation strategies developed through this AR approach. There is little literature that evaluates through a stakeholder perspective and action research approach. Moreover, despite it being a contextual issue, AR applied to a rail construction project issue is even more limited, and this study aims to contribute towards that area.

Figure 7 below depicts several construction-related research papers that do not use AR based approaches or a stakeholder perspective. Azhar, Ahmad, and Sein's (2010) report

contribute towards an AR approach and evaluates the solutions found, however does not apply a stakeholder perspective. Further two research papers using AR within the construction sector are Wu & Fang (2017) and Connaughton & Weller, (2013). Other literature, shown in the middle right of Figure 7 consist of two papers using AR but are not construction industry related. In the middle of figure 7, the colours depicted indicate that most papers in this category are within the construction field, numerous safety management papers and one paper relating to engineering projects, one related to highway transportation, one relating to biopharmaceutical sector and one relating to a variety of sectors. Although there are numerous construction-related papers, there are few that investigate AR-based approaches using a stakeholder perspective.

To the top left-hand corner, the predominant literature has to do with management, one paper relating to the construction sector and a couple of papers on safety culture.

The position of this research study has to do with investigating the effectiveness of an AR based approach within a railway environment, using a stakeholder perspective. As can be demonstrated in figure 7, there is limited literature that fulfils this area of research, and it is the aim of this paper to offer a contribution towards this area.

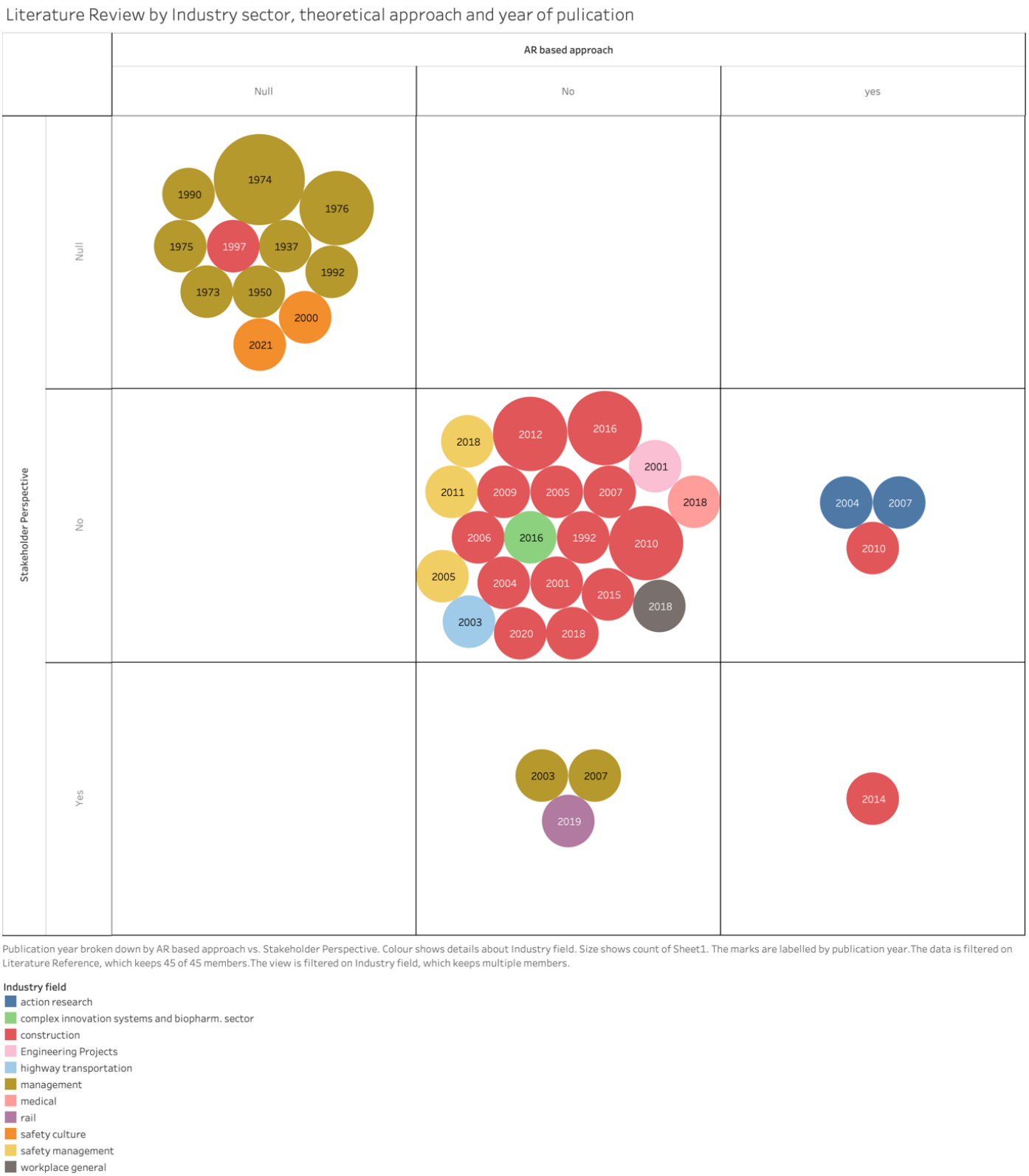


FIGURE 7 - EXTANT LITERATURE ANALYSIS BY INDUSTRY SECTOR, THEORETICAL APPROACH AND YEAR OF PUBLICATION

METHODOLOGY

INTRODUCTION

Projects undertaken at TFL (Transport for London) provides upgrades to existing assets, maintaining existing assets whilst other projects introduce new asset installations. I am involved with project types that involves new asset installations and upgrading of existing assets. We install advertising or retail space assets that generates a secondary revenue stream to supplement the primary TfL revenue. TfL's primary income is generated by transportation ticket sales. As such, we are often faced with new risks during a project lifecycle. Key safety risks can be identified using various accepted methods, but at TfL we currently use a PMF (Programme Management Forum), SLT (Safety Leadership Team) forum and the specific project teams themselves to identify key safety risks and prioritise them. The method of managing specific risks varies within our business, but an accepted practice approach in managing risks is to reduce the likelihood of them occurring or eliminating them altogether, thus, reducing or eliminating the potential to cause injury to our operatives on site (RM3, 2019). Our specific business problem is the increase of injuries over the last five years within London Underground. Within the TfL PITTA project, we have applied an AR based approach as one method of managing safety risks. Thus, the purpose of this study is to explore what lessons can be learnt about the perceived effectiveness, implementation challenges and the institutionalisation of the AR based strategies.

The objectives of this research are:

1. To explore what strategies were implemented.
2. Which strategies were perceived to be effective, needed refinement or improvement?
3. What challenges were faced and how were they addressed?
4. To explore how well these strategies have been institutionalised.

The TfL Programme for the Investment & Transformation of TfL Advertising (PITTA) is a programme of work within TfL, which is involved in the installation and upgrade of advertising assets within the TfL estate. This study focuses on the PITTA programme of work. Programmes are managed in a similar way within TfL, in that they follow a governance process to ensure the project falls within an acceptable legal and safety framework. The TfL governance process is named Pathway, and this TfL-wide governance process makes all the various TfL different transportation modes follow in a uniform process throughout (TfL Process and Guidance Pathway Product H068, 2018). Therefore, the way projects are managed and implemented is similar throughout TfL, and similarly, safety risks are managed in the similar way within TfL projects. The TfL Pathway governance model is implemented by initially identifying the characteristics of a project, namely, complexity, value, and risk profile. After defining project characteristics, a document product matrix is produced which defines what document and at which phase in the project it should be produced and updated. Thus, TfL projects will have similar TfL

governance documents that are produced (TfL Process and Guidance Pathway Product H068, 2018).

Figure 8 below depicts the TfL Pathway lifecycles at programme, project, and delivery levels. Programmes start from the left of figure 8 and progress towards the right. The initial stages of programme level, options are identified for the whole programme of works, followed by the definition phase, then installation of assets and finally the close out phase, where benefits are realised. Similarly, the programme level information supports the project level deliverables, which include outcome definition, feasibility, concept design, detailed design, installation, and project close out. Finally, the installation or delivery phase is defined by three distinct phases, namely definition, management for the installation and close out phases. All three levels, programme, project, and delivery levels are integrated and depend on each other for progression to close out. The TfL Pathway management system ensures that all the safety and legislative requirements for a TfL programme of work meets governance standards. Also included within the TfL Pathway process are the TfL safety management systems, and these run concurrent to the governance process.

Figure 8 has been included as an informative table that shows the TfL Pathway process which is applicable to all TfL projects. In this study we explore in greater detail the strategies used within the TfL PITTA project, how effective these have been and where improvements could be made.

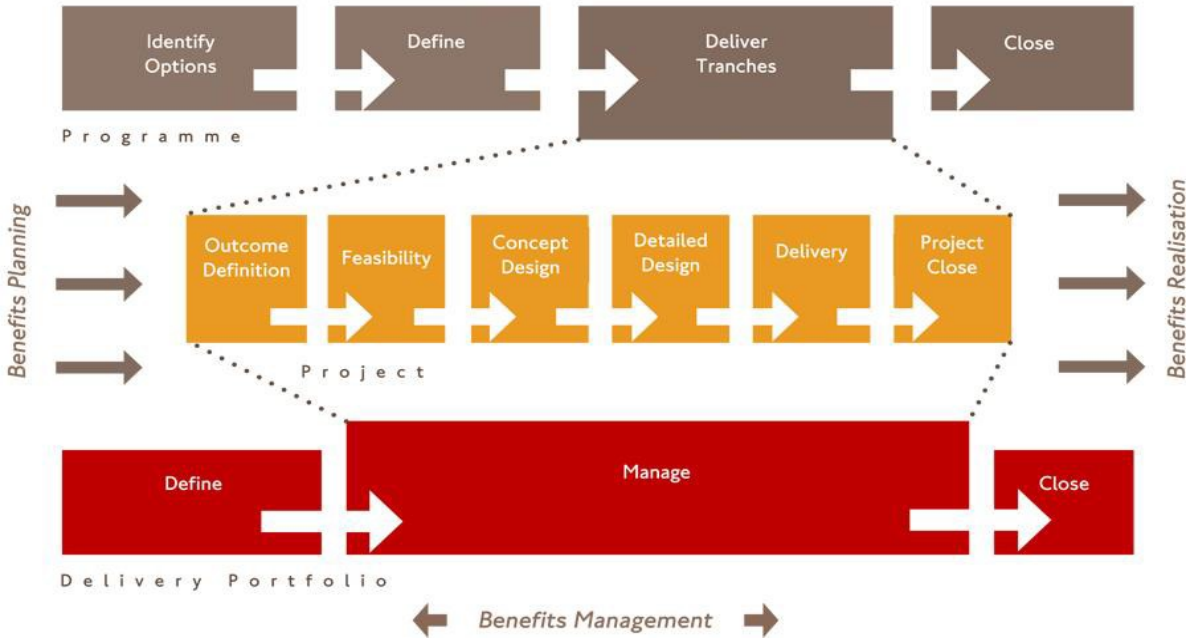


FIGURE 8 - TFL PATHWAY LIFECYCLE DIAGRAM
(TfL Process and Guidance Pathway Product H068, 2018).

Action research (AR) is one such method that the TfL PITTA programme is applied, where our team uses the method to try and remove or reduce specific construction related safety risks and solve specific problems. The AR based approach provides solutions that are implemented between 2018 to early 2020. Action research is the preferred method

chosen because the problem risks are live and complex. The solution required inside, specialist knowledge. A consultancy approach was considered, but the time to procure such a service was problematic for live problems and the inside specialist knowledge was available immediately within the SLT and PLF teams. In addition, the potential to offer bespoke TfL solutions is more likely with an AR based approach because all delivery stakeholders had the expertise to enable solutions more readily. Enabling bespoke solutions on TfL requires the approval and certification of such specialist plant, and within the TfL environment it is a complex and lengthy process. The stakeholder AR team has specialist TfL knowledge to enable these solutions quickly.

Manual handling safety risks and working at height safety risks are two such key safety risks identified though SLT and PLF, amongst others. Other safety risks identified were behavioural safety risks, quality risks and slips, trips and falls safety risks, however, I focus on the former two key risks to draw as examples because these risks are addressed specifically through the AR based approach. This study aims to investigate the impact and effectiveness on reducing key safety risks using the AR based approach. We explore the strategies used to manage safety risks, the effectiveness of AR as such an approach, the challenges that this method poses and how well this strategy has is institutionalised. This study aims to develop an AR-based strategic framework for which is applied within TfL projects to reduce workplace incidents.

PHILOSOPHY

This study proposes to use data collated through interviews from participants who offer various perspectives. The participants are comprised of the delivery stakeholders. This study also looks at the safety data over the period where the AR solutions were active. As such this study sits in a relativist ontological position. Epistemology provides assumptions in the way an inquiry is made into the nature of a problem. Epistemology may range between positivism and social constructionism. Positivism includes the observer as independent, and explanations show causality. The research progresses through hypothesis and deductions can concepts are defined so that they can be measured. The unit of analysis is reduced to the simplest terms and generalisations are developed through statistical probabilities. Sampling involves large, randomly selected numbers. In contrast, social constructionism includes the observer as part of being observed, and explanations enhance the understanding of a situation. The research progresses through gathering data where concepts are produced, and concepts include stakeholder perspectives. The unit of analysis may include entire situations and generalisations are developed through theoretical abstraction. Sampling involves small numbers and cases are chosen for specific reasons.

This study is focusing on a single case, the unit of analysis is the TfL project, and the sampling involves a small number of interviewees chosen for their specific involvement within the AR project. The study aims to increase the general understanding of our specific business problem. As such, this study's epistemology is positioned towards social constructionism. Existing safety data informs us of what AR solutions are effective and

reduced risks, but we do not know how these became normative everyday practices. Interviews will highlight the safety practices and safety culture that enabled these safety practices and develop actionable knowledge so that this AR based approach can be institutionalised into the wider TfL project environment. Linked to both ontology and epistemology, a methodology may be derived to support the philosophical approach of a research. My exposure to an engineering discipline and sciences makes me more inclined towards positivist research approaches. Thus, the notion of positivism is appealing to me as an engineering practitioner and this type of research typically follows a quantitative approach.

The sense-making and comparison of information is important to this study because the data is be collated through semi-structured interviews. Various perspectives are offered, and these perspectives provide the valuable data required to enhance the understanding of our problem. This study explores what safety risk-reducing strategies are applied within our organisation, it seeks to investigate how these strategies perform in terms of efficacy, what challenges are encountered, and ultimately how these strategies are institutionalised. These explorations will generate data in the form of a human construction of the perceptions of three groups of stakeholders looking at the problem. This study is positioned in a relativist ontological position, and a constructionist epistemology.

Easterby-Smith, Thorpe & Jackson (2013) table out the methodologies related to relativist ontologies and constructionism epistemology, and in this study the aim is one of convergence. The starting point is a set of questions, with words being the primary data. Secondary data is used, namely safety data. Analysis is undertaken by triangulation or comparison and at times making sense data collated. However, the outcome is not theory generation as described in table 2.5 under constructionism (Easterby-Smith, Thorpe & Jackson, 2013, pg.25). It is leaning more towards a constructionist epistemology to do with developing new insights and actions. Overall, the epistemology this study follows is constructionism.

Given that this study focuses on a single TfL project, namely the TfL PITTA project, it is limited to this single programme of works. There are limitations on single case studies, one of which is of how strategies are institutionalised throughout the organisation. Through AR we co-construct actionable knowledge to roll out the safety strategies into other areas of TfL. This is possible due to the governance structures of TfL and that the projects typically follow these governance pathways. Constructionism finds strength and value from different data sources and enables generalisations beyond a unit of analysis. There are also limitations in resolving conflicting information and analysis and interpretations can be difficult. In this study I have included three groups of stakeholders, where each stakeholder group typically consists of three members. Analysis of the data should provide saturation of ideas in each categorical aim, and where this is not achieved, then further considerations shall be made to explicate the divergence. This is not particularly worrisome for me as an insider where further information may be sought, or insider knowledge may be applied.

METHODOLOGY

Primary data is collated through semi-structured interviews. The interviewees are all involved with the SLT, PLF, and/or the AR based group. All interviewees have expertise within specific disciplines and are also competent within the TfL environment. In addition, the stakeholders are decision-makers in the implementation of construction methods who are making professional judgements about their operatives on site. The data collected through interviews is qualitative data. Thus, this study follows a predominantly, qualitative methodology. Positivist research designs include experimental and survey research according to Easterby-Smith, Thorpe & Jackson (2013), which this study was not going to pursue. However, we do have the safety data over the time period that the AR solutions were implemented, so we do know what worked in terms of reducing risks and where we had solutions that were reducing risks. We do not know why these worked and how these became everyday practices, and the interviews undertaken within this study will aim explain how enabling and enacting behaviours within a safety culture helped to make these solutions normative.

Constructionist research designs incorporate action research, archival research, and ethnography. Case methods, however, may follow either epistemology. The key features that distinguish the epistemological position of a case study have to do with design, sample, analysis, and the underpinning theory (Easterby-Smith, Thorpe & Jackson, 2013). Thus, a case study with a prior design, with a sample greater than thirty, analysis cross-case and incorporating a testing theory is immersed in a positivist epistemology. In contrast, an emergent design, with a small sample and analysis sits within the case and is supported by action theory, is positioned from a constructionist position.

The line of inquiry and questioning for the interviews explores the strategies that stakeholders apply, followed by investigating which strategies are perceived as more effective than others, challenges encountered, where improvements should be made and how these strategies have been institutionalised. These lines of inquiry sit in a qualitative methodology because stakeholder perspectives are sought, the number of interviewees is less than ten, and strategy efficacy is measured through stakeholders' perceptions. Effectiveness is supported by the backdrop of existing safety data provided. The challenges are again the stakeholder's perception or personal experiences on application of such strategies. This data is valuable to me as a practitioner because stakeholders are experts in their respective fields and their experiences are a vital source of information on how strategies are implemented. Challenges and improvements may be made with the use of such information. I note that these perceptions are expert perceptions in the sense that the interviewees are experts in their respective fields.

In contrast, the methodological design for this study may have followed a quantitative approach, where the effectiveness of the AR based approach may have been tested and evidenced through quantitative methods. The data required to support this is provided as a backdrop to demonstrate if risks because significant to trigger off an incident or accident for the specific risk areas the AR based approach was trying to reduce or remove. The data collated through interviews as stakeholders' perspectives provide the potential

for further clarity on strategies, safety culture, future directions for TfL, richer data for institutionalising into TfL and higher levels of learning though the action research perspective. This study also integrates an action research design because it is rooted in a practice-based problem, it aims to produce actionable knowledge and travels through cycles of reflective action. Action research is detailed out later in this chapter.

DESIGN OF THIS RESEARCH

This study uses a qualitative method. Using a case study to investigate a workplace problem in a natural workplace setting is supported by Creswell (2013). Thus, being a researcher and a practitioner within TfL has the benefit of being an insider and inherits the risk of losing impartiality. Impartiality and conflict of interests are addressed later in this chapter.

At TfL we have an action research (AR) project that this study uses to reveal experiences in using the AR approach and to explore if the strategy reduces construction risks, and to evaluate what mechanisms or processes may have led to such an outcome (Pawson and Tilley, 1997). The case was developed to support the value it could add by collating information to explore the impact the AR strategy had on the TfL teams and on incident numbers. Action research is also used in this research study to co-construct new knowledge on how to reduce safety risks within other departments in TfL, namely the TFL ISR project.

This qualitative study will seek the convergence of ideas about safety strategies and safety culture through interview questions and the analysis of these ideas to gain new insights or generate new methods of risk mitigation at TfL (Yin, 2016). As a practitioner, I want to explore and evaluate how strategies, including AR, help to reduce workplace accidents. This epistemology is based on realities co-constructed between myself and the researched, and shaped by the individuals' experiences. Thus, by this co-constructed epistemology, this research falls within the relativist ontological position (Yin, 2016). Safety data is used to support or negate the effectiveness of strategies, and where challenges are identified.

There are numerous qualitative methods that could be considered as a research method. There may have been some justifications to consider grounded theory, because being a participant of the AR project in question may have explored the AR process. I have opted to use an action research method over case study method or grounded theory as there is less inclination to develop theory through practice and more emphasis on exploring and evaluating the effectiveness of an AR approach that has been applied recently within a TfL project. Having also considered different types of methods such as experimental, survey, archival, and historic types of research, this research focuses on how and why questions with a focus on contemporary events (Yin, 2014).

We do not know at this stage whether the AR based approach has been effective, or how easy or difficult it has been to use from the perspectives of the different stakeholders. We do know that the AR based approach, solved very specific work-based problems, and we wish to explore how effective these solutions have been in reducing safety risk and therefore incidents to our workforce. By using stakeholder theory, this study will provide the three perspectives through semi-structured interviews. Therefore, the proposal is to have three participants from each stakeholder group.

As with any research design, there are potential limitations. Case studies can be prone to the lack of strength in generalising the findings (Yin ,2014). TfL projects are assembled in similar ways and legislative requirements ensure that project follow a rigorous governance approach, thus the potential of a new strategy in one project being successfully applied into another is strong. AlSehaimi, Koskela and Tzortzopoulos (2013), pose the notion that there is a need for alternative research approaches within construction management. The alternative research approaches would steer more towards a non-traditional approach. Their study notes that traditional research approaches are valuable in discovering the cause of delays but do little to solve them, and especially when they are live. Furthermore, the gap between research and practice is not reduced as might be the case with action research due to its participative approach. The study identifies construction delays in developing countries and assesses proposed solutions. In support of this notion above for alternative research methods, for this study there is a case study that focuses on a TfL Project, and in addition, there is an action research element within it. This is explicated below in further detail.

ACTION RESEARCH

The design of AR has a diagnostic, evaluative, action-based and learning capability when applied (Azhar, Ahmad, and Sein, 2010). The theoretical design above of action research is formulated by some of the more prominent developers of action research (AR) (Argyris and Schon, 1978). In contrast, Schenkels and Jacobs (2018) propose that the definition of the construction of a conceptual design, as developed by, Babbie (2007), comprises of four components, namely, concepts derived from mutual agreement called, "face validity, criterion-related validity, construct validity and content validity" (Babbie, 2007. P 146). However, this theory is more applicable to quantitative research methodology. In qualitative research, the concept of "maturity" is more appropriate (Morse, 2004; Cutcliffe and McKenna, 2005; Penrod and Hupcey, 2005 as cited in Schenkel and Jacob's, 2018). This is more suitable to Critical Action Research (CAR) due to its more dynamic nature. Schenkels and Jacobs (2018) note that CARs' epistemology is supported by practitioner participation because it is the joint assembly of ideas that creates the concepts referred to above in conceptual designs. Burns (1999) and Jacobs (2010), place great importance on this joint interaction and democratic decision-making. Burns (1999) goes even further in this notion by defining the validity of the participation, and in measuring the involvement of all participants, and the extent of involvement and the measure of a change in the profession or practice within the research field. However, Baskerville (1997) reports of the difference between action research and participative

case studies as important to distinguish. Action research is a two-stage process as defined by Blum (1955), where there is the initial diagnostic phase followed by a therapeutic stage, whereby collaborative change is trialled. Susman and Evered (1978), develop AR into five stages, and aligns with Azhar, Ahmad, and Seins' (2010) findings. The model consists of diagnosing, planning for action, taking action, evaluating and learning. For these stages to occur, a research environment must be present, which is usually the client environment. This environment defines the responsibilities of the client and the researcher and assumes a position that no action will be taken that would cause harm. Action research adopts a more collaborative process when diagnosing an internal problem (Baskerville, 1997). Having inside knowledge of an organisation positions the ARs team in a unique position to find a specific solution to an organisational problem.

The need for action research to be effective in practice is emphasised by Azhar, Ahmad, and Sein's (2010). Addressing a live practical problem which creates theoretical and conceptual knowledge is valuable to organisations. AR used within the construction industry can be an effective method for solving live issues and in creating new academic knowledge. In addition, it has the potential to build strong relationships between practice and academia.

During the TfL PITTA project an AR based team was formed to specifically address the key risks identified at the SLT and PLF teams. Thus, the first AR cycle was the formation of the action group to solve very specific safety risks within the TfL PITTTA project. The first key safety risks addressed were manual handling of advertising assets into London Underground stations and especially on escalator environments. The second safety risk working at height and especially within escalator environments inside a station. The manual handling was addressed by researching what was available in the market to use for transportation of materials on staircases and deciding and planning how to transfer these solutions to the escalator environment. One solution of the manual handling solution that involved a mechanised, track stairclimber, underwent seventeen separate tests and trials, to test and record specific predefined test criteria that were needed to test, prove, negate options, and provide new data that fed into the next cycle of reflective action. Some tests were congregated together as a set-of-tests before new actions were determined. Once new actions were undertaken, a new set of data would feed back to the decision-making and reflective action process to create new pathways for testing. Reports were generated for these tests that captured predefined test requirements. Similarly, the working at height safety risks followed a similar process where solutions to a practice-placed problem were found through actionable knowledge produced through cycles of reflective action.

Research designs have limitations and shortfalls. AlSehaimi, Koskela and Tzortzopoulos' (2013) case study criticizes the lack of recommendations made to solve the issue of the delay problems and furthermore finds that when recommendations are made, they are do not match findings. Five out of the sixteen reports reviewed provide a solution for poor planning even though fourteen identify this element as a significant delay cause. The case study identifies the five reports that provide recommendations and ascertains the specific shortfall within each report. The case study identifies that diagnosing the

problem is only a first step in solving a problem. Management research could use a further step in prescribing a solution. A better solution, the authors suggest, is to transition from descriptive knowledge to prescriptive knowledge, taking the description of the problem and proposing a solution. Action research can be used to generate such solutions and test them within the construction arena.

The AR proposal has the potential to enhance construction practice and to confront some of the stubborn managerial challenges in construction and to contribute to construction knowledge. Azhar, Ahmad, and Sein (2010) identify how current non-AR approaches fail to find practical solutions within construction engineering projects. AR is grounded in a practical approach that yields solutions to live practical problems on site. One of the key elements of construction sites is the ever-changing environment. There are always assumptions about what state the construction site will be in at the planning stage, given any specific activity in the future.

Making contextual assumptions is a typical construction planning approach, but it is almost always the case that these assumptions should be challenged continuously, because the environment may have changed to something not previously assumed. An approach that may well work within a previously assumed contextual background, may prove to be an unsafe approach given an alternative environment. AR is effective in addressing this anomaly in construction planning, as the very nature of critical reflection required in AR, constantly tests underlying beliefs and assumptions, and seeks to understand the context in which action is planned. AR is particularly effective in this contextual challenge.

AR does have weaknesses though (Azhar, Ahmad, and Sein, 2010). It may assume that the applicable theory is adequate for action to be taken. This might not always be the case. In addition, AR finds bespoke solutions for specific problems, which make the solutions arising from AR, less generalisable. In addition, organisations might not prioritise theory development that may prove inadequate for action research. As such, action research was the preferred method of choice when we were trying to solve our TfL PITTA risks. Moreover, since we have data that indicate the solutions developed through AR were working well, we still do not know why these worked and how they become normative applications. This study investigates the safety strategies and culture that enabled these solutions and furthermore explores the institutionalising of such strategies into other TfL departments, by adopting an AR based approach within this study.

Semi-structured interviews allow me to probe for information and yet retain the control of a structured interview. Semi structured interviews allow me the flexibility to explore elements further and yet retail the structure of interviews. This study uses the semi structured interviews as a primary source of data. The interviewees are all connected directly or indirectly to the AR based approach. All the interviewees are members of the SLT or PLF where the AR base approach was implemented. The interviewees are all experts in their respective fields of safety management, project management or construction and their specific and collective views on what is perceived by them as effective, or challenges that they face, and their views on how to improve ways of using

these safety approaches is valuable information. Interviews make it possible to collate the perspectives of the three main delivery stakeholders to achieve the aims of this study. The interviewees are specifically clustered into the separate stakeholders to try and reach a saturation of three specific perspectives. Since we have new TfL ISR project that I want to apply AR as a safety approach to reduce safety risks, I use the lessons learnt from the TfL PITTA project to develop the AR approach further. It is important to note that AR is not applied in isolation, as there are numerous other strategies and methods that TfL use to reduce safety risks, and some of these are perceived to be effective in this regard, so I do not wish to replace them. AR is a complimentary approach that is integrated into the other safety reducing strategies used. I have a work-based safety issue that I wish to reduce the potential safety risk, AR is one such method (Azhar, Ahmad, and Sein, 2010) that can be applied and lessons learned through cycles of application. This approach is thus recommended for this study as offers a way to co-construct new knowledge and solve specific safety risks related to the TfL ISR project. Semi-structured interviews allow me to probe for information and yet retain the control of a structured interview.

In the backdrop, I use the secondary existing safety data to support or challenge safety strategies that are perceived to be effective based on the safety outcomes of the periodic reports. This data is gathered, and it is used to be discussed with focus groups of the AR team for the co-construction of new knowledge. It is also used to be discussed with the new TfL In-Station Retail Team where the further co-construction of knowledge is developed to enable the institutionalising of these AR based safety approaches as an evolved AR based approach. In this sense, this study is based on an action research approach. It will progress through cycles of knowledge co-creation.

DATA COLLECTION

There are several sources of data that this study collates. Semi-structured interviews. Secondary data sources will be collated from existing TfL safety data and from the UK Health and Safety Executive (HSE). Extant literature will explore how other industries have approached the issue of reducing workplace injuries and provide another secondary source of data. In addition, existing TfL Action Research data from our TfL project will also be used. Yin (2014) lists the types of data that case studies are supported by and highlights their strengths and weaknesses. Interviews offers strength in focusing on the specific case study and may offer insights or explanations about how and why things are done in a certain way. Yin (2014) notes that the pitfalls with interviews can stem from poorly worded questions, poor recollections, and interviewee bias. Documentation offers strength in the broadness on depth required and data can be viewed repeatedly. Yin (2014) notes that the limitation with documentation is that it can be difficult to find.

PRIMARY DATA COLLECTION – INTERVIEWS

The primary source of data was collated from semi structured interviews. The interviews were undertaken from a variety of stakeholders within our project. These include programme and project level managers through to operatives on site who were affected by the actions undertaken by the action research process. The interviews fulfil the

requirements of a qualitative case study. The interviews explored the AR approach among other methods used, and how the stakeholders are affected by the strategies applied, how the teams were affected, how the operatives experienced challenges and how these were resolved, and how effective these strategies were in relation to reducing safety risks. It will examine how the AR based approach addressed the problems it sought to solve.
Interviews were structured to address safety risk reduction strategies, and how improvements could be made in practice. It studies how outcomes were generated and focuses on specific methods that were employed in addressing safety risks and how these compared in practice. The interviews investigated how these strategies could be institutionalised into the wide context of TfL.

SECONDARY DATA COLLECTION – ORGANISATIONAL SAFETY DATA

TfL undertake periodic safety reports. Within these reports, incident numbers, trends in non-compliances and near misses are reported. The safety reports also note how many safety visits have been undertaken versus the number of hours worked over that specific period. In addition to these specific project reports are more general TfL safety reports that provide a broader context to the safety status of TfL during a specific time period.

SECONDARY DATA - EXTANT DATA

Existing safety data has been used from sources such as United Kingdoms' Health and Safety Executive (HSE) public data sources. This study has extracted HSE data from within construction industries and compare it to other business types. Literature reviews have been undertaken using existing literature that explicitly sought to reduce workplace injuries within other business sectors coupled with specific transportation sectors such as aviation, or marine cargo transportation areas. The health industry is another specialist area that may offers insights on workplace injuries and ways to reduce them.

SECONDARY DATA - ACTION RESEARCH DATA FROM TFL PROJECT

The TfL PITTA Project undertook an AR approach in addressing specific construction risks. The AR approach diagnosed, planned for action, and collated evidence to learn from the action and data was collated along the way to learn and prepare future action. AR data has been provided towards this case study. This study also examines the AR approach for challenges, effectiveness of AR solution to address a problem, and how AR has been institutionalised.

PARTICIPANTS

The SLT and the PLF were formed after the TfL PITTA project commenced project operations. The SLT was introduced to highlight high-level key construction safety risks within a collaborative environment and then decide how to address them. The SLT consisted of various stakeholders involved in the TfL PITTA project delivery. Landlord stakeholders, client stakeholders and contractor stakeholders were involved. The SLT also included sub-contractors, the operatives who were on site, or involved with sending operatives to site and who were the closest to the physical works on site. The PLF was a

higher-level meeting that consisted of directors of stakeholders and senior managers within the SLT team. Action groups were formed from the SLT to address very specific safety risks that were identified within SLT. I was a participant of SLT, PLF and action groups that addressed safety risks and found solutions for them through an AR based approach.

Participants of this research study had to be members or participants of the SLT, PFL, or members of an action group. The selection was also dependent on accessibility to the individual. Being a member of the PLF or the action groups or both, was regarded as valuable for this study in terms of being able to provide unique stakeholder perspectives.

The total number of potential interview participants for all three groups, namely, PLF, SLT and AR groups are fifteen. For this study is was important to represent all the three stakeholder perspectives with a number of participants to reach saturation. When saturation is achieved the interview process is concluded for each stakeholder group.

As this study uses the TfL PITTA case to extract experiential knowledge, the design of the interview draws from a sample of between nine to twelve participants. This study also considers stakeholder theory as there is a need to include all the delivery stakeholders to gain a full perspective in the lessons learnt. Easterby-Smith, Thorpe & Jackson, (2013) support the sample size for a case that is supported by action theory and is positioned from a constructionist position. Having three distinct stakeholder groups, the goal is to achieve saturation for each stakeholder group. I wanted to get representation of all stakeholders and thus interviewed individuals until I got similar responses for each stakeholder group (Naaranoja, Kähkönen, and Keinänen, 2014). Interviewees were deemed to be managers involved in the three AR-based groups and are repositories of knowledge. Tacit knowledge gained through daily practice and the AR participation makes the participants the most suitable candidates to achieve the aims of this research. No workers were included in the interview sample, as it is the managers that plan the works for the workers and any AR solutions applied are planned and designed by the managers involved within the AR process. Future research may include the workforce perspectives, but to achieve the aims of this study this workforce group has not been included but represented by their respective managers.

For the Landlord stakeholders, achieving three participants was not possible due to Covid 19 and being unable to contact TfL senior managers who either lost their roles or moved on to other industries, thus I was unable to include them. There were challenges also within the contractor participants, also due to covid-19 and personnel migrating to other organisations, without direct access to them. Since being a member of an action group was perceived as a potentially valuable insight, I decided to include a sub-contractor who worked under the contractor but was also a member of an action group. I believe this to be a valuable source of information for this study. In mitigation to the shortfall in one landlord participant, it is my view that being a member of the landlord team myself, I did have adequate insider information which I could use to make sense of data gleaned from the landlord stakeholder's perspectives. The risk with this approach is insider bias, which is addressed later in this chapter.

Below is a table of stakeholder's profiles, which includes their roles and areas of responsibility. It also includes membership profiles to the SLT, PLF and action groups.

Ref.	Stakeholders	Role	Areas of responsibility	Member of SLT	Member of PLF	Member of Action Group within SLT
L1	Landlord 1	Senior Project Manager	Responsible for specific programmes and overall project manager lead reporting to programme manager. Involved in SLT.	Yes	No	No
L2	Landlord 2	Health and Safety advisor	Safety business partner for TFL commercial development and advisory role for anything to do with safety. Member of SLT	Yes	No	No
C1	Client 1	Senior Project Manager	This role was to listen, feedback, discuss and provide areas of improvement from a client perspective. The role included organising SLT information to be escalated to PLF level so being a member of both SLT and PLF this role could facilitate between the two teams and that the topics and direction of focus was the right one. Member of both SLT and PLF.	Yes	Yes	No
C2	Client 2	Lead Quality Manager	An internal consultant role, sitting alongside projects and taking an overview of client activities to ensure that the client duties were being met under CDM 2015 regulations. Member of SLT.	Yes	No	No
C3	Client 3	Health and Safety Manager	This role was responsible for the approach to safety on the project, mostly for the construction phase of the work. Member of the SLT.	Yes	No	No
PC1	Contractor 1	Lead Project Manager	A senior management representative for the Principal Contractor and the Principal Designer under CDM 2015 regulations. Member of both SLT and PLF.	Yes	Yes	No
PC2	Contractor 2	Health and Safety Manager	A safety manager and advisor to Principal Contractor. Member of SLT and PLF. Member of Action Group.	Yes	Yes	Yes
PC3	Contractor 3	Operations Manager	The operations manager for the Principal Contractor for all works going to site. Member of SLT.	Yes	No	No
PC4	Contractor 4	Operations Manager	The operations manager for the subcontractor working under the Principal Contractor. Member of SLT. Member of Action group.	Yes	No	Yes

TABLE 1 - PARTICIPANT PROFILE

DATA COLLECTION

Primary data is sourced from semi structured interviews. This study takes a relativist ontological and a constructionist epistemological position, thus, multiple realities or perspectives are valuable for this study. This is done in practice by providing stakeholders' perspectives from three groups, namely, the landlord, the client, and the contractor groups. Interviewees' stakeholder perspectives offer valuable insights in relation to contextual settings. Different perspectives illuminate new ideas about AR-based approaches used within this TfL project. Interviewees were asked fourteen pre-defined questions and there were times where I probed deeper into topics that would generate more insight into areas of interest. Interviews were conducted through Microsoft TEAMS software, where the participants were remote from myself. This was due to Covid-19 restrictions and this method was approved by the University of Liverpool Ethics Committee. A specific application for ethics approval was sought for this study. Every participant was asked to participate in the study via email with at least two weeks lead time to the interview. Attached within the email was the "Participant Information Sheet 8th March 2021" (Appendix D), and the "Participant Consent Form" (Appendix C). Participants confirmed consent to the interview prior to the interview through a confirmation email or electronic signature and return consent form. With participant consent, interviews were conducted through Microsoft TEAMS and the interviews were recorded and transcribed electronically. The questions asked were categorised so that they collated data about the stakeholders' involvement, the strategies used to reduce workplace incidents, the effectiveness of the strategies, the challenges encountered in using the strategies, and how these strategies have been institutionalised. The questions were further split up into pre-construction and during construction, as there are significant distinctions in these phases of work. Pre-construction phase focuses on planning and design elements before the works commence on site and during the construction focuses on monitoring and checking elements. Both these phases attract different strategies which manage safety risks, and this distinction is important. The questions asked of the participants are listed below in table 2 where the categories are listed next to group of interview questions.
After the data was collected, the data was tabulated and linked back to the second order themes so that new emerging themes could be found. Each stakeholder category was collated collectively and labelled so that references could be made in the findings section of this study. An example of the landlord stakeholders is shown below as an example of this in table 3. Each stakeholder has a reference label as noted in table 1 above. Thus, each response was collated and labelled as per this reference identification. In the example below, table 3 we had two stakeholders from the landlord category thus referenced as L1 and L2.

The interview questions asked of the participants were designed to ask a general perspective, followed by a focus on the pre-construction phase and then the construction phase. The purpose of using this approach was to separate strategies used in the planning phase from the strategies used in the execution phase. This is an important distinction within project phases and this study wanted to separate how the AR-based approach, among other strategies, was applied specifically and during which phase of the works.

Interview Questions		
	question	category
1	What was your involvement with the Programme Leadership Forum (PLF) OR Safety Leadership Team (SLT)?	involvement/ context/ stakeholder
2	What strategies did you implement in order to reduce workplace incidents?	strategies used to reduce workplace incidents
3	Which of these strategies were done during the pre-construction phase?	
4	Which strategies were used during the construction phase?	
5	Of the strategies used during the pre-construction phase, which of these strategies do you feel were more effective ones in relation to safety related risks?	effectiveness of strategies used
6	Of the strategies used during the construction phase, which of these strategies do you feel were more effective in relation to safety related risks?	
7	Of these strategies, where do you think improvements or refinements could be used to improve the strategies?	
8	What challenges were experienced in implementing these strategies?	challenges encountered using strategies
9	Were there specific challenges in the pre-construction phase strategies that you can highlight and how were they addressed?	
10	Were there specific challenges in the construction phase strategies that you can highlight and how were they addressed?	
11	Which of these strategies, have you used in other parts of the organisation or other projects that you are involved in?	institutionalising of strategies
12	Which of these strategies would you recommend in implementing into other areas or industries you are involved in and why?	
13	How well have these strategies been institutionalised into other areas of your organisation?	
14	Which of these strategies would you NOT recommend in implementing into other areas or industries you are involved with and why?	

TABLE 2 - PARTICIPANT INTERVIEW QUESTIONS AND CATEGORIES

Data collection was tabulated for each stakeholder category and labelled as per table 1 reference to the stakeholder so that new emergent themes and patterns could be found. An example of the landlord stakeholder data collection is shown below in table 3. Similarly, the client and the contractor stakeholder's interview data was collated using the same method. The headings of each section were titled with the aggregate theoretical themes as noted in table 4 below so that these could be linked back to the theoretical categories of this study. Thus, safety management systems, strategy efficacy, implementation issues and/or barriers and Institutional context are categorised as per the table 3 below.

stakeholder / Theoretical categories (2nd order themes)	Landlord	Client	Contractor
safety management systems			
safety system and approach	TfL Pathway governance system - using the TfL declaration checksheet to ensure the contractor has everything in place to be safe and legal. The use of letter of no objection (LONO) used to control the design element - L1 Most of the strategies had already been decided prior to starting to work on the project. But checking of RAMS and documentation was required. Also, incident reporting was key to good safety management by the client, and this could also have an effect of reputation. - L2	data collated similarly for each stakeholder group	data collated similarly for each stakeholder group
safety planning	Pathway documentation and declaration checksheet used pre-construction - L1 RAMS - specifically looking to protect existing infrastructure / pre-construction plan, PCIP, incident reporting, environmental risks, noise control - section 61, competency to do the job - L2	data collated similarly for each stakeholder group	data collated similarly for each stakeholder group
safety interventions	Monitoring the work with supervisors. SLT successfully introduced specialist equipment used on escalators such as stair climbers and specialist access scaffolds. SLT was used to collectively bring together contractors and subcontractors to solve specific problems - so not just the leadership but the workers could bring good ideas to the table. SLT included stakeholders on the delivery teams only - so not global stakeholders. - L1 RAMS monitored during construction - they are never as site specific as they are intended to be. The "Zonzini" was used during the construction phase to make the job safer/easier. Dynamic or point of work risk assessments were used during construction. - L2	data collated similarly for each stakeholder group	data collated similarly for each stakeholder group
strategy efficacy			
Continued…	Continued…	Continued…	Continued…

TABLE 3 – *EXTRACT* OF LANDLORD STAKEHOLDERS DATA COLLECTION METHOD MAPPED AGAINST 2ND ORDER CATEGORIES AND AGGREGATE THEORETICAL THEMES (SIMILAR TABLES EXIST FOR OTHER STAKEHOLDER GROUPS)

DATA ANALYSIS

The semi-structured interviews were undertaken using remote methods due to covid-19. Interviews were recorded using Microsoft Teams software, and consent was provided by each participant prior to the interview. The questions asked of the participants are noted above. Using the questions above, I undertook open, or first order coding followed by second order coding and then aggregate theoretical dimensions. These were defined using a table, see table 3 below. Open coding is the first step in organising the data collated from the interviews, and this is done so that we may begin to relate the data to the broader conceptual issues (Yin, 2016). Second order themes were developed to capture the broader concepts that relate to this study. Second order themes relate to the general, pre-construction and construction phases of the project and thus these categories collate the data that refer to the systemic, pre-construction planning phase and the construction intervention phase. The final column is the aggregated theoretical dimensions which relate to theoretical notions that relate to this study.

Provisional categories and 1st Order codes	Theoretical categories (2nd order themes)	Aggregate theoretical dimensions
Statements about the stakeholders' category; client, landlord, principal designer, principal contractor, subcontractor	stakeholder category	stakeholder theory
Statements about stakeholders' responsibilities and/or role or function	roles and responsibilities	
Statements about the functions of SLT or PLF within TFL	context of SLT/PLF within organisation	
Statements about general strategies used to reduce workplace incidents or manage safety risks	safety system and approach	safety management systems
Statements about strategies specific to the pre-construction phase that reduce workplace incidents	safety planning	
Statements about strategies specific to the construction phase that reduce workplace incidents	safety interventions	
Statements about the effectiveness of strategies specific to the pre-construction phase that reduce workplace incidents	planning efficacy	strategy efficacy
Statements about the effectiveness of strategies specific to the construction phase that reduce workplace incidents	action and intervention efficacy	
Statements about the improvements or refinements to strategies that reduce workplace incidents	enhancing efficacy	

Statements about the challenges of implementing of strategies in general that are used to reduce workplace incidents or manage safety risks	systemic barriers	implementation issues and/or barriers
Statements about the challenges of strategies specific to the pre-construction phase that reduce workplace incidents	safety planning barriers	
Statements about the challenges of strategies specific to the construction phase that reduce workplace incidents	safety action and intervention barriers	
Statements about the use of strategies in other parts of the organisation or other projects	institutionalising strategies	Institutional context
Statements about recommending strategies that could be used in other areas of the organisation or industries	recommended elements for institutionalising	
Statements about how well the strategies have been institutionalised into other areas of the organisation	ease of strategic adoption into broader organisational context	
Statements about NOT recommending strategies that could be used in other areas of the organisation	Institutional blockers	

TABLE 4 - 1ST ORDER CODES, 2ND ORDER THEMES AND AGGREGATE THEORETICAL DIMENSIONS

INSIDER BIAS / ROLE DUALITY ISSUES

Being both a researcher and a practitioner can potentially pose a risk of bias and judgment. Three biases as noted by Bazerman et al. (2008), namely, availability biases, representativeness biases and confirmation biases are all elements of potential risk. Availability bias has to do with decisions being made based on information that is readily available or access to people that is easier to gain, leading to a bias outcome. Representative bias is a bias where two or more situations are incorrectly compared, or not comparing situations that are similar in context. Confirmation bias occurs when data is collated that confirms one's predetermined assumptions, prior to the data being collated.

Having personally expended much effort and energy within the SLT as a practitioner and more so within the action groups, I consider myself as a close insider to this area of work. Of the biases noted above I believe that confirmation bias poses the greater risk, as I intimately know how the solutions were developed within the action groups. Interviews were recorded and transcribed so that I could return to them to ensure what was being said was captured accurately.

The interviews were recorded so that I could return to listen to them and observe with more objectivity as required. However, as I progressed through more interviews, I found that listening carefully to the responses was a skill that I was enhancing over time. As a

researcher I had to ensure that I approached the interviews with an open mind and avoid falling on an area or predetermined conclusions.

My own role as an AR facilitator is important and I believe that bias was minimised due to the participants being peers or higher up in the organisational chart. As such, the collation of data is deemed trustworthy.

From a practical point of view, I thought it might be useful to answer the questions myself. As a practitioner, I am a landlord stakeholder, the lead of all TfL PITTA project construction activities, a member of the SLT, PLF and a lead within the AR groups. I provided the key words of what I believed to be answers I would have provided should I have been asked these fourteen questions in an interview. I have referenced my responses as L3 (Landlord no 3). This exercise is to make explicit answers I would have provided and make myself more aware of the inclinations I had prior to undertaking the interviews so that confirmation biases were mitigated. Being aware of internal biases that could corrupt data is important to identify as a researcher.

Stakeholder Theoretical categories (2nd order themes)	Landlord	Client	Contractor
safety management systems			
safety system and approach	TfL Pathway governance system – RAMS (Risk Assessment Method statement), prestart meetings and surveys, involvement with designers to eliminate risk - **L3**	n/a	n/a
safety planning	Construction Phase Plan (CPP) and RAMS Also SLT and PLF - **L3**	n/a	n/a
safety interventions	Monitoring the work against RAMS - **L3**	n/a	n/a
strategy efficacy			
planning efficacy	CPP and RAMS - **L3**	n/a	n/a
action and intervention efficacy	RAMS and strong site monitoring - **L3**	n/a	n/a
enhancing efficacy	SLT could have been progressed more with more action groups as we had some effective solutions that came out of that platform of collaboration - **L3**	n/a	n/a
implementation issues and/or barriers			
systemic barriers	Document approvals were very lengthy and unnecessarily so. Client sometimes lacked specialist knowledge and relied heavily on TfL to undertake client role - **L3**	n/a	n/a

safety planning barriers	Action groups should have been created to deal with SLT key risk diagnosis. Paperwork often was lengthy and not concise enough for site personnel to use easily on site - L3	n/a	n/a
safety action and intervention barriers	The physical delivery of assets and equipment was a major challenge. The SLT provided a very successful solution to the delivery problem (by introduction of the stair climber) - L3	n/a	n/a
Institutional context			
institutionalising strategies	CPP and RAMS are used with all the pathway products TFL, but we have not rolled out SLT and PLF, something which I believe we will do. - L3	n/a	n/a
recommended elements for institutionalising	The SLT is very useful as it can address specific risk areas and come up with innovative solutions. Within PITTA TfL this was tried and tested, and it could provide huge benefits. - L3	n/a	n/a
ease of strategic adoption into broader organisational context	Adopting the SLT and action group required time and resource and financial support - so aside from these challenges it could be used in the broader TfL context - L3	n/a	n/a
Institutional blockers	None - L3	n/a	n/a

TABLE 5 - RESEARCHERS' RESPONSES TO INTERVIEW QUESTIONS

LIMITATIONS OF THIS STUDY

This research paper explores a specific case study, which is a specific project within TfL. The findings of this research may not necessarily apply to other TfL projects or indeed other projects in general. This research explores the specific details of a particular TfL project which had unique set of characteristics. The case study explores ways that TfL and its stakeholders use to reduce workplace injuries, specifically for this case study and explores AR as one such strategy that may be effective in reducing workplace injuries. The TfL AR approach sought to solve a specific set of problems of which reducing workplace injuries, was one of many. This research explores whether an AR strategy may be effective in attaining this goal. Generalising and institutionalising this concept to all projects is not within the scope of this research (Yin 2014). This study is an action research study, in that it is rooted in a practice-based problem and aims to produce actionable knowledge and has cycles of reflective action. Recommendations are provided later in this study.

ETHICAL ISSUES

Ethical consideration was made and applied for, to the University of Liverpool Ethics Approval prior to any data collection. Considerations in relation to data storage and the associated protection measures were made explicit. Anonymity of the interviewee details were clearly stated as to not compromise the identity of any interviewee. Other ethical considerations to do with conflict of interest of the researcher and employee of the organisation were considered upfront, with proposals made to explicate the strategy if the conflict of interest arose.

Before any data was collated from an interviewee, a personal information sheet and a consent form were sent for their approval. The personal information sheet detailed out the purpose of this research and guidance in the event of the withdrawal of the interviewee, and about anonymity. The consent form confirmed the acceptance of the terms of data collection. It is noteworthy to mention that ethical approval was also gained to collate interview data remotely given the covid-19 pandemic, thus interviews were conducted remotely through the University of Liverpool licenced Microsoft Teams software and recorded and transcribed.

Stakeholders are interviewed to gain perspectives from each specialist interviewee. In this study I also use safety data to develop a deeper understanding of outcomes related to these perceptions. There are instances where the perceptions nominated by the stakeholder hold a certain perspective, and the safety data supports these. There are times where the safety data indicates specific issues with safety methods, and this is used as a contrast to stakeholder perceptions. There are ethical considerations in how the safety data is used in this study and how this data is interpreted.

FINDINGS

INTRODUCTION

The TfL PITTA programme was divided into nine separate projects, namely P1 to P9. Each project had dedicated team overseeing and delivering the works. The project teams typically consisted of project managers, project engineers, construction managers, commercial managers and health and safety managers. The TfL PITTA Programme had unique contractual setup, in that it partnered with an advertising specialist. The advertising partner assumed the client role (CDM 2015), TfL acted as the landlord. Together TfL and its advertising partner oversaw the delivery partner, who was responsible for the design and installation the work. The media assets were installed over several different rail modes, namely, Docklands Light Railway (DLR), TfL Overground, London Underground, Crossrail, and TfL Rail. Each rail environment had its own set of rules for access and approvals.

A statutory requirement of any construction project where more than one contractor is employed (CDM, 2015) is to produce a construction phase plan (CPP). The CPP details out how the principal contractor should be managing the works and the way in which safety risks shall be addressed. The PITTA TfL Project had CPP produced by the principal contractor. In addition to the CPP a document called the project execution plan (PEP) is developed by the client. The PEP details the legal framework, design assurance requirements, health and safety strategies, the organisational structure, and delivery approaches. The PEP is a client document that essentially describes the client's role, and in this case, the landlord's role also, and the CPP is a document that features how the contractor will manage the installation of the works.

Safety risks are a concern to all stakeholders within the project delivery context, in that safety risks must be considered as early as the very first conceptual stage of a programme or project. At a feasibility and concept design, designers must consider the asset being developed and designed and the subsequent risk implications. Size, weight, shape, and material type are all elements that can impose safety risks during manufacture, delivery, installation, and maintenance phases. During the initial design phase (feasibility and concept design) the designers produce a designer's risk assessment (DRA). The DRA provides a list of risks that the designer has considered and assessed, and the residual risk retained after the design has been completed. The DRA residual risks are of particular importance during the planning and installation phase of a project because these risks may impose a safety risk especially during installation.

Within the TfL PITTA project, two organisational platforms were created to manage key safety risks for the programme. Namely the Programme Leadership Forum (PLF) and the Safety Leadership Team (SLT). PLF was developed to involve the most senior management including directors and department heads, and SLT included the project and discipline heads. The PFL and SLT spanned over client, landlord and principal contractor

organisations, thus providing a collective and collaborative approach to addressing safety risks. PLF predominantly focused on overarching direction and focus, whereas in contrast, the SLT was the research and implementation arm in relation to safety risks. The Action Research team was formed within the SLT by myself, as a proposed strategy to solve live safety risks within our programme, the risks that were identified through the SLT mechanism. Once AR routes to solutions were investigated, proposed budgets were offered at the PLF for approval and funding. Some aspects of the AR approach would involve the purchase of equipment for testing prior to formal introduction to the TfL estate. Aside from the PLF and the SLT (including the AR teams), safety risks are managed as noted within the literature review. Different parts of the organisation utilise specific methods such as defining safe systems of work with safety risk assessments, whilst others may focus on the designers' risk assessment. AR was introduced as one exploratory method within our leadership team by myself, given the supporting literature such as Azhar, Ahmad, and Sein (2010). The authors note the failure of addressing issues and risks given the fast-changing environment of construction sites.

RESEARCH QUESTION AND OBJECTIVES

The objectives of this study are:

1. To explore what strategies were implemented.
2. Which strategies were perceived to be effective, needed refinement or improvement?
3. What challenges were faced and how were they addressed?
4. To explore how well these strategies have been institutionalised

The aim of this study is to develop an AR-based strategic framework for which can be applied to reduce workplace incidents at London Underground and TfL.

In the following sections, I will define how the research question was addressed from interview data, followed by the specific aims of this study. Note that within this chapter I shall collate the three stakeholder perspectives, namely, the landlord, the client, and the contractors' perspectives. As referenced in table 1 above, the stakeholders have been referenced as L1, L2, C1, C2, C3, PC1, PC2, PC3 and PC4. Each of these refers to either a landlord, abbreviated to L followed by their allocated number; similarly for the client, this is abbreviated to C followed by the number and principal contractor, abbreviated to PC followed by their respective numbers.

EXPLORE WHAT STRATEGIES WERE IMPLEMENTED

One specific TfL PITTA AR project to do with a key safety risk of the manual handling of a large glass media screen provided a possible solution where new equipment was to be tested and trialled to vertically transport our assets using escalators as transportation and access routes. The equipment or plant was modified specifically for our TfL railway environment and more specifically for our escalators. The primary aspiration in solving

this key risk was to eliminate manual handling altogether. The secondary aspiration was to uncover a whole life-cycle manual handling solution, from delivery, to installation though to the maintenance phase of our media assets. Since the plants' initial use, the potential in achieving these aspirations is possible. Further exploration into whether this plant was used and when was used it to be investigated further. One aim of this research is to establish how this specific solution may have reduced workplace accidents. There is scope to explore further whether the proposed solution introduced new risks, or if problems arose in relation to the procurement methods deployed.

Another example of a key risk identified within SLT was the safety risk of *working at height*. The AR team provided several solutions to mitigate this risk for very specific contexts. This case study explored if our initial intentions compared to was happening in practice though this study's interviews. This case study captures the challenges, how these were dealt with, and where improvements could be found and further probes into how these strategies could be institutionalised.

LANDLORD STRATEGIES THAT WERE IMPLEMENTED

From a general, landlord perspective, the strategies used were noted to be predominantly the TfL Pathway process which fulfils safety, commercial, technical, and legislative requirements within TfL. L2 noted that the risk assessment and method statement (RAMS) which details out the safe working proposals of the works and defines and assesses safety risks, as is required under CDM 2015 regulations, was a main method applied. In addition, strong incident reporting process was followed, according to L2. "Most of the strategies had already been decided prior to starting to work on the project. But checking of RAMS and documentation was required. Also, incident reporting was key to good safety management by the client, and this could also have an effect of reputation" stated L2. Focusing more on the pre-construction and safety planning phase, both L1 and L2 allude to the TfL Pathway process, as defined above, with L2 offering a more specific detail on the requirement of pre-construction information pack (PCIP), as the area most contributing towards the strategy that reduced safety incidents. This has to do with TFL pre-existing information that is provided to the contractor so that accurate information regarding the context of the physical site is established before works on site commence. "RAMS and specifically looking to protect existing infrastructure, pre-construction plan, PCIP, incident reporting, environmental risks, noise control, section 61, competency to do the job", noted by L2. "TfL Pathway governance system, using the TfL declaration check sheet to ensure the contractor has everything in place to be safe and legal. The use of letter of no objection (LONO) was used to control the design element" noted L1.

Both landlord stakeholders noted that the strategies most effective in reducing safety incidents during the construction phase was the SLT (safety leadership team) process that incorporated the AR-based approach. L1, specifically noted the collaborative and collective platform that the SLT offered to all delivery stakeholders. "Monitoring the work with supervisors. SLT successfully introduced specialist equipment used on escalators

such as stair climbers and specialist access scaffolds. SLT was used to collectively bring together contractors and subcontractors to solve specific problems, so not just the leadership but the workers could bring good ideas to the table. SLT included stakeholders on the delivery teams only," remarked L1. Both, L1 and L2 noted the use of the specialist plant used to transport media screens on the escalator environment within London Underground stations. This specialist plant was ultimately provided as a solution through the AR-based approach that was set up to solve manual handing safety risk for the TfL Pitta project. "RAMS monitored during construction; they are never as site specific as they are intended to be. The 'Zonzini' was used during the construction phase to make the job safer, easier. Dynamic or point-of-work risk assessments were used during construction," said L2. The 'Zonzini' was the specialist stair climber plant used to carry heavy media screens up or down escalators for the TfL PITTA project and was modified and developed by the AR team.

CLIENT STRATEGIES THAT WERE IMPLEMENTED

The general strategies used with the TfL PITTA project from a clients' perspective were CDM 2015, a legislative process, and more specifically elements produced through CDM 2015, such as the construction phase plan (CPP) as noted by C1. C3 also alluded to CDM 2015 regulations. C2 commented on the use of pre-construction information (PCIP) and site-monitoring as the predominant elements in reducing safety incidents. Moreover, both C1 and C3 specifically noted the SLT as a strategy used to reduce safety-related incidents. "At tender stage, all the basics including CDM, CDM experience, CDM competence, experience in undertaking similar types of works. Post tender documentation, health, and safety documentation, writing all the plans, some driven from TFL pathway, some from CDM legislation, so CPP, CDM plans to map out roles and responsibilities. SLT and PLF also was adopted to increase collaboration and communication through the supply chains - to home in on some of the challenges, that not only what the client thinks, but what the guy on the ground thinks. Also, through construction works, monitoring was undertaken, such as safety, planned, general inspections. The strategy was to be visible on site, meeting the contractors for not just SPM but PMs and directors," said C1. "Appointment of principal contractor under CDM to undertake the works. The SLT provided the direction to the PC to manage the key safety risks. SLT was at strategic level with the contractor implementing the actions and decisions agreed at the SLT," stated C3. During the pre-construction phase C1 focused on the tender documentation where roles were defined, and the competence of the contractor examined. C2, paid attention to the pre-start surveys and focused on the escalator environment where specialist equipment was sought. "All the tender elements, documentation, all the planning, agreeing key roles, contractor competence, schedules and setting your metrics and targets. So, setting the goal from a H&S point of view. Also having a very experienced contractor" noted C1. C2 stated "Reviewing the design work, feasibility of design, loading review on escalators, manual handling, looked at the use of specialist handling equipment to carry the large loads down escalators." C3 joined the TfL PITTA project at a later date and during the construction phase and stated, "I was not

involved at the preconstruction phase so I cannot say. I was brought in at the construction phase."

During the construction phase, C1 and C3 emphasised the use of SLT as a strategy used in reducing safety incidents. C2 made the point that when programmes approach the end of installation, that most risks would have been identified and addressed and that the SLT was not as readily used towards the end of the programme. "RAMS, monitoring of works through site supervision and shift reports, use of specialist equipment, there were no RIDDOR incidents over a three-year installation. Being at the tail-end of the programme, and working under Crossrail, there doesn't seem to be a formal collaborative platform to assess risks, but the same team has been dealing with these risks previously for four years so we would be hard pressed to come up with new risks now. The main risk now is how the mothballing of the assets and how to protect them at the end of programme," noted C2. C3 indicated, "The SLT was the high-level forum where safety decisions were made. The SLT was comprised of senior managers. Manual-handing risk was looked at specifically, at the SLT where solutions were found to deal with the risk. You led the team that found the 'Zonzini' stairclimber."

PRINCIPAL CONTRACTOR STRATEGIES THAT WERE IMPLEMENTED

From a contractor stakeholder perspective, the general strategies used for reducing safety risks were noted to be risk assessments, operative training, monitoring of the site works, and SLT and PLF, as noted by PC1. PC2 also makes specific reference to people training and accident prevention strategies. There was a distinction made between people and system risks by PC2. System risks are where the proposed works are assessed as to how they affect the existing assets and people risks are assessed to avoid accidents in doing the work. "Plan - do - check -act type of approach. Risk analysis. Telsafe system to record incidents on site. So as PD we did things in design to minimise risk in the first instance. Having work package plans, risk assessments, a lot of training on our site supervision to minimise the risk. Inspection system to monitor site activities and check if procedures were being followed. SLT/PLF are being used currently too," reported PC1. "The key strategy was accident prevention, on a risk-based approach looking at people issues, occupational health risks, and systems risks. System based risks, are how the works affect assets around what we are doing, and people-based risk, is avoiding accidents to people assigned to the works. People based risk involves looking at training, which is a key element, which provides competence, then we look at the monitoring regimes," commented PC2. PC3 refers to mentoring, competence, and information as key elements in reducing safety risks. Workmanship standards were developed for every activity so that the detail of exactly what needed to be done was made explicit in a document format so that it could be retrieved on site. "Information, competence and mentoring. Information was provided so that it was easy to be found and understood. Lots of work went into site briefings, implementing a workmanship standard document. That covered all specific activities to the minutest detail. The workmanship standard provided the finer detail that linked back to the method statement," expressed PC3. PC4

noted risk assessments and pre-start surveys as contributing the greatest towards reducing safety risks.

Strategies adopted during the construction phase PC1 noted the site monitoring and appropriate approaches for specific risks. Specialist type risks required a specialist team to address them and develop solutions. "Ensuring the monitoring was in place, site briefings, toolbox talks, briefing the whole workforce, especially when there are near misses, reporting system called 'Telsafe' to look at trends and incident types. Depending on the type of risk, if it is a specialist type risk then special owners are assigned to deal with it, otherwise if it is run-of-the-mill type risks then we made sure processes and procedures are followed," remarked PC1. PC2 also noted site monitoring that collated leading indicators, as opposed to lagging indicators. Leading indicators allow for proactive approaches such as the AR based approach to be used. "Before site start, people were identified plus equipment. Near misses were looked at. Site personnel were encouraged to report issues on site to ensure key leading indicators were captured so that RAMS were modified accordingly. Examples of leading indicators were manual handling, where we had to do more to find new equipment to solve that issue. KPIs were also used for accident reporting, injuries, near misses," stated PC2. PC3 pays attention to the pre-start information, design documentation and spending time to distil all relevant information on one page for the site operatives. "Information and design documents. Time was spent making the information accessible on one page, drawing. This was the most effective element," identified PC3. PC4 noted site-specific risk assessments as the method, contributing most to reducing safety risks.

The main findings for each stakeholder category are depicted and linked this back the 2nd order themes. This similar the top part of table 3, but with a summary of themes collated for each stakeholder group.

stakeholder Theoretical categories (2nd order themes)	Landlord	Client	Contractor
safety management systems			
safety system and approach	• TfL Pathway • RAMS • Incident reporting	• CDM 2015 • CPP • Pre-construction information (PCI) • SLT	• Risk assessments • Training • Accident Prevention • Mentoring • Competence • Workmanship standards • Pre-start surveys

safety planning	• TfL pathway • RAMS • Pre-construction information plan (PCIP) • Incident reporting	• Role definition • Competence • Pre-start surveys • SLT	• Monitoring • Specialist risk reducing teams • Leading indicators • AR based approach • Pre-start information
safety interventions	• Monitoring of the work • SLT • RAMS monitored during construction • Point of work risk assessments	• Monitoring of the work • SLT • RAMS monitored during construction • Point of work risk assessments	• Monitoring • Specialist risk reducing teams (AR-based approach) • Pre-start information • Site specific risk assessments

TABLE 6- STAKEHOLDER STRATEGIES AND METHODS USED

WHICH STRATEGIES EFFECTIVE, NEEDED REFINEMENT OR IMPROVEMENT?

In this section I present the findings of how each stakeholder group perceived the strategies most effective in reducing safety related risks. The interview questions were designed to collate data regarding strategies used in pre-construction phases and during the construction phases. In addition, the participants were asked where specific improvements could be made to improve the strategies. The TfL safety data is used on the discussion section to compare and contrast against these perspectives.

LANDLORD PERSPECTIVES ON EFFICACY

For the strategies most effective during the pre-construction phase L1, claimed this had to do with ensuring that the selection of suppliers had the relevant experience with TfL. Suppliers that had strong understanding of the TfL station environment and the constraints was critical to the success of safety elated risks claimed L1. L1 stated "The selection of suppliers that harbour experience in the LU, TfL environment with a strong understanding of constraints was critical." There was a correlation with L2 with regards to accurate surveys and understanding the station environment well, prior to works commencing on site. L2 supported the face-to-face pre-start meetings, where high level risks were discussed. "The face-to-face meetings where people talked about high level risks worked well. Getting accurate surveys done," noted L2. "Declaration checklist was critical to success of controlling activities on site day-to-day control. Clear stop points were made explicit on the declaration checklist. The SLT was very good in the implementation of specialist equipment - but this required approvals, testing - which took time to gain," stated L1. L1 also noted "to insist for a fully compliant design would improve control by eliminating risk to do with activities that are not authorised to proceed. The biggest risk was people 'jumping the gun' to do works that were not authorised."

CLIENT PERSPECTIVES ON EFFICACY

Similarly, from the clients' perspective, C1 reinforced the open and frank discussions where stakeholders met to discuss key safety risks. C1 stated, "I felt you got more out of those sessions, those collaborative sessions, that might have been based on a particular document, like reviewing a method statement for example or a construction phase plan, but they become wider discussions than that." C3 specially pointed to SLT as a risk reducing strategy that was effective pre-construction phase. The SLT also supported this open discussion forum where stakeholders were encouraged to discuss safety risks. In addition, C3 noted the required documentation such as the risk assessment and method statement (RAMS) and the CPP (construction phase plan) as effective methods for reducing safety risks at the pre-construction phase. "The preconstruction information, the CPP dealt with the risks on site and how these would be addressed. Also, the RAMS, no activity took place without RAMS. Without doubt the RAMS is the most effective in my view. This is because every activity had been risk assessed. No activity take place without the risk been previously considered, and the site team make sure that the content of method statement is briefed out to the men carrying out the work. So, they were made aware of what the risks were, and the mitigations that had been put in place to make sure they were significantly reduced or eliminated," noted C3. C2's view was that an objective overview with strong similar experience in conjunction with good collaboration between the teams, provided that most effective strategy during the pre-construction phase. "The 3rd party overview, and past experience and first-hand knowledge, and a very good collaboration between teams brought that knowledge to the table at the pre-construction stage" pointed out C2. The construction phase plan and the risk assessment method statement (RAMS) were also noted by the client (C3).

The contractors' perspective in relation to safety risk reduction strategies pointed out to the designer risk assessment (DRA) and robust planning for the work during pre-construction phase (PC1). "Designers risk assessments on pre-construction phase were the most effective, because we can design the risk out of the works, that is the first defence, then second is the planning of the works is a good defence because once the residual risk is left behind, we plan the work with the right procedures and appropriate resource to the work" stated PC1. PC2 emphasised training and behavioural safety as the predominant contributing strategies most effective, prior to the start of site activities. "People, behavioural and cultural safety issues, training. We should have looked at behavioural based safety more, and the feedback from site so we had to tweak the site-based strategy to capture some of those behavioural issues going forward, and this was dealt with by using a fair cultural approach, learnt lessons for the subsequent phases of work," identified PC2. PC3 pointed towards the pre-construction validation check sheet, that listed all required documentation to ensure a safe and legal site. PC4 noted the pre-construction meeting as the most effective strategy. PC4 noted "Kick-off meeting, to show operatives what they were up against. The site layout."

For the strategies perceived as most effective in reducing safety risks during the construction phase, the landlord stakeholder L1 alluded to the pre-construction validation check sheet, and the SLT. "Declaration checklist was critical to success of controlling activities on site, day-to-day control. Clear stop points were made explicit on the

declaration checklist. The SLT was very good in the implementation of specialist equipment, but this required approvals, testing, which took time to gain," noted L1. L2, went on to declare the risk assessment method statement (RAMS) and competence of operatives as the main contributing factors in reducing safety risks. Moreover, the monitoring of the works was also important as noted by L2. Monitoring works requires a predetermined safe method to be defined so that there is something to check against when monitoring, and this is the one purpose of the RAMS document.

The clients' perspective, C1 and C2, were clear about the SLT as being a major contributor to the reduction of safety risks during the construction phase. C1 pointed out, "Definitely the SLT was the single most useful forum that we had. I feel that the PLF didn't add much value, it largely repeated the SLT, and it became more of a reporting meeting. The SLT where robust conversations were had and that is where certain innovations, you know as well as I, the innovation that included the stairclimber, a real targeted focus on 'where are we going with this?" C2 complimented this notion, "SLT and the amount of time we put into the manual handling was the most beneficial. This was very effective in reducing safety risk." C3 noted the construction phase plan (CPP) and the RAMS, which are linked documents. The RAMS document is underpinned by the CPP document. "The CPP because it was a plan of action as to what was going to happen on site, everyone on the project was made aware of their role in implementing the plan. The RAMS is supported by the CPP so on site the RAMS became important too," indicated C3.

PRINCIPAL CONTRACTOR PERSPECTIVES ON EFFICACY

The contractor, PC1, noted site briefings and monitoring as the predominant strategy, most effective on safety risk reduction, where PC2 strongly links the pre-planning as the most effective contributor during construction. "The site briefings and the site policing and governance checks, to make sure the right documentation is on site, and that the site people read them. So, a lot of the briefing and communication is the most important in that phase. Also, specifically briefing all the control measures out." stated PC1. PC1 in addition noted that the "DRA (designers risk assessment) on pre-construction phase were the most effective, because we can design the risk out of the works, that is the first defence, then second is the planning of the works is a good defence - because once the residual risk is left behind we plan the work with the right procedures and appropriate resource/people to the work."

"The pre-construction strategies put in place reduced the safety risks during the construction phase, because this defined how things were implemented, the training that was put in place for deal with people related safety risks came the fore during construction, so having the correct site people plus the monitoring regime made safety risk reduction more effective. Pre-construction strategies and construction strategies, you can't divorce the two. Lessons learnt used during construction were effective because they directly affected the upcoming future works on site," specified PC2. PC3, favoured the distilled information method used to collate all relevant build information on one-page for site personnel and stated "The preparation of the single A3 sheet that

collated all the salient design points and notes was the more effective. This avoided the supervisors having to go through the entire site file to find information. Also having this on paper as electronic formats on site can still be problematic. I'm not sold that the tablet is the end all and be all of everything. Also maintaining competence and information were the two most important elements." PC4 highlights the SLT as the most effective strategy. "Reducing manual handling through SLT. I highlighted the problem with manual handling, and then through the SLT we tried to find ways to reduce the risk. We went off in teams and came up with some ideas," indicated PC4.

Participants were asked where improvements or refinements could be made to improve the strategies used for both pre-construction and construction phases. L1 pointed to the need to drive through a fully complaint design, as opposed to the partially approved method, often adopted to improve programme and noted, "to insist for a fully compliant design would improve control by eliminating risk to do with activities that are not authorised to proceed. biggest risk was people jumping-the-gun, to do works that were not authorised." L2, was in favour of having a simplified approval process for documentation, improving the readability of documents, by reducing their size and increase the monitoring of works on site. L2 clarified this, "RAMS approval process needed to be simplified, a simple spreadsheet collating all comments. Also, the selection of suppliers needs improvements and involvement from SHE team. Monitoring the works more on site. Reducing the RAMS to a readable size, who reads a seventy-five-page RAMS?"

The client was more focused on introducing data driven initiatives through the SLT, where quantitative data could have been collated. C1 pointed out, "We could have used data driven approach for SLT to further drive some of the efficiencies there. I never felt we quite got there, we qualitatively kind of identified some of the issues, like the manual handling. Data from site visits of the client, contractor and subcontractor using their own health and safety inspectors, there could have been a large data set that identified not just weaknesses but good practice. We did the qualitative part quite well but could have improved using quantitative data too." C2 felt that strategies and methods needed to be formalised more and briefed so that shifting of mindsets could been achieved more. C2 noted "formalising the strategies and publishing them, maybe, in a one-hour talk, for people on the ground. Improving communication and provide briefings to change mindsets for people on site, who are used to using muscle power to carry things. Shifting the culture." C3 noted that the CPP needed to be improved by more regular updates. The contractors' perspective pointed out the safety system the contractor used provided enough information to allow the team to introduce changes and efficiencies.

PC1 said, "On both pre-construction and construction phase, the 'telsafe' system. It allowed us to learn a lot more effectively, so it helped us improve our systems as we went along." PC2 chose behavioural safety as something that more should have been done. "We should have looked at behavioural based safety more. If we did this work again, we would look at behaviour model first and training would be built into the training framework. We would look at a climate survey. SLT detected behavioural safety as a key risk, but we did not drive through an action group solution like we did for the manual

handling and working at height. But to change behaviours takes a long time and the cost-benefit is questionable because we had a transient type of workforce, so no lasting effect was going to be realised. We could have used a modified training programme to address this, even though we did an induction, we could have expanded the inductions include those behavioural elements," described PC2. PC3 noted that the a 'permit-to-work' system, where more control on site activities is achieved would been better and noted, "changed the 'workmanship standard' to a 'permit to work' system. The relationship between delivery and design has to be better." PC3 also noted the relationship between the delivery teams and design teams could be improved. PC4 would have preferred for more to be done on manual handling risk solutions, and to improve the mechanical solutions even further.

Table 7 below maps the key points of stakeholder against 2nd order themes.

stakeholder Theoretical categories (2nd order themes)	Landlord	Client	Contractor
strategy efficacy			
planning efficacy	• Experienced suppliers • Face-to-face meetings • Accurate surveys	• Open and frank discussion • Colocation • Objective overview • Experience • Team collaboration • The Preconstruction information (PCI) • CPP • RAMS • SLT and specifically the manual handling solution	• DRA (designers risk assessment) • Behavioural and cultural safety issues • Training • Declaration checklist • Pre-start meetings
action and intervention efficacy	• Declaration checklist • SLT • RAMS • Following procedures • Right skill sets • TfL station environment • Monitoring	• SLT • CPP • RAMS	• Site briefings • Monitoring • The pre-construction strategies put in place reduced the safety risks during the construction phase • The preparation of a single A3 sheet that collated all the salient design points • SLT
enhancing efficacy	• Fully compliant design	• A data driven approach for SLT to further drive some of the efficiencies there.	• The 'Telsafe' system • More behavioural-based safety

	• Avoid unauthorised work • Simplify RAMS approval process • Increase monitoring • Reducing the RAMS document to a readable size	• Formalising the strategies and publishing them • Improving communication • Improvement on CPP updates	• Changed the workmanship standard to a "permit to work" system • Improving delivery and design relations • Enhancing manual handling solutions (SLT)

TABLE 7-STAKEHOLDERS' PERCEPTIONS OF STRATEGY EFFECTIVENESS

WHAT CHALLENGES WERE FACED AND HOW WERE THEY ADDRESSED?

The interview questions relating to the challenges faced in implementing strategies were posed as a general inquiry followed by the pre-construction and then construction phases.

GENERAL CHALLENGES

Presenting the landlord perspectives, L1 noted that the contractor internal conflicts posed a challenge to implementing safety strategies. This led to the site teams trying to enforce control before the works commenced on site and the contractor project managers insisting on progressing the site works on a risk-based approach. Often the landlord, TfL, would intervene and mediate. "Contractor's delivery teams were more stringent on controls, but contractors' project managers were more prone to proceed nonetheless, and this caused internal contractor conflicts", pointed out L1. L2 criticised the lengthy approval process and the time delays this caused. L2 suggested that the approval process could have been streamlined and this could have saved weeks. Furthermore, L2 pointed out the RM3 safety management process and that despite policies being detailed out there, that more work was needed to make safety polices practicable. "Approval process needed to be streamlined, it would have saved weeks. The short window of time to do the works on operational railways, which rushed the job and increased safety risks. Safety policies need to be made practicable to operatives on site. RM3 deals with this from documents and policy to culture. How do people implement this?" indicated L2.

From the clients' perspective, C1 thought that more engagement was needed within the SLT from sub-contractors. Another challenge noted C1 was taking ideas and converting them into practical outputs and that the stair climber solution was a good example. This study would like to point out that the stair climber solution was produced from the AR-based team that was dealing with manual handling safety risk within the SLT team. C1 described, "To get subcontractor buy in into the process of SLT. In the early days you

would turn up and maybe you would get one out of five 'subbies' represented, which kind of defeats the purpose. Some 'subbies' contributed but some thought it was a chore and didn't really contribute too much. The challenge was to take these great ideas and translating those ideas into actionable, tangible outputs. The great example was the stair climber, the LOBO is another good one. To turn a great idea into something meaningful takes a lot of buy in from stakeholders from senior stakeholders up and down the supply chain. It takes directors to get behind it and sometimes it just takes cold, hard cash." C2 noted that the "mentality and culture of the industry was a challenge, and in bringing a safety focus to the workforce." C3 also points out to engagement in support of C1's view but goes on to focus more on the leadership engagement and how critical this is to the success of any strategy to be effective. "For any strategy to work, senior leadership needs to be engaged. Without seeing a leader, no strategy will work. On PITTA project we had senior leadership engagement, and most plans that were agreed were implemented," stated C3.

From the perspective of the contractor, PC1 thought that the people complacency was a major challenge and that shifting attitudes towards safety was a particular challenge. PC1 commented, "The people part is the most challenging, there is a lot of complacency on site, and once people are complacent it is very had to get them off that, and to learn something new, no matter how much briefing you do, you can only get so far if the attitude doesn't change. We learnt a lot about the processes between pre-construction and construction, but people, is the biggest challenge." PC2 viewed the limited timeframe within London Underground stations, to undertake the work was a major challenge. In addition, working on another principal contractor's site was another challenge noted by PC2. "Site access within a limited timeframe was major challenge. Having three productive hours per shift which included getting all the equipment to site plus materials and also make sure the site is cleared too. Reducing any rework by improving quality was a challenge. Also, working within other PC environments was challenging like Crossrail. So, working within someone else's worksite," noted PC2. PC3 pointed to the lack of accurate pre-existing information. PC4 corroborated PC2 on the time constraints to undertake the work in conjunction with the challenges of transporting materials to and from the site within a station environment. PC4 said, "the challenges were the actual physical assets and weights of these mechanical machines and getting permission to use them on TfL escalators. Working with TfL or LU and the approvals, permits and procedures are challenging."

PRE-CONSTRUCTION PHASE CHALLENGES

More specifically on the pre-construction barriers and challenges posed for effective implementation of strategies, L1 confirms that the sheer volume of documentation required to work on TfL assets is challenging; in addition, L2 goes on to indicate the disproportionate amount of time to approve documents was a barrier. L2 pointed out that "the client got financial penalties for reporting incidents, which is why so few incidents were reported, so contractual setup was flawed. Disproportionate amount of time to get stuff approved." C1 thought that the contractors faced challenges initially

because of the "maintenance" mentality needed to shift to a project approach. This posed a cultural challenge, and much time was initially expended trying to rectify this approach. C2 noted that specific resources to do with safety hindered the safety strategies and C3 points out the main challenges were how to drive through the solutions for the key safety risks identified within the SLT. "Having the senior leadership involved helped getting things done on the project. Before works started on site we were unsure of how we were going to handle the manual handling issue and the lifting of equipment to the point of use on site. So, the introduction of the stairclimber helped resolve the issue through the SLT. The main challenge was overcoming the risks identified in the SLT," identified C3.

Pre-construction phase posed challenges in that the site surveys were underestimated. PC1 noted that, "site surveys, we underestimated the importance of survey, and we had a number of incidents, although no-one was hurt, no major health and safety risk to individuals, but there were a lot of close calls that could have become on injury, so we put much rigour to the pre-construction phase. This is one big lesson we learnt." PC2 said that much greater importance had to be given to pre-start survey information. "Getting the correct PCIP information was challenging. Sometimes for obsolete assets, we had to do more intrusive surveys to accumulate adequate information for site activity or developing designs. Client information was not adequate, especially some of the civil, structural information was not readily available so we had to do intrusive surveys to resolve this," recognised PC2. PC3 highlighted the issues relating to unauthorised works being given the green light to proceed and how this proved challenging during this phase. PC3 stated, "the contractor PMs authorising works that were not authorised on the validation sheet. Getting design approval especially on components. Product approval was the hardest problem and trying to get to site without the product approval." PC4 noted the challenges faced with approval of documents and permits within TfL to authorise the works to proceed. PC4 stated "Working with TfL/LU and the approvals, permits and procedures are challenging. Plant approval process and finding the right plant."

CONSTRUCTION PHASE CHALLENGES

During the construction phase L1 thought that the movement of materials within the TfL environment to be most challenging. "The physical delivery of assets and equipment was a major challenge. The SLT provided a very successful solution to the delivery problem," noted L1. L2 noted the need to make policy more practicable for site operations and that complacency on site was another contributing challenging factor, given the repeat nature of some of the works. L2 also highlights the exaggerated TfL document requirement placed on smaller suppliers. L2 states that more flexibility on contractual obligations is needed for smaller suppliers within TfL. "Making safety policy more practicable and documents more site specific. Complacency of workers undertaking repeat-type activities. Monitoring sites on commercial development picked up 21 category A safety breaches, so significant issues on site with tenant fit out works. Retail tenants, some of them did not have a clue, to be honest they probably looked at the yellow pages. Also, the cost to undertake works on TfL is a barrier, as most tenants are unaware of the costs.

The LU barriers is overbearing and over the top probably. QUENSH is useful but places too many demands for a small contractor. FORS (vehicle compliance) is required for all vehicles, but for small contractors this is a cost that is mostly unaccounted for, thus more flexibility on the contractual obligations is needed. No one goes to work to work unsafely, but things happen, usually because of poor planning," detailed out L2.

C1 reflects on the time constraints imposed, as the project progressed, in undertaking site visits and monitoring the works more. C1 also contemplated on how the SLT could have incorporated a data driven element in conjunction with the qualitative approach adopted within the SLT AR-based team approach. "Time is a big challenge in going to site to do inspections. In the beginning this was easier but as the project progressed time became more scarce and trying to keep a level of consistency on site visits became more challenging. Also, the site visits were essentially night shift and that takes you out of the game for a day and a half. SLT struggled to find the space to be data driven, I never felt we quite got there, we qualitatively kind of identified some of the issues, like the manual handling," noted C1. C2 pointed to the challenge of trying to resource the site monitoring for the "ebb and flow" of the works, stating "Ebb and flow of work was challenging so that deploying site supervisors was challenging, it was done on a risk-based approach. So allocating people to the more risky sites.". C3 noted the leadership support that was required to drive through solutions during the construction phase in addition to the transportation of assets. "A major challenge was the carrying of assets and it was dealt with through the SLT. Implementing the solution was another challenge, but the involvement of the senior leadership through all stakeholders helped to drive through the solution through the construction phase," described C3.

PC1 noted that clearer role definitions were needed so that there was less confusion about who was responsible for what element of work on site and noted, "clear roles and responsibilities, having subcontractors who manage their own work and our site supervisors on site, we had to define clear roles because we had several close calls that could have led to an injury, so if there is a gap in what people understand as to what they should be owning and doing, it allows issues to recur." PC2 and PC3 both indicate the TfL time constraints in undertaking works on TfL sites. PC3 details out, "the reduced time on railway environment, if you're not organised, you're going to lose shifts, you're going to lose time. Managing time was the biggest lesson." PC4 indicated that during the construction phase, buried services posed a great challenge. This links to the lack of accurate pre-existing information previously expressed earlier in this section.

The salient points have been collated in table 8 below for each stakeholder against 2nd order themes and the aggregate theoretical dimension.

stakeholder	Landlord	Client	Contractor
Theoretical categories (2nd order themes)			

implementation issues and/or barriers			
systemic barriers	• Internal contractor conflicts • Streamline approval process • Practicable safety policies	• Improve subcontractor buy in into the process for SLT • The mentality and the culture of the industry was a challenge • Senior leadership engagement	• The people part is the most challenging • Complacency on site • Site access within a limited timeframe • Working within other PC environments • Incorrect pre-existing information • The movement of materials • Gaining permission for specialist plant for use on TfL escalators. (SLT) • Working within TfL/LU and the approvals, permits required
safety planning barriers	• Sheer volume of documentation required to work on TfL • Financial penalties for reporting incidents - contractual set-up was flawed • Disproportionate amount of time for approvals	• Contractor had to put on a project CDM hat on, NOT a maintenance CDM hat • Safety Personnel was a barrier • Engagement of senior leadership	• Pre-start survey importance • Getting the correct pre-construction information was challenging • Client information was inadequate • Contractor PMs authorising works that were not authorised on the validation sheet • Gaining design approval especially on components • Product approval was a challenge • Working within TfL/LU and the approvals, permits and procedures were challenging • Plant approval process and finding the right plant was challenging
safety action and intervention barriers	• The physical delivery of assets and equipment was a major challenge • Making safety policy more practicable • Complacency of workers • More flexibility on the contractual	• Time constraints is a big challenge in going to site to do inspections • SLT struggled to find the space to be data driven • Ebb and flow of work was challenging so that deploying site supervisors was challenging • A major challenge was the carrying of assets	• Clearer roles and responsibilities • Time constraints, site access • The reduced time on railway environment • Buried services were a major challenge

	obligations is needed for smaller suppliers	and it was dealt with through the SLT • Implementing the SLT solution was another challenge	

TABLE 8 - STAKEHOLDER CHALLENGES IN IMPLEMENTING STRATEGIES

EXPLORE HOW WELL THESE STRATEGIES HAVE BEEN INSTITUTIONALISED

The interview questions asked of the participants were to do with which strategies were used in other areas of the organisation, which elements or strategies would be recommended, how well these strategies have been institutionalised and which strategies would not be recommended for use.

INSTITUTIONALISED STRATEGIES

The landlords' perspective (L1) notes that SLT could be used in specific environments. An example being the specific solutions that were generated through the SLT addressed key risks within a TfL escalator environment within stations. L1 considers that specific projects within the TfL retail sector would benefit from the SLT AR-based approach. "Using the specific solutions of SLT could easily be used when the environment is conducive to do so, however, at the moment the type of works being undertaken do not warrant this solution. The use of the star climber and the LOBO scaffold system require an escalator environment, this is a specialised area of work. The SLT approach could be used to some degree, however, in the specific area of work with retail tenants this would be less useful given the variety of contractors involved. Over time, tenant fit out area could provide trends that could inform an SLT approach, but it is too early for that now. Perhaps in the landlord works area where there is more consistency of contractors and teams over greater periods of time it would be more useful. Also, within Kiosks and Carts - there would be more benefit," informed L1. L2, felt that reducing the size of documentation so that is more readable, in combination with scalable safety management systems could be institutionalised. "The pre-construction documentation, including the condensing of a seventy-page contract to a five-page one that have all the relevant elements by exception. Using appropriate size of documentation for commercial development projects, off station, such as CPP, RAMS. Safety management systems need to be scalable but not letting contractors off the hook either," pointed out L2.

Although certain members of the client team have not had the opportunity to apply strategies due to new job roles, others, namely, C2 reinforces the idea of independent monitoring within organisations as something that has been expanded into their

organisation. "The inhouse but external-to-project supervision is used. This is to have an independent and objective view of the works. You want to be in a position to be able to stop works when they are not safe, irrespective of programme or cost. The wisdom is knowing where and when to intervene. It also needs the buy in from the company, an independent oversight that reports directly to the director. The SLT, four years into the programme seems to be in the background and it's become part of routine," noted C2. C3, offers strong leadership engagement for any strategy to be institutionalised effectively and stated, "senior leadership engagement, across all levels, is being implemented in current my area where seventy-five percent of senior managers must be engaged statistically for the project to be successful. Also, the SLT is being used. But cascading the strategy so that everyone is engaged and has an idea of what the vision and the strategy is."

The contractors' perspective selects SLT and PLF as established organisational strategies (PC1) combined with the contractors own monitoring system, Telsafe. PC1 notes, "Telsafe system gets used and is rolled out to the wider organisation. We are trying to rollout SLT and PLF throughout a number of projects at the moment." In addition, PC2 points out, "lessons learnt form PITTA, we have replicated strategies in other projects. SLT and PLF, these were key elements in what we learnt from the project, and how we escalated issues. We carried this forward onto other projects now. This encourages leaders to get involved. This gets collaborative approach engaged and highlights any financial impact or support that may be required for solving issues." PC3 notes "The contractors three-day supervisors' course. All the above elements are things that I've introduced to this business and the challenge in implementing them is competence and the lack of it. Maintaining a good relationship with the client is key. We never had major issues or major accidents on PITTA."

STAKEHOLDER RECOMMENDED STRATEGIES

When recommending strategies to be used in other parts of the organisation, L1 recommends the SLT as an effective method in reducing safety risks, because of the collective perspectives offered by the SLT platform. L1 confirms this "the SLT is useful because it differs from lessons learnt, in that people are discussing problems and talking about solutions that potentially offer solutions not initially envisaged. SLT conversations and dialogue offer a valuable insight versus reading a report. SLT offers a variety of perspectives to a solution." L2, insists on the one-to-one meetings and the lessons learnt method and stated, "I don't think you can beat the one-to-one and maybe what was needed was more auditing, the supervisors take it more seriously when you're on site and I think you would have a much higher accident rate if that wasn't in place. Short concise documents, with simple risk register and a realistic programme. Verification schemes like "CHAS" "considerate constructors' schemes. Improving lessons learnt and this is now proposed into Pathway Gate seven, a defined lessons learnt gate review. So, learn lessons and make changes to make it easier for contractors and TfL. Getting the SHE team involved much earlier on in the gate process to help projects in the right direction."

C1 and C3 support the SLT, PLF forums for adopting into the wider business. "I would definitely recommend an SLT type forum. PLF, I would also recommend but to define the terms of reference. Both need a little bit more governance around them in terms of who should be there, what you are trying to achieve, what the agenda is, what the outputs are, and I think PLF especially could become a very useful meeting as well. For me everything is about collaboration, it's about talking, it's about learning lessons. The value is not writing something in a CPP and putting it in a drawer for five years, it's about taking about it, challenging, listening. You could ring fence a fund and everyone gets measured against your budget, and you are measured against health and safety stats, but let's be brutally honest, when you're up against the sponsor or the finance director he's looking at your numbers. That's from client side and contractors' side. So, if you at the outset, ringfenced a certain amount of cash, like a health and safety innovation fund and you got that approved on the outset, that would massively help turning ideas into reality" stated C1. C2 recommends the independent audits for wider adoption.

PC1 also recommends PLF, and SLT with support from PC2. "SLT and PLF is key recommendation. Behavioural safety to be included into induction. Looking at work equipment to reduce safety risks, like we looked at the 'Zonzini' for manual handling, the LOBO for working at height, I would recommend all of these. Also, leading indicators are better than lagging that most people look at," identified PC2. PC3 believes that condensing the relevant design information on one page so that site personnel have easy access to it is highly recommended for reducing safety risks and stated, "collating all design information into one place. You want one place of the work you are doing tonight and where it is detailed." PC4 has specific endorsements for a buried services strategy to be more widely implemented.

STAKEHOLDER EASE OF ADOPTION STRATEGIES

The ease of adoption into other organisational areas must be carefully considered, warns L1. It is important to have consistency of suppliers for SLT to be effective because a constant engagement is required. C1 noted that the restart of the works post covid 19 site-work stop, the SLT was late to be mobilised and incident began to rise. "When covid hit, the works were stood down for six months and when the works restarted the SLT and PLF were not restarted and there were a few incidents on PITTA Crossrail sites, on the contractor's side, no injuries but a number of near misses, and so we had not institutionalised this brilliantly on our own project. All three stakeholders had to put their hands up and say, 'works have started on site - let's get the SLT going again.' It just got missed in the chaos and pandemonium of COVID. SLT was the forum to discuss and challenge key personnel changes. So SLT could have indirectly contributed towards avoiding these incidents," said C1. "It has been institutionalised well and also used in the day-to-day construction works" stated C2. C1 believes that the SLT platform could have avoided such incidents. Independent monitoring has been easily expanded in the client organisation according to C2. C3 felt strongly about consistently repeating the organisational vision for strategies to be more easily adopted stating, "it is a journey, because one of the core concepts of change management that I'm involved in now is

repeatedly describing the vision. Before any change can be embedded, it has to be repeated, repeated, repeated until everyone understands it. So, it's a journey not a destination."

PC1 explained that there is nothing new about the way things are done within their organisation, but small refinements are often done to improve safety. PC2 confirmed that SLT and PLF are strategies that have been easily adopted into other organisational areas. PC3 noted that some of the strategies set up by this stakeholder were still in force, despite moving onto other organisations and projects. PC4 noted that buried services strategy has been easily expanded into the wider context, and that SLT would be used if all stakeholders agreed to implement it.

The final question asked of stakeholders was to detail out any strategies or safety approaches that would not be recommended for implementation within their organisations. Landlord, L1 thought that all strategies were to some extent useful, but some more useful than others. "All approaches were useful to some degree, maybe some more that others, but there are no elements that would not be recommended, but perhaps question their usefulness,' pondered L1. L2 was explicitly clear about getting rid of bureaucracy within TfL, which was perceived as a negative contributor towards safety and considered the following, "Get rid of the bureaucracy, if safety procedures are not followed you can end up with a fatality."

C1 and C3 also confirmed that all discussed strategies had a usefulness to varying degrees. C1 went further to state "I would definitely recommend an SLT type forum. PLF, I would also recommend but to define the terms of reference both need a little bit more governance around them in terms of who should be there, what you are trying to achieve, what the agenda is, what the outputs are, and I think PLF especially could become a very useful meeting as well. For me everything is about collaboration, it's about talking, it's about learning lessons - the value is not writing something in a CPP and putting it in a drawer for five years, it's about taking about it, challenging, listening. You could ring fence a fund and everyone gets measured against your budget, and you are measured against health and safety stats, but let's be brutally honest, when you're up against the sponsor or the finance director he's looking at your numbers, that client side and contractor's side. So if you at the outset, ringfenced a certain amount of cash, like a health and safety innovation fund and you got that approved on the outset, that would massively help turning ideas into reality." C2, recalls a previously tried scheme called 'close call cards' that made more sense from an office perspective that on site, and recommends against using this on site. "The lack of communication was a weakness that we don't want to repeat. Close call cards, great for the office but not good for the shop floor, so would not use this again," reflected C2.

PC1 specifically noted that using sub-contractors without a strong monitoring regime in place would not be recommended. "I would not recommend subcontracting without having a strong monitoring regime in place, even though we have install partners that are accredited for health and safety, there needs to be that healthy tension between contractor and subcontractor to make sure they get briefed correctly and the right

people are engage. So, without monitoring, complacency sets in. So monitoring is twofold, making sure the suppliers have monitoring in place and that we also monitor them," noted PC1. "If it's a long-term project with a fixed resource, the SLT and solving behavioural safety would be beneficial. For transient type workforce perhaps, other methods could be explored, like the induction approach," stated PC2 who focused more on a consistency of resource and that without this in place, behavioural safety is more challenging to implement. PC3 had personal experiences with stopping work and noted, "refusing to work when designs were not fit for purpose has cost me personally, probably my job, this worked against me. I didn't feel I got the support from the rest of the company for standing up to this. Under CDM I was working as PC and I felt that it was not recognised, we have working at height, working on electricity, manual handling and we had not one injury. I don't think this got recognised."

Table 9 below notes the key points for each stakeholder against 2nd order themes and the aggregate theoretical dimension.

stakeholder / Theoretical categories (2nd order themes)	Landlord	Client	Contractor
Institutional context			
institutionalising strategies	• Specific solutions of SLT could easily be used when the environment is conducive to do so • Condensing the pre-construction documentation • Safety management systems need to be "scalable but not letting contractors off the hook either"	• I haven't had the opportunity yet • An independent and objective view of the works • Senior leadership engagement	• Telsafe system • SLT and PLF • The contractor's three-day supervisor's course • Buried service strategies • SLT and specifically an Action group
recommended elements for institutionalising	• the SLT is useful because it differs from *Lessons Learnt* • One-to-One contact • Short concise documents	• SLT • PLF • Independent monitoring resource	• Telsafe system • SLT and PLF • Collating all design information into one place • Buried service strategy
ease of strategic adoption into broader organisational context	• The SLT approach could be used	• SLT and PLF Objective independent monitoring • Repeatedly describing the vision	• Small refinements - site validation checks, are being used site wide • Buried services
Institutional blockers	• All approaches were useful to some degree • Remove bureaucracy	• All had an element of value • Lack of communication • None	• Strong monitoring regime • The SLT and solving behavioural safety would be beneficial. • Refusing to work • Stopping unauthorised work • No - anything that improves safety must be implemented

TABLE 9 - STAKEHOLDERS AND INSTITUTIONALISING STRATEGIES

DISCUSSION

In this section, I will discuss the findings from the previous chapter and link these to the literature theory. Safety culture is also looked at given the organisation context. This will be followed by actionable knowledge, implications for practice, limitations, research directions and finally the researchers' reflections.

DISCUSS FINDINGS AND THE LINK TO LITERATURE THEORY

In table 4, 1st order codes, 2nd order themes and aggregate theoretical dimensions have been tabulated. These are linked to the interview questions so that data can be collated and linked to second order themes. A cluster of second order themes aggregate to form wider theoretical concepts referred to as aggregate theoretical dimensions.

STAKEHOLDER PERSPECTIVES

At TfL we want to create an environment that is safe to work in. Innovation that is developed with stakeholders can be valuable to the organisation (Dougherty, 1992). Innovation is especially relevant to this study because the valuable information sits within the stakeholders that have been engaged within the AR-based approach within TfL. Innovative ways were developed to address specific work placed problems and the AR-based approach engaged stakeholders to help solve them. The ethical contribution is that TfL and its stakeholders have a duty of care to ensure the workforce is provided with a safe environment to work in. Freeman *et al*., (2007) goes on further to identify the reciprocity where the workforce is treated well and in return, they treat the organisation well. Reputational contributions are also factored into the stakeholder notion, and an organisation that is safe to work in positively influences the perception of an organisation. Having collated perspectives from the delivery stakeholders within the TfL PITTA project, the perceptions and the views of the stakeholders contribute greatly towards improving the way we manage safety risks, and highlighting areas where challenges were faced and potential new ways to further improve our safety systems.

In this study we have collated three stakeholder perspectives, namely landlord, client, and contractor. All three are delivery stakeholders involved in the TfL PITTA project and involved within the SLT or PLF. Table 1, summarises the participant profile and allocates the stakeholder category and number to each participant. In addition, members of SLT, PLF or AR team are captured within this table. There are opposing views to the value of a stakeholder perspective (Williamson, 1975) whereby stakeholders place profit over ethical grounds. I believe this to be a less significant issue in this study, because TfL is a public body not driven by profit but rather benefit to the customer, and specifically in our study there is also the issue of reputational damage should incidence occurrences increase, providing the perception of an unsafe organisation to work in. This would be detrimental to our organisation. TfL and its stakeholders have strong common ground in ensuring that operatives undertaking TfL projects are kept safe.

Safety management systems are defined within the literature review chapter of this study. Figure 2 depicts how safety management systems relate to theoretical, practical and compliance levels. The findings (table 6) show the methods, strategies, and approaches that each stakeholder group selects as the method that reduces workplace incidents. Figure 2 depicts safety management systems comprising of methods, techniques, and audit tools on a practical level. These are governed by standards and underpinned by theory. Thus, risk assessment method statement (RAMS), incident reporting, construction phase plan, pre-construction information, accident prevention methods and surveys are all methods, techniques and audit tools that contribute towards a safety management system at a practical level. TfL Pathway is a TfL governance system and has bases in several areas in figure 2, from standards, to practical methods and theoretical levels.

All stakeholders nominated the SLT and AR based approach as a strategy used to reduce workplace incidents. SLT was a collective of stakeholders, who worked collaboratively to identify key safety risks for the TfL PITTA project. Thus, SLT, is categorised as a methodology within the safety management system. The AR based approach was also a specialist method that is underpinned by critical theory in relation to figure 2.

Using the secondary safety data over the 2018 and 2019 period, there are no reported incidents or accidents related to manual handling or working from the specific scaffold developed for working at height on escalators. The AR team specifically solved these two problems for the TfL PITTA project and implemented them over this period. We know that the solutions developed through the AR approach reduce safety risk, because they are assessed for risk through the risk assessment method. The risk assessment method demonstrates that the risk before the implementation of each solution is compared to the risk with mitigations in place. The safety risk is significantly reduced. Thus, the AR solutions reduce safety risks or eliminate them. It is not possible to suggest that the AR based approach reduced workplace incidents because we have no previous comparisons to use on this TfL project. However, the safety data indicates no incidents related to AR solution specific manual handling incidents or working at height incidents. If these AR based solutions were not effective, incidents or accidents would have been detected over this period. This suggests that the stakeholders' nominations to use the AR based approach has validity as an effective method to reduce safety risks and since we also have no indication of near misses or incidents over this period of time, it could be argued that the solutions sought through the AR mechanism contribute towards the reduced incidents.

Form a legal standpoint, ROGS (2006), Health and Safety at Works Act (1974), and CDM 2015 all underpin the TfL Pathway project control process. This was noted in table 6 by the landlord stakeholder and CDM 2015 was also noted by the client. In addition, the elements noted such as risk assessments method statement (RAMS) and construction phase plan (CPP) in table 6 by the stakeholders, are specific regulatory requirements within the CDM 2015 regulations.

SAFETY MANAGEMENT SYSTEMS

As noted within the literature review chapter, there are several key perspectives in relation to safety management systems. Safety management systems are developed from accident and incident models, and Deming (1950) helped from the PDCA (plan, do, check, act) method as a control process. RM3, which is used on TfL as a safety management system is underpinned by this control process. The legal perspective is discussed above and as noted, the TfL PITTA project stakeholders all elected legislative requirements, or components of these legal requirements as effective strategies in managing safety risks. There is also a medical perspective that the literature provides, lumber-disc surgery (Fouquet *et al.*, 2018.) where construction is noted as significant contributing sector of such injury. Manual handling is a high contributor towards work-related ill health as noted in the literature review. Within our findings, and where strategies were perceived to be the most effective in reducing safety risks, the manual handling solution, was specifically noted by the client, and moreover the contractor would have liked to have seen this manual handling solution progress even further (Table 7). The manual handling solutions were developed through the AR based team within the SLT. Finding mechanical solutions for manual handling problems, prevents musculoskeletal issues to our workforce that stem from manually handling assets onto our infrastructure. The AR team tested three possible solutions, where manual handling was one such approach. The alternative two solutions were mechanical. The AR assessments post implementation showed that manual handling was discounted for specific conditions, and the mechanical solutions were the preferrable option where vertical transportation was involved, so where there were steps or escalators involved in transporting the assets to the final installation point. There were specific instances where manual handling was found to be an acceptable method of use.

SAFETY LEADERSHIP

Organisational culture plays an important role in promoting safety issues in the workplace. There is a need for leadership commitment, where leaders must demonstrate their commitment to safety and set the tone for the organisation. In addition, employee involvement is necessary to safety initiatives to be successful (Conchie, 2013; Hoffmeister *et al*., 2014; Stiles, Ryan, & Golightly, 2018). Furthermore, training and education equips employees with the skills required for performing their duty safely and to identify potential risks. Recognising and reinforcing behaviours in conjunction with continuous improvement enhances the safety culture of an organisation.

Attitudes towards safety is important in generating the intrinsic motivations and safety culture that sustain any safety aspiration. At TfL PITTA project the commitment from leadership and the attitudes towards safety promoted a strong safety culture.

It is important to be trusted as a safety leader and the collaborative AR approach adopted within TfL ensured the trust of delivery stakeholders as the teams collectively sought solutions to improve the safety for the PITTA programme. Active management is

proactive and focuses on prevention and AR allowed the solutions for specific safety risks to be eliminated or minimised.

Supervisor engagement in safety leadership is crucial in relation to safety outcomes (Conchie, Moon, & Duncan, 2013). At TfL PITTA and the delivery stakeholder's supervisor engagement is crucial to the implementation of safety solutions found through the AR process.

Without safety leadership within the TfL PITTA project, the SLT, PLF and AR teams would not have been formed in the first instance. Safety leadership is essential for achieving good safety outcomes and for introducing safety initiatives.

SAFETY CULTURE

Safety culture within and organisation is the result of three components, namely, psychological, situational, and behavioural factors (Cooper and Phillips, 1995). At TfL we have an existing organisational strategy and a comprehensive safety system. AR was an approach we implemented within the TfL PITTA project to solve specific complex safety problems. We do not fully understand why or how the TfL safety teams became engaged in adopting this approach. Glendon and Stanton (2000) point to safety culture as one such possible explanation. Bisbey *et al*. (2021) defines the required enabling and enacting factors that activate and engage safety strategies and approaches within organisations, as depicted in figure 6. Organisational enabling factors need to be in place, and these consist of two categories, namely, leader commitment and prioritising safety, and policies and resources for safety. Within the TfL PITTA project, and more specifically the SLT, PLF and AR teams, we had director involvement of all delivery stakeholders. Safety policies are firmly in place and resources, regarding personnel and finance were made available for the AR team to develop and purchase plant and equipment. The PLF team consisted of director level engagement specifically designed to enable these functions.

The second category of safety culture enabling factors, consists of group enablers, and categorised into two enablers, cohesion, and psychological safety. Cohesion as defined by Bisbey *et al*. (2021) is the commitment and support of team members, and the AR approach using the various delivery stakeholders encouraged cohesion amongst the teams. This is because the AR approach is a democratic, and collaborative platform to work within. AR is not restricted by contractual obligations but focused on solving safety issues by all the delivery stakeholders. Moreover, phycological safety is supported and enabled through AR because as solutions develop, the AR teams must be honest about what is working or not and not in a judgemental way. There are challenges and risks in developing novel solutions and having a team that is willing and supportive through these periods is required for the solutions to become fully enabled within TfL. Individual enabling factors consist of safety related knowledge, sense of control and an individual commitment to safety. Within the SLT and the AR teams we had health and safety specialists from each stakeholder group. The AR team was fully autonomous in that we were free to explore options and procure specialist plant and equipment so that it could

be tested and trialled for use on TfL. In addition, the setting up of SLT, PLF and the AR teams was a demonstration of prioritising safety, because it was the primary function of these teams, to solve the issues TfL PITTA had with specific safety risks. The SLT, PLF and AR teams are not a standard method within TfL projects.

Enacting behaviours as per Bisbey *et al*. (2021) figure 6 are explored within TfL PITTA project. Enacting factors consist of four categories, namely, communication and information exchange, teamwork and collaboration, incident reporting and fair rewarding and punitive behaviours. Regarding information and communication exchange, these were problematic areas as per stakeholder interviews, because more could have been done to communicate the AR solutions that were achieved. There were numerous control processes that needed to be enabled to implement the solutions. The TfL safety data also in period nine in 2019 picked up on a specific near miss, where the working at height solution was being implemented. This was a specific bespoke access tower that was developed through the AR team. The tower was not used as per the agreed safe system of working. The interview data and the safety data suggest that more could have been done in these enacting behaviours area. Teamwork and collaboration within the SLT, PLF and the AR team yielded positive safety outcomes, insofar as finding solutions that reduced or eliminated safety risks. Interview data, and highlighting figure 12, collaboration and colocation are detected as effective area for reducing safety risk. The TfL safety data also shows that quarter of a million person hours were achieved with arguably few incidents, twenty-three in total, which is a positive safety outcome.

AR by design evokes collaboration, and this may have played an important role in encouraging stakeholder collaboration and teamwork within the TfL PITTA project. Incident reporting is a well-developed system within TfL, however, given the nature of the TfL PITTA contractual set-up, the media specialist takes on the role as the client. By assessing the number of incidents raised in 2018 versus 2019, there is an indication of five incidents versus eighteen respectively. The number of person hours worked is similar in both years so this may suggest less safety monitoring activity on sites. In addition, we know from the interviews that the contractual setup had some problematic areas regarding financial penalties being charged for incidents reported. This penalty indicates a flawed approach in incident reporting and in the fair rewarding and punishing enacting behaviours required for safety culture to thrive. In 2019, the incident levels are more than in 2018. Nevertheless, the total is low compared to the person hours worked. Although incident reporting is adequate, the findings suggest there are areas in both safety reporting and how these are rewarded or punished needs to be revisited.

In summary, the enabling factors, and enacting behaviours regarding safety culture, as depicted in figure 6, are well embedded within the TfL PITTA project. Safety culture proves the environment for safety initiatives such as AR to be effective and it also provides the safety outcomes as noted by the interviewee data and is supported by the incident levels within the safety reports. Safety culture is important for AR to work, because without these enabling factors and enacting behaviours, the TfL PITTA stakeholders would not have been engaged or have stayed motivated to see the solutions, sought though AR, to a successful completion.

MANAGING SAFETY RISK

Managing risks on construction projects essentially fall into two categories, probabilistic and systematic approaches, as noted in the literature review. Probabilistic approaches as defined by Miller and Lessard (2001) and Mills (2001) consider work activities in uncertainty terms. Within TfL this is undertaken within the work risk assessments and safe systems of works (RAMS) prior to works commencing on site. In addition, the construction phase plan (CPP) also defines how risks will be managed within a project. Both the RAMS and the CPP are legal requirements for construction projects under CDM 2015 regulations. Our findings above detect RAMS and CPP in several instances within table 6, where stakeholders nominate these approaches as methods used to manage safety risks. Moreover, in table 7, where stakeholders were asked about the more effective methods used to reduce safety related risks, RAMS and CPP were methods elected by the stakeholders. The second approach for managing risks is systematic, and for this approach we have two specific methods within TfL, namely the RM3 safety management system and TfL Pathway as systems that address safety risks in a systematic way. In table 6, we can detect the TfL Pathway is offered by the landlord stakeholders as a safety related risk-reducing method.

RAMS (Risk assessment method statement) is also referred to as a SSOW (Safe System of work). In the existing TfL safety reports these are noted as SSOW. A 'near miss,' is the term used to define when a safety breach has the potential to cause damage to persons or assets. It is not an injury or an accident. Near misses are used to report close calls on safety breaches so that safety interventions can be actioned to help reduce and prevent accidents. Using the exiting safety data, it is tricky to isolate the CPP as a specific method because the CPP is the overarching document that underpins the specific safe systems of work. It is possible, however, to identify SSOW breaches, insofar as incidents which are clearly identified where the agreed safe system was not followed. There were three near misses detected in 2018 related to not following the SSOW. In 2019 there were eighteen near misses of which nine were related to operatives not following the SSOW or the SSOW had not been briefed out correctly. Thus, in total the number of near missed over the 2018 and 2019 period are twenty-three. Two of these were injuries. the total hours worked on the TfL PITTA project was nearly two hundred- and fifty- This is not a high number given the thousand-person hours by the end of 2019. In addition, the injuries were not listed as RIDDOR (The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013) injuries. These are significant injuries with lost work hours. There is a viable argument to be made that the SSOW is effective in reducing injuries because the near misses we can detect have to do with not following the SSOW rather than the SSOW itself being the issue. An important observation to make also is that the RAMS or SSOW by itself is not effective unless it is communicated and briefed to operatives undertaking the work and that it is monitored closely so that the agreed safe methods are followed on site. On its own it is not effective unless communication and monitoring are also included.

SAFETY RISK INTERVENTIONS

Safety risk interventions are specific involvements that are imposed on a project in some way, with the view to reuse safety risks. Van der Molen *et al*. (2018) suggests the following categories, namely, legislative, educational, informational, facilitative, and multifaceted interventions. Educational interventions may have an impact in reducing safety related risks (van der Molen *et al*., 2018). In table 6, the contractor stakeholder provides "workmanship standards" as one such intervention. Workmanship standards were developed by the contractor to make explicit specific activities that relate to the proposed works. These standards were a detailed, best practice, safe method of executing specific tasks on site. In this sense they were educational to the installer. These were over and above the required RAMS (risk assessment method statement) as a method to ensure adequate level of detail was provided to execute the works safely. This notion goes even further, where we have the same intervention mentioned again as not only effective but elected to progress the notion further and develop the "workmanship standards" to "permits to work". This enhancement which offers to improve efficiency, involves that the material offered as a "workmanship standard" to require a higher level of controls that would require the official acceptance of such standard by the installer and an endorsement by the managing team of that installer.

Legislative interventions are a strong contender of safe managing interventions within TfL because it is a heavily regulated environment. Legislative requirements or components of such requirements are collated within the stakeholder interviews. Table 6, notes CDM 2015, RAMS (risk assessment method statement), CPP (construction phase plan), monitoring and prestart information as legislative interventions. These are picked up again in table 7, where more efficient interventions were requested. It is also noted that in table 7, under all second order themes that RAMS (risk assessment method statement) is proposed as a planning and an intervention method for reducing safety risks but could do with improvement in reducing the document sizes to something more easily readable. Given the complex railway environment, it is often the case where these RAMS (risk assessment method statement) are seventy-five pages long. "Who reads a seventy-five-page RAMS?" asked L2, a safety adviser. This is a valid point as given the short window of opportunity to undertake the works on stations, this length of documentation needs to be condensed to make it easier to read for the operative on site. In relation to information interventions, we do have RAMS (risk assessment method statement) as one such intervention, even though it also appears as a legislative requirement. This is because this documents also contains specific information to do with specific hazards or safe practice methods. These are most effective when monitoring regimes are in place too and this is also pick up in table 6 and table 7. More specifically, the TFL PITTA may have gone further according to the client stakeholders in table 7, where improving efficacy could have involved formalising and publishing solutions that were developed through the SLT. The next intervention to note within the TfL PITTA project was a multifaceted intervention that the SLT provided for both the manual handling and the working at height safety risks. SLT is noted throughout table 6 and table 7, and the manual handling solution developed through the SLT, and AR-based approach is specifically

noted in table 7. This study proposes that this was a multifaceted intervention because it contained educational, informative, and legislative components to the overall solution.

AR based approaches are also noted in the literature review, as an approach that may be appealing to complex infrastructure projects that exhibit emerging risks. Azhar, Ahmad, and Sein (2010) argue that this approach offers a practical way, in solving workplace problems. Within this study, we have noted that aside from the usual project requirements that are done for "business as usual" there is a significant collation of data that suggests that SLT and the AR based approach was a method applied to reduce safety risks (table 6) and it was perceived by the stakeholders to be an effective safety reducing method (table 7). Notable areas where further improvements could be made are also noted with this approach, and we discuss these further in the following sections. In this section we are connecting the literature theory to the findings only. "In short, AR is particularly relevant in solving construction industry problems that require innovative and untried solutions. Such solutions are inherently risky and thus go against the grain of the construction industry that assiduously seeks to avoid risk." (Azhar, Ahmad, and Sein, 2010, p. 97)
This study proposes that innovative solutions were developed, and at times there were risks being considered that would not typically be tolerated within TfL, so very strict site controls were developed alongside the trial and testing that I oversaw for the specific solutions that we tested through the AR approach.

RESEARCH QUESTION

"What lessons can be learnt about the perceived effectiveness, implementation challenges and the institutionalisation of the AR based safety strategies in the TfL PITTA project."

The AR based approach used within the TfL PITTA project was embedded within the Safety Leadership Team (SLT). The action group was formed to tackle specific safety risks that were identified within the SLT. The SLT comprised of a collective stakeholder group which was involved with the delivery of the TfL PITTA project. As such it comprised of the Landlord (TfL) and the Client (Advertising Partner) and the Contractor. The contractor stakeholders comprised of the main contractor and subcontractors. The action groups formed were a collection of stakeholders that were assigned to find solutions to key safety risks identified within the SLT. The Programme Leadership Forum (PLF) was the steering group for SLT and comprised of director level stakeholders and senior managers. I was a member of both the SLT and the PLF, in addition to leading two action groups that were formed within the SLT.

To address the research question, I will follow the logic of the objectives made explicit at the start of this chapter. Initially we explore which strategies were used, how effective these strategies were, followed by the challenges faced, then note some points on institutionalising these strategies and finally assess how effective the AR based strategy has been in reducing incidents to our workforce within TfL PITTA project.

For the general strategies used to reduce workplace incidents, as is summarised in table 6, all stakeholders elected regulatory or legislative strategies or at a minimum a regulatory element. Under CDM 2015, the regulatory document governing construction works in the UK, risk assessments, construction phase plans, safe systems of work, monitoring, and competence are all included with the legal requirements of construction projects. The landlord and client chose more strategic notions, whilst the contractor stakeholders homed in on more detailed elements that are a component of the higher-level strategic systems. This is not unusual, in the sense that the landlord and client co-ordinate projects at a more strategic level, whereas the contractor produces a more detailed output. In the safety planning phase, or preconstruction phase, the data collated suggests the usual "business as usual" project deliverables, thus, RAMS (risk assessment method statement), pre-construction information, pre-start surveys. However, both the client and the contractor begin to introduce SLT and AR-based approaches. This is important, because the questions asked of the participants relate to strategies used during the pre-construction phase and ones that specifically perceived as effective in reducing workplace incidents. Similarly, in the construction phase, the strategies or approaches noted are again the legislative requirements, but in this instance, all the stakeholder groups identify the SLT or AR-based approach as an effective, construction phase strategy to reduce workplace incidents.

The next line of inquiry within the interviews, posed questions specifically to do with perception of effectiveness of the strategies used in relation to safety related risks. Table 7 summarises the key themes from the data collated for each stakeholder group. During the pre-construction phase, the landlord and client placed value in the face-to-face meetings and open and frank discussions. The client specifically noted the collaborative approach and colocation of stakeholders, including the SLT as strategies or approaches for this phase. The contractor stakeholders elected behavioural safety and design risk assessments amongst the regulatory requirements. During the construction phase, all stakeholders nominated SLT as an effective safety related risk approach, over and above the typical regulatory items. The final question asked in this category, had to do with areas where improvements could be made. I will focus only on the AR based elements to align with the research question. The client stakeholder noted that the SLT could have included a more data driven element to drive further efficiencies there.

The next stage of inquiry probed into specific challenges faced in implementing the strategies and how these were addressed. Table 8 summarises the stakeholder findings above. I will focus on the SLT or AR based approaches to address the research question. In general, the client stakeholder thought that more engagement was needed from subcontractors, the suppliers that support the main contractor. The contractor stakeholder noted the challenges faced with gaining permission within TfL to use specialist plant on escalators. Specific plant to be used on TfL escalators was developed as a solution though the AR team. Challenges faced during the pre-construction phase strategies were specifically noted by the contractor stakeholder as to the difficulty in gaining TfL approvals for specialist plant used on TfL escalators. During the construction phase, challenges were noted by the landlord stakeholder as to the difficulties faced in

transporting assets and equipment within TfL stations. The client stakeholders thought that it was challenging to encourage a more data driven SLT approach.

The next phase of inquiry explored where strategies had been used on other parts of the stakeholder organisations, and elements which stakeholders recommended, and how well these strategies had been adopted. The contractor elects that SLT and PLF are used and recommends the use of this approach. Both the landlord and client recommend the SLT and PLF approach and the client confirms the ease of adoption with their organisation. The SLT and PLF are not detected as "not recommended" when the interview questions were posed to the stakeholders.

The research question asks, "what lessons can be learnt about the perceived effectiveness, implementation challenges and the institutionalisation of the AR based safety strategies in the TfL PITTA project." Given the findings in this chapter, we can confirm that AR type approach was used, especially during the construction phase of the works, and that it was perceived by the stakeholders as an effective approach in reducing safety risk. Despite the perceived effectiveness of this approach this study also uses the existing safety data to support or discount some of these nominated safety strategies. More could have been done to increase the effectiveness and provide better quantitative data to detect areas of further improvement. Perhaps in future research, more safety resource and collection of more specific safety data is one area that can ringfenced for future research. Applying the AR based approach did not come without its challenges. Namely, the lengthy approvals required from TfL, especially for specialist plant proposed as viable solutions to solve the manual handling safety risk. There was wide stakeholder support for institutionalising the AR based strategy as an effective method for reducing safety risks. None of the stakeholders recommended against the SLT, PLF or AR group approach.

ACTIONABLE KNOWLEDGE

An AR based approach was implemented within a TfL project, namely TfL PITTA project. As such we have had the first cycles of actionable knowledge using AR. At the start of this study, our practice-based problem is that we did not know how or why these strategies have been effective in reducing workplace incidents. We know from the TfL safety data that incidents related to the solutions developed though the AR approach were not evident over the application period. We also know that in one instance, we eliminated the manual handling issue in solving a very specific safety problem through AR. We know that for the working-at-height problem solved through the AR process, we reduced the risk significantly by developing a specialist safety access platform, bespoke to our problem. The safety outcome of these solutions is that there were no safety related incidents noted throughout this period.

This study explores what strategies have been used within TfL PITTA project, collating stakeholders' perspectives through one-to-one interviews. Further aims of this study

where to explore which strategies were more effective in reducing safety related incidents and how these strategies could be refined further or improved. In addition, we investigate what challenges were faced, how they were addressed and how we can institutionalise them. This study aims to produce actionable knowledge through the discussions within this discussion section. I use the existing TfL safety data to compare and contrast stakeholders' perspectives on specific elements of effectiveness, improvements, challenges and institutionalising these strategies.

STRATEGIES USED

The stakeholders were asked what strategies they have used, in general, to reduce workplace incidents. Participants were then asked which strategies or methods were applied during the pre-construction phase and which strategies were implemented during the construction phase. Figure 9 below shows the three stakeholder areas and areas of overlap. In the centre, where all three circles overlap, all stakeholders agree. This does not infer that they disagree if there is no overlap. What is evident in the general selection of methods and strategies in figure 9, is that the stakeholders elect strategies in alignment with the strategic level within the contractual setup. Thus, the landlord, TfL, elected governance strategies such as TfL Pathway, and has concerns about the system of incident reporting and is involved in the review and acceptance of RAMS (Risk assessment method statements) documents. The client stakeholder chooses strategies that are legislative, CPP (construction phase plan) which details the methods and controls at strategic level, pre-construction information and in addition selects the SLT (safety leadership team) where AR based approaches were applied. The contractor is more focused on the details of the strategies, the nuts and bolts, and nominates workmanship standards, training, accident prevention, risk assessments and prestart surveys. These are more granular than the landlord or the client selections. In general, the landlord and client have more investments in the strategic, legislative and governance strategies, whilst the contractor is more concerned about the detailed output of such strategies. This is not surprising as these also correlate with the areas of contractual obligation for each stakeholder. They are all looking towards the same problem, which is how to reduce workplace incidents.

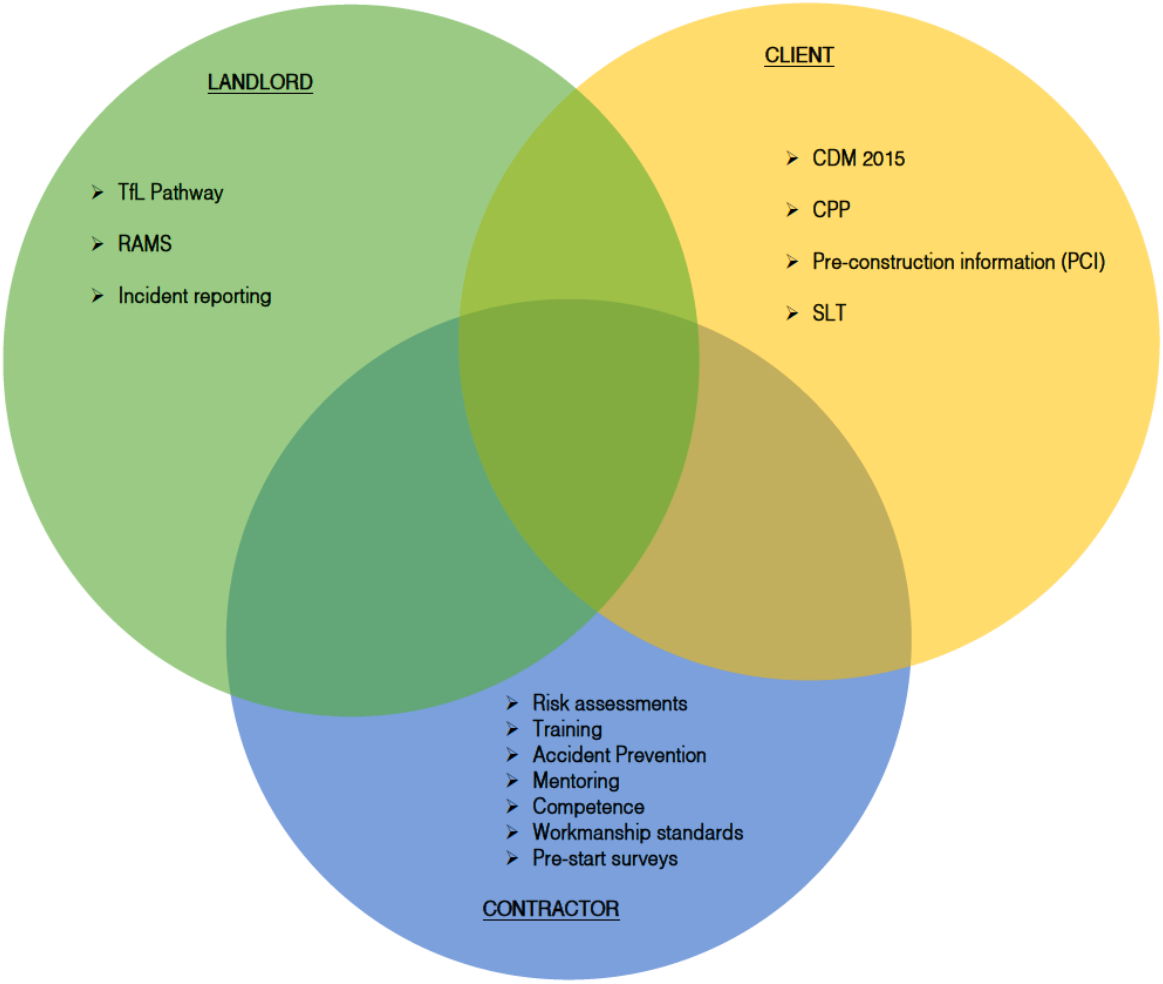


FIGURE 9 - SAFETY MANAGEMENT SYSTEMS - GENERAL

The stakeholders were then asked about specific strategies that were applied during the pre-construction phase, and these may be viewed as strategies which are used as safety planning. Figure 10 depicts the findings in the same format as above. The landlord stakeholder selects governance processes, TfL Pathway, in addition to areas of contractual obligation, which is to review RAMS and accepts them, provide pre-construction information, and focuses on areas of concern such as incident reporting processes and systems. The client stakeholder elects areas of obligations such as clear role definitions, levels of competence and providing accurate surveys of existing assets. The contractor nominates setting up monitoring regimes, teams that will address specialist areas and collates leading indicators to pre-empt incidents in the future. There is an overlap of approaches, and this is the SLT approach and specialist risk reducing teams between contractor and client. The specialist risk reducing team refers to the AR based team that was part of the SLT team, but for accuracy the stakeholders referred to specific areas as shown in figure 10. What is evident is at the planning stage, and preconstruction stage, the stakeholders are making selections based on obligations as defined for each role, thus the landlord focuses on governance, RAMS which are documents to be reviewed and accepted prior to the start of any site works, pre-construction information that must be provided and the area of concern about incident

reporting process, which impacts directly on the landlord. The client elects obligatory areas where they are compelled to review competence, role definitions, and provide information about the site status. The contractor selects a more granular methods to do with the monitoring of site activities, leading indicators gleaned form site audits and areas of concern of how to deal with specialist risk areas. I emphasise that the stakeholders are all looking at the same problem, which is how to reduce safety risks, and yet in general and preconstruction phase, the methods and strategies are dispersed but function to achieve the same end, which is to reduce safety risks.

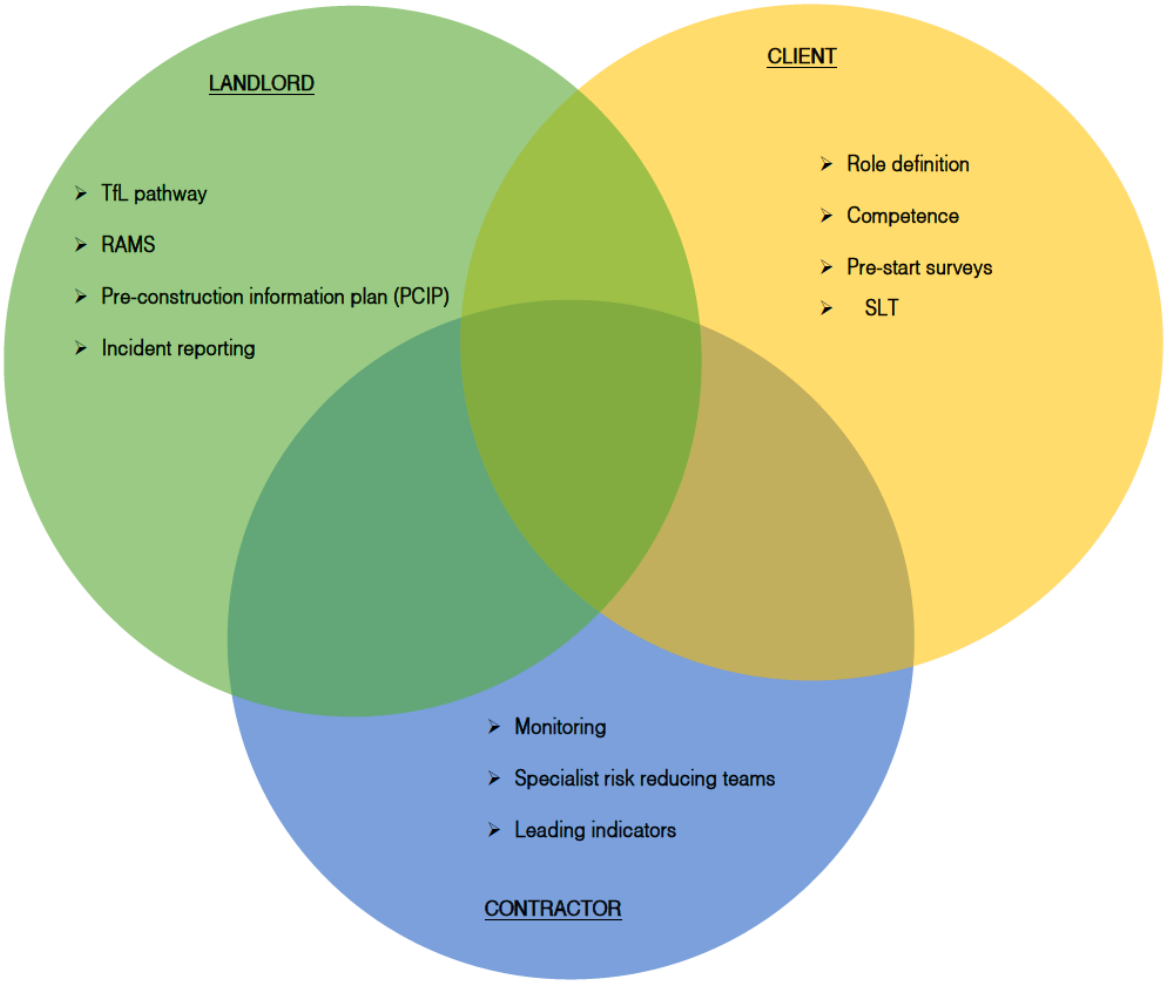


FIGURE 10 - SAFETY MANAGEMENT SYSTEMS - PRE-CONSTRUCTION PHASE

In the next selection of questioning, the stakeholders were asked which risk-reducing strategies were used in the construction phase. Here, we begin to see something of significance in pattern change. There is a strong overlap of strategies evident between all the stakeholders. Methods and strategies shared by all stakeholders include monitoring of the works, risk assessments and the SLT with the AR approach. The client and landlord have common interests in the RAMS as a risk-reducing process. The contactor isolates the pre-start information as important in reducing safety incidents. Another interesting point to note is that all the elements that are typical of most projects such as monitoring and risk assessments are evident, but we have the SLT as an inclusion here for risk reducing

strategies, and since the SLT/AR approach was new to the TfL PITTA project team, it is a remarkable inclusion. It is remarkable because SLT was a new approach and as such has unequal historic status or value as the other methods have in reducing safety risks, and that SLT is significant enough to be referred to in the interviews because the perception of all the stakeholder groups, is that it was perceived as an effective safety reducing strategy.

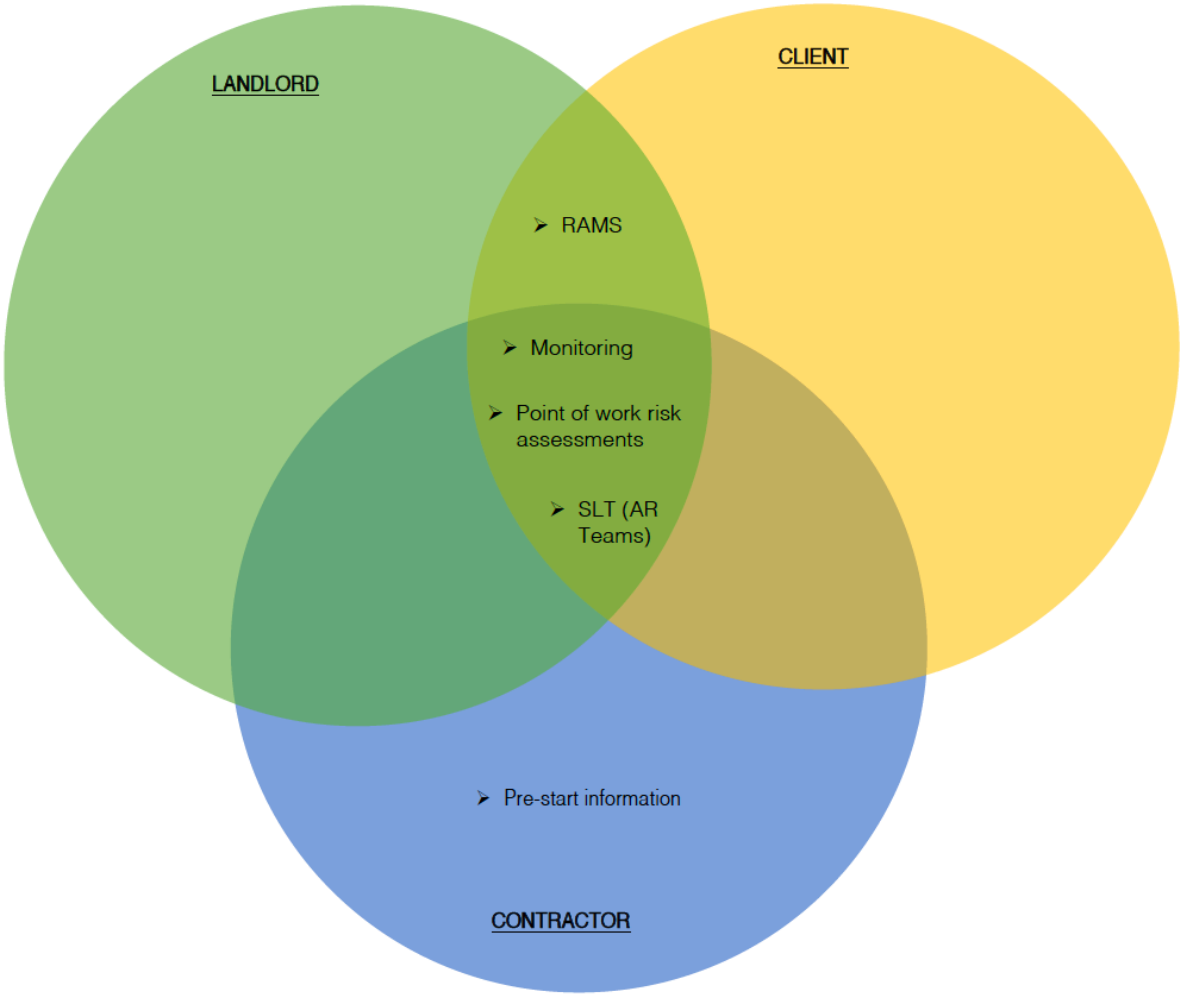


FIGURE 11 - SAFETY MANAGEMENT SYSTEMS - CONSTRUCTION PHASE

EFFICACY OF STRATEGIES USED

Stakeholders were then asked about their perspectives on where they thought strategies were more effective in relation to safety related risks. Figure 12, below, depicts the stakeholders' selections in methods or strategies they thought most effective in the pre-construction phase. Once again, the methods or strategies are not overlapped. Prior to the construction phase, stakeholders seem to be focusing on their areas of contractual obligations or areas of direct influence. The landlords select items such as ensuring the suppliers are experienced, and that the client and contractor surveys are accurate enough. The clients perceive the team collaboration, an objective overview, and experienced suppliers amongst others as more effective. The contractor group perceive

the designers risk assessments, training, pre-start meetings and checks to be more effective, during the pre-construction phase.

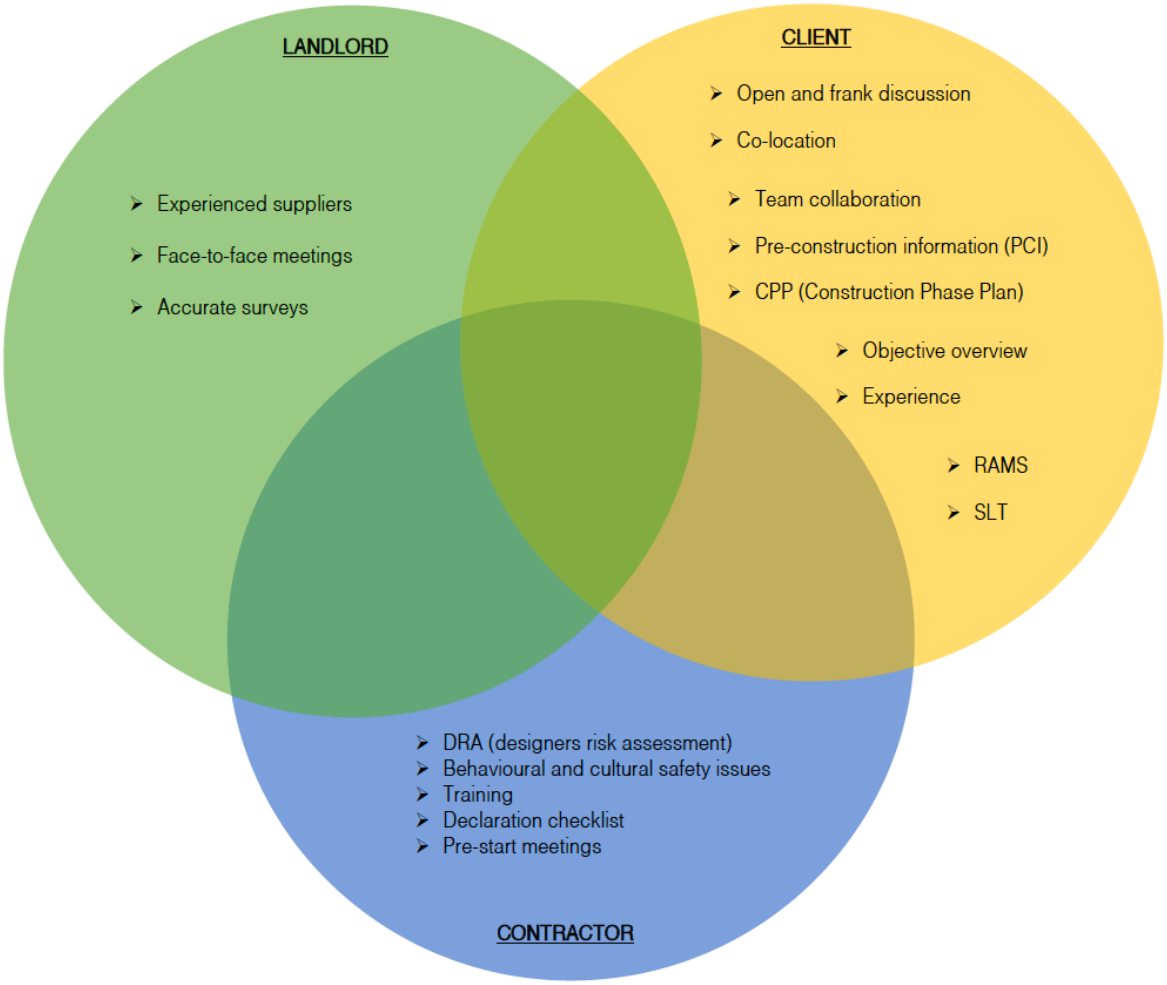


FIGURE 12 - STAKEHOLDERS' EFFICACIOUS STRATEGIES - PRE-CONSTRUCTION PHASE

Stakeholders were asked about which strategies they considered to be more effective during the construction phase. This is shown in figure 13 below. The stakeholder selections are significantly more shared in perspectives. SLT was selected by all stakeholders, and the RAMS (risk assessment method statement) document is shared by client and landlord; monitoring the work is shared by the landlord and contractor. There are elements that each individual stakeholder perceived as more effective. The correct skill set, pre-start checklist (declaration checklist) and the following of procedures, the landlord perceived as most efficacious. The client selected the CPP (construction phase plan), and the contractor thought that site briefings, the pre-construction strategies previously put in place and the synthesising of design information as more effective.

The existing safety data over the 2018 and 2019 period to have twenty-three near miss incidents reported. Two of these were injuries. The injuries had to do with slip and fall, and the second injury was the result of not following the SSOW. Given that there were two hundred- and fifty-thousand-person hours worked the incident levels are low. There were no reportable RIDDORs. Ten near miss incidents relate to issues with briefing the

SSOW or not following the SSOW, and that is significant because the stakeholders specifically single out the RAMS in figure 13 as an effective strategy for reducing incidents. Moreover, in table 14, where the landlord stakeholder elects to improve the RAMS document and approval process and figure 15 where approvals posed a challenge, it may suggest that the underlying cause of the incidents indicated in the safety reports is because of the limited time the contractors had after a lengthy approval process. The safety reports do not show any incidents related to solutions developed through the AR team and the SLT. This suggest that these strategies were not ineffective in reducing incidents. The premise of this argument is made by assuming that if these solutions were not effective, then incidents or injuries related to the AR solutions would have been indicated. The safety reports also show a marked increase in 2019, suggesting that monitoring of the worksites was in place, and as such, incidents would have been observed.

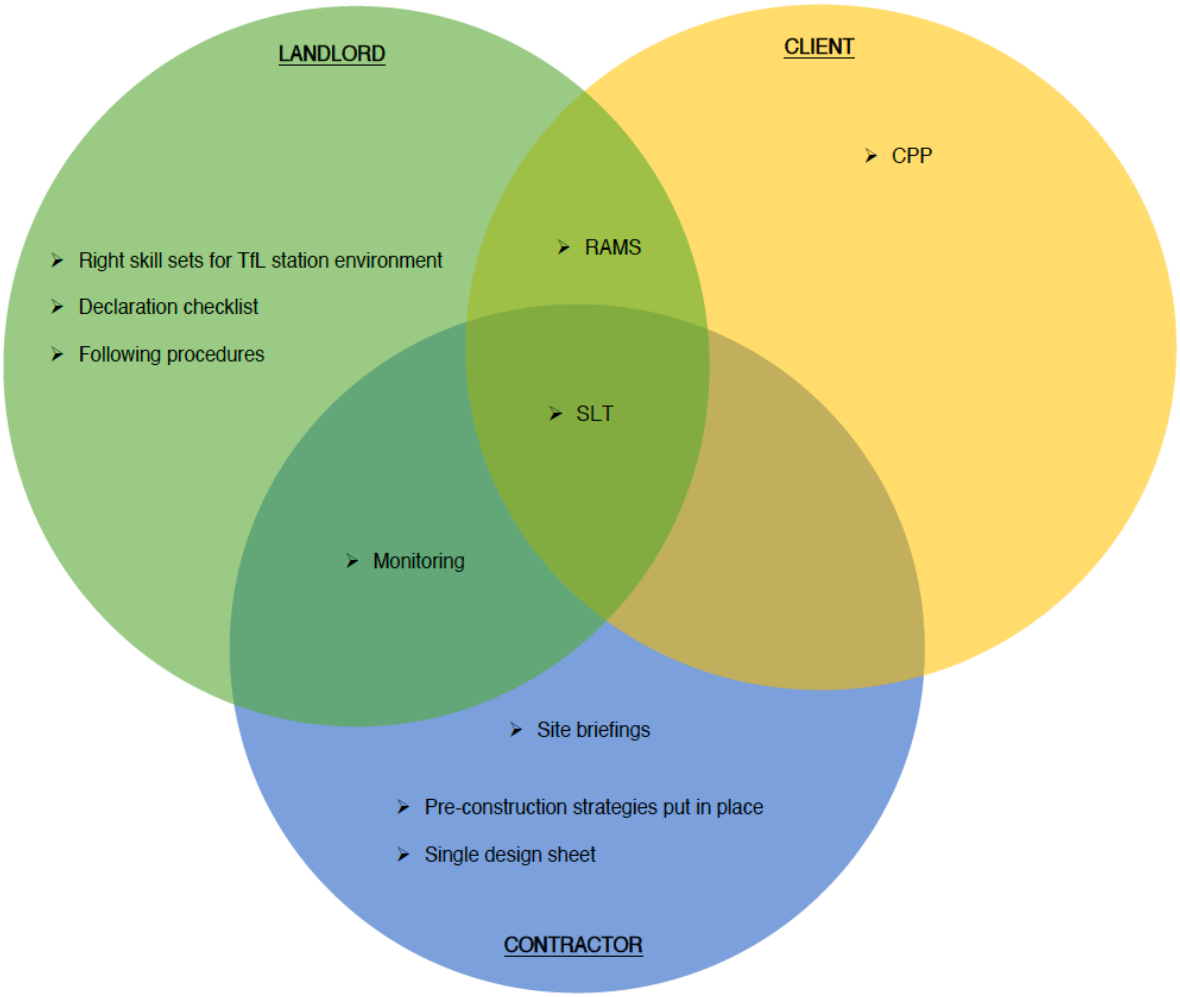


FIGURE 13 – STAKEHOLDERS' EFFICACIOUS STRATEGIES – CONSTRUCTION PHASE

In figure 14, below, we show the results of the areas that the stakeholders felt improvements could be made to improve or refine the safety related strategies. Here the stakeholders seemingly focus on areas of responsibility or obligation. However, on closer inspection, there seems to be a connection between the landlords fully compliant design, avoiding unauthorised works; the contractors' selection of improving delivery and design

relations, changing the workmanship standard to a permit to work; and the clients' selection of improving communication. These seemingly diverse elements are related in that often construction works are undertaken without a fully developed design, and specific authorised elements of the design are carried out to save programme time. This is not unusual and with stringent project controls, can be effective in saving programme time. However, it does introduce an element of safety risk because operatives may knowingly or unknowingly carry out works that are unauthorised. We become aware of incremental design approval methods, subsequent installations and risks that these harbour. Improving communication about this method, enforce stricter controls, but having a permit to work system and improving the construction and design team relationships are important actions to take away. Another take away action is the improvement of a readable RAMS document, and this also ties in with communication improvement. Another significant action to take away is the notion of a data driven SLT to further enhance the SLT and action group effectiveness. We believe that monitoring is seen as an effective risk reducing tool as seen in figure 13 during the construction phase; also figure 14 confirms that monitoring could be improved further. Monitoring the site activities has the potential to provide a rich source of data, because work shift reports are generated that capture important information, such as safety issues, observations, hours worked, plant used, weather conditions and various other site related activities performance indicators. This rich data could be used to provide a more quantitative addition to the AR based approach.

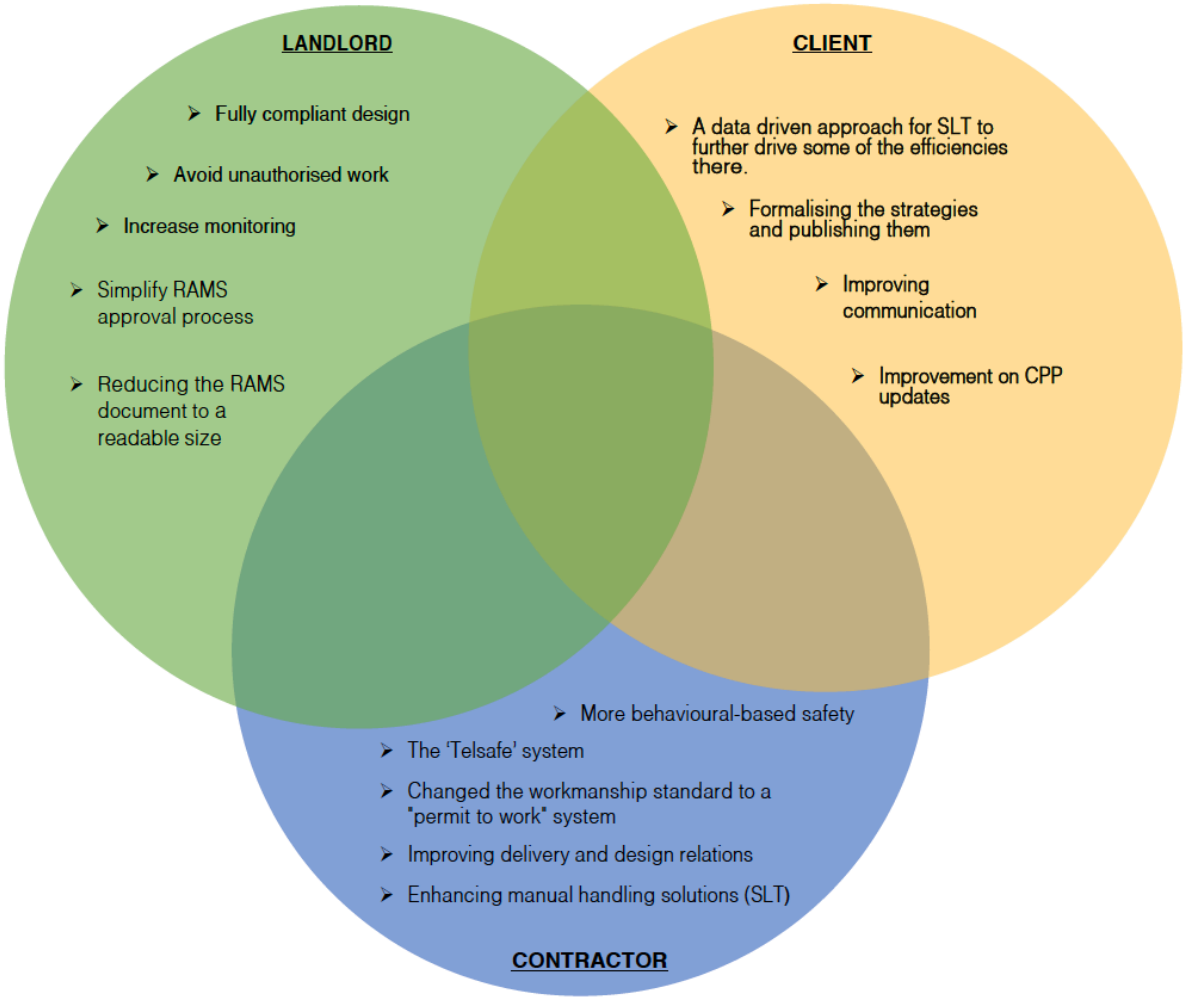


FIGURE 14 – STAKEHOLDERS' PERSPECTIVES ON STRATEGY IMPROVEMENT

CHALLENGES EXPERIENCED ON STRATEGIES USED

The next section deals with what the stakeholders found as challenges in implementing safety related strategies. Figure 15 below shows the general challenges for each stakeholder. One common theme between landlord and contractor is the challenge of gaining approvals on the TfL estate, and the recommendation is to streamline this process. Another commonality in themes is the culture, mentality, people, and complacency issue elected by contractor and client stakeholders. These issues fall broadly into behavioural safety issues, which we will address later in this section. The last pattern we see is engagement issues of senior leadership and subcontractors as selected by the client. A recommendation is to improve stakeholder engagement.

The safety data indicates a significant number of safety incidents to do not following the SSOW and the point below by the contractor nominating that the people part poses a great challenge suggests that there is validity in this point. Whether the SSOW is not briefed properly or the operative has not received the briefing or has decided to undertake the work in a way not agreed, suggests that the communication needs improving as noted in figure 14 and that the people part is challenging to manage in which

case either one or both could be true, and as such the safety data draws out attention to these specific elements for further discussion through the AR process.

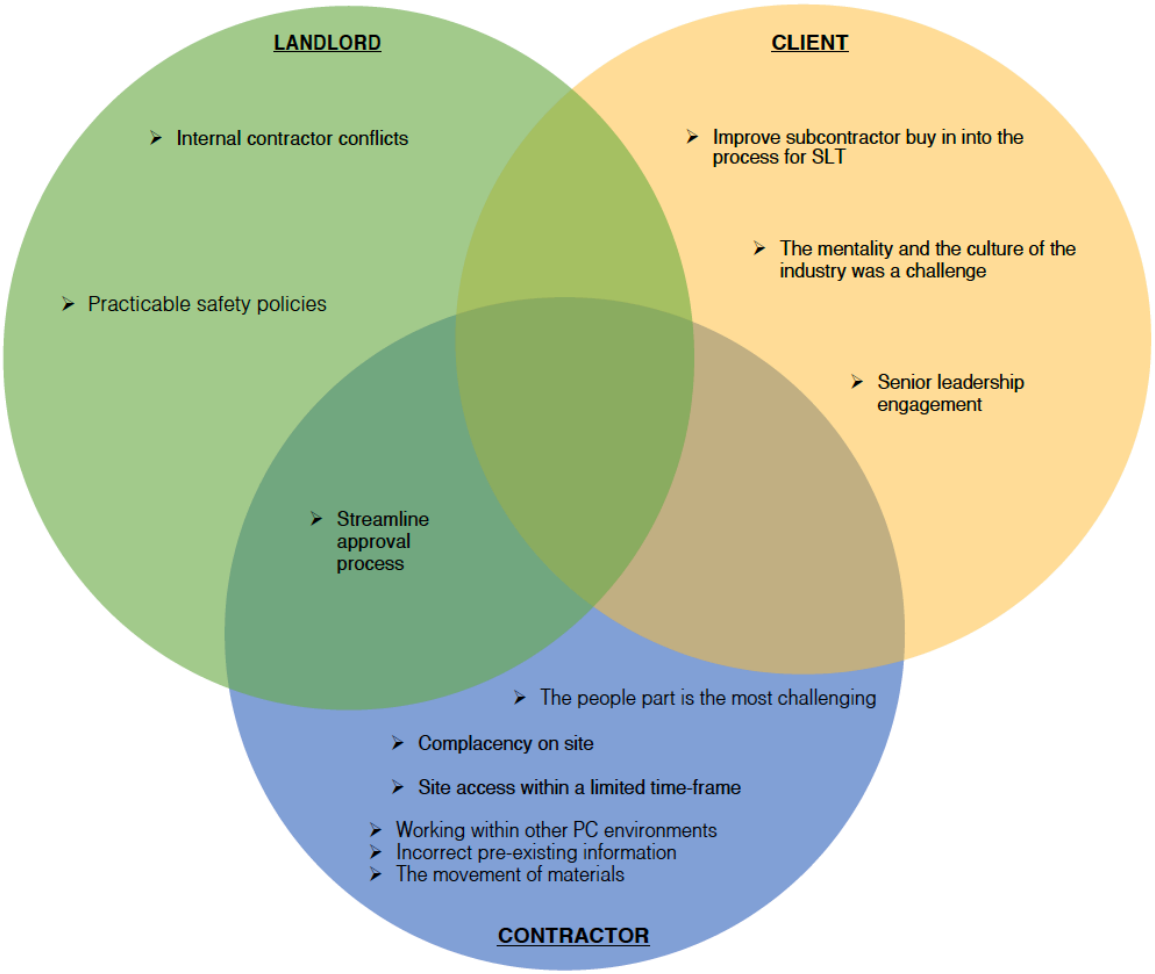


FIGURE 15 - STAKEHOLDERS' PERSPECTIVES ON GENERAL CHALLENGES

The challenges faced in implementing safety related strategies have a few patterns emerging. One these is the approvals, documentation volume, permits and procedures which are required within the TfL environment. Again, streamlining these TfL approvals and reducing the documentation requirements would be a recommendation for the business. The other elected elements seem dispersed into stakeholder categories. There is a note about the contractual set up and how one stakeholder saw the financial penalty linked to incident reporting as flawed, because it encouraged the wrong behaviours. Operatives are less likely to report incidents or near miss events if there are financial penalties associated with them. In addition, the contractor nominates specific challenges about the importance of pre-start surveys, pre-construction information and the control of unauthorised works. The client has specific challenges with internal safety resources and in ensuring that the contractor adopted a project-based approach in contrast to a maintenance-based approach to the works.

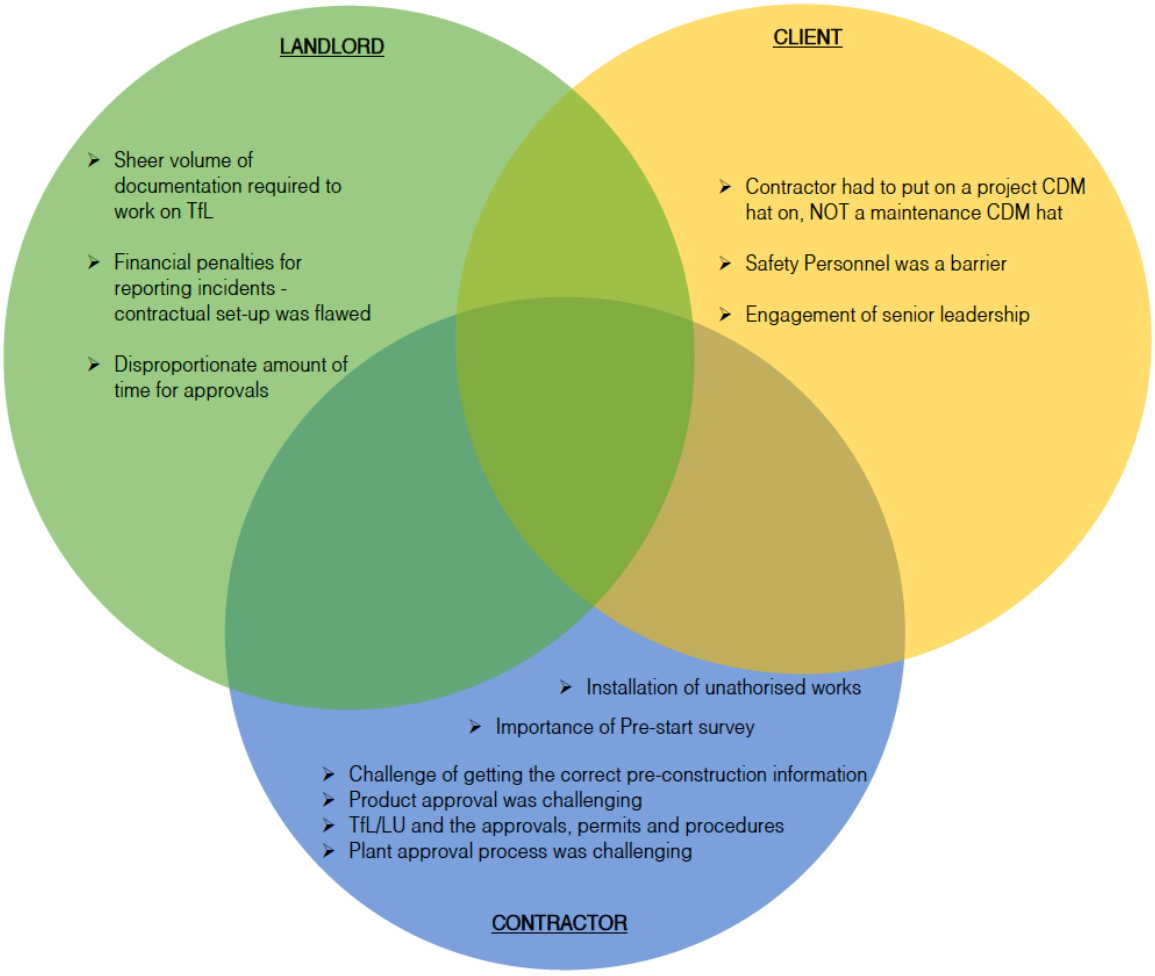


FIGURE 16 - STAKEHOLDERS' PERSPECTIVES ON CHALLENGES DURING PRE-CONSTRUCTION PHASE

The final section on implementing challenges during the construction phase is depicted in figure 17, below. A few patterns emerge from the stakeholder selections. Time constraints to executing the works and undertake monitoring of the works emerges as an issue. The second pattern is the challenges of the physical delivery of assets to the workplace. The latter challenge coupled with the former poses a significant issue for TfL works, because if the physical delivery of getting assets and equipment to the workface is challenging, then limiting the time will exacerbate the issue further. Indeed, the SLT and the AR based approach sought to solve this specific issue of manual handing of assets to the TfL workface. Other issue was monitoring of the works by the client, and the challenges faced were time constraints and the nature of the ebb and flow of the work. This is also related to the issue of collating data, to further inform the SLT; another issue which was noted.

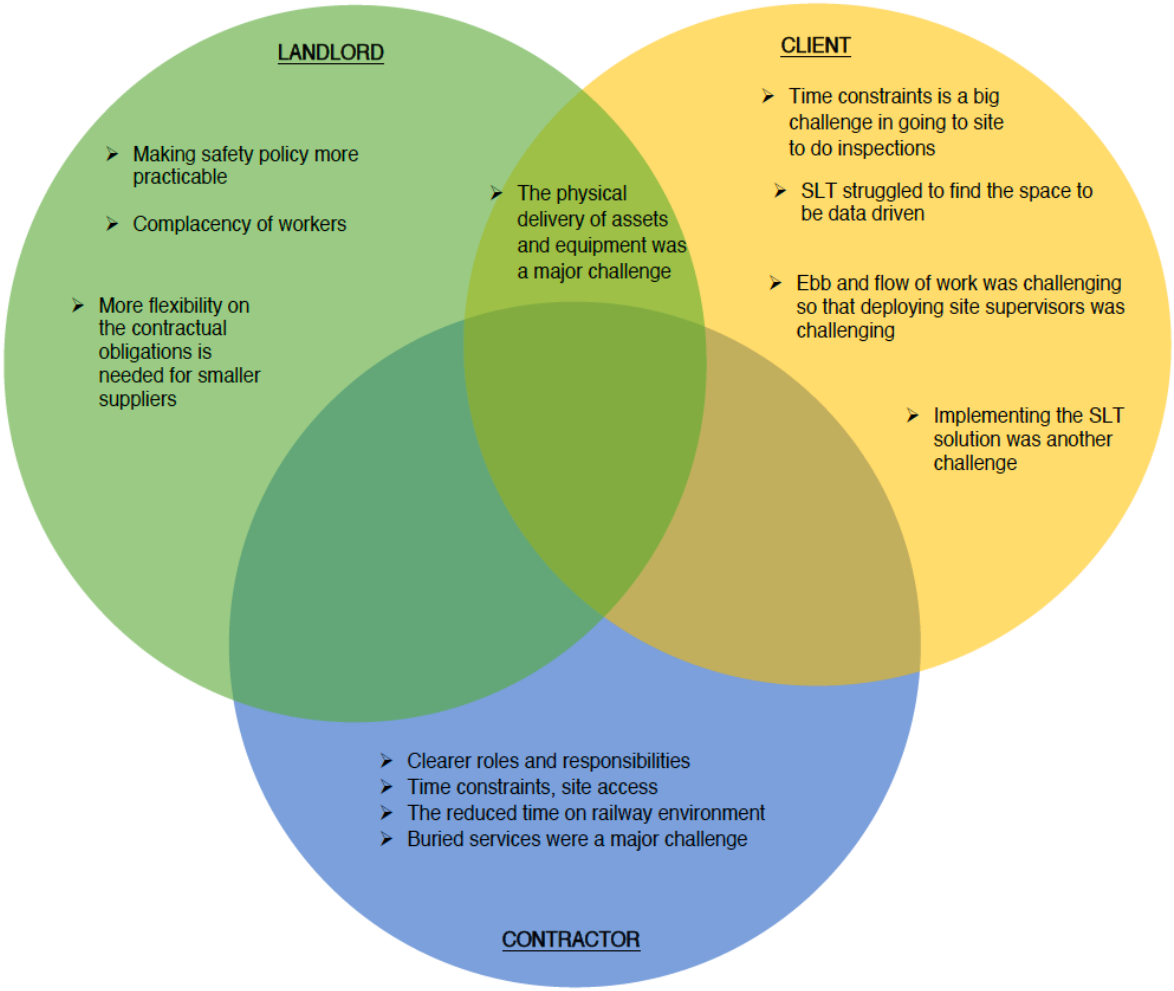


FIGURE 17 - STAKEHOLDERS' PERSPECTIVES ON CHALLENGES DURING THE CONSTRUCTION PHASE

INSTITUTIONALISING OF STRATEGIES USED

The following paragraphs of this section relate to institutionalising strategies. Stakeholders were asked which strategies have been institutionalised in their organisations. One common theme emerging is the SLT which included the AR based approach. The contractor stakeholder had adopted this strategy into their organisation. The client and landlord nominate SLT should the right opportunity present itself for application. The client has institutionalised a senior leadership engagement programme and maintained an outsider monitoring approach with an independent review and monitoring of their works. The landlord proposes reducing the documentation volumes and scale the safety systems to appropriate levels for the work undertaken. It is evident form the challenges mentioned above that the streamlining of TfL approval processes and making the TfL document requirements less onerous, would alleviate some of the challenges mentioned previously.

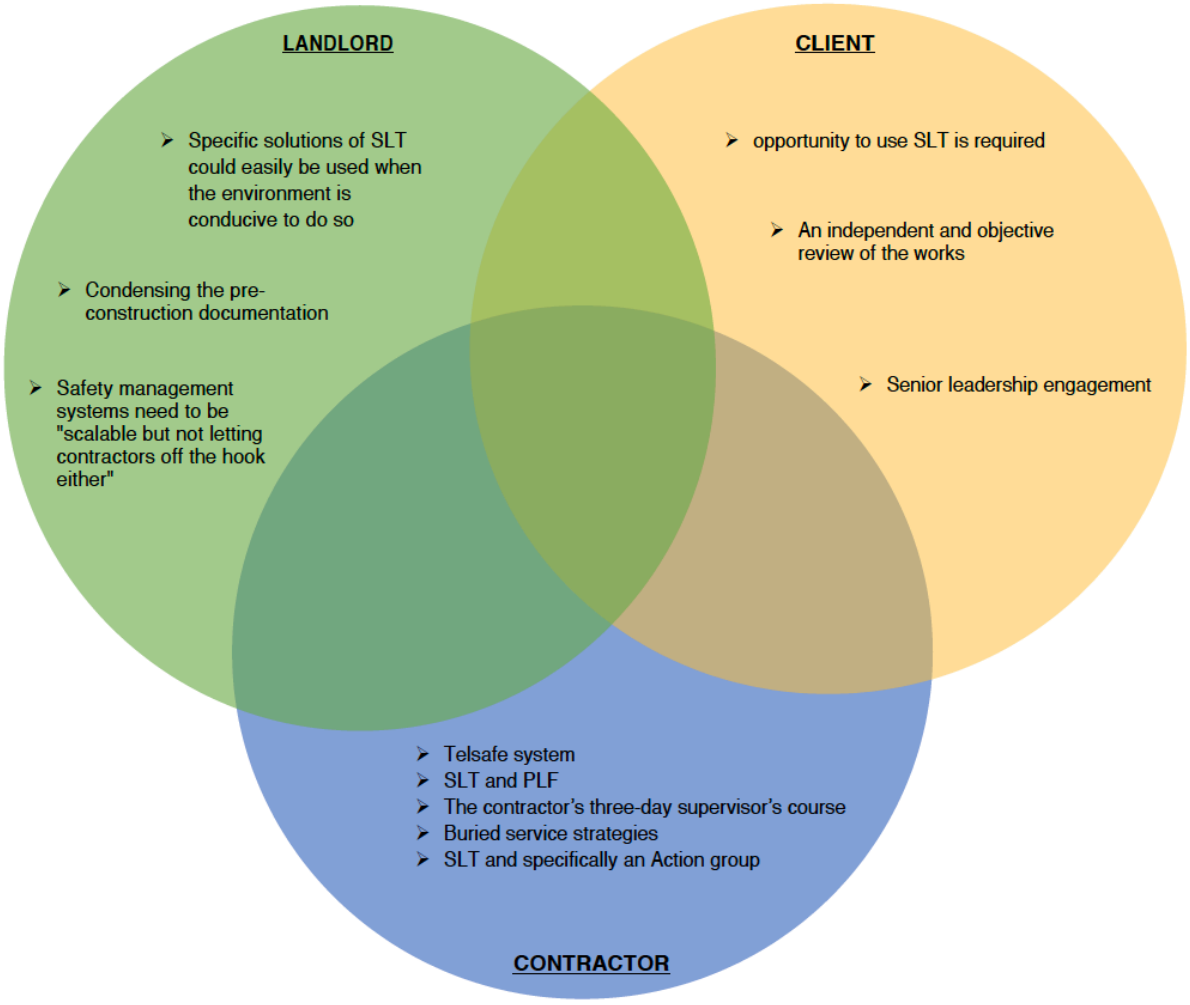


FIGURE 18 - INSTITUTIONALISED STRATEGIES

Stakeholders were asked to recommend strategies for institutionalising. Figure 19, below depict the elements elected by each stakeholder. A common theme is SLT and PLF. All stakeholders agree on this as a safety reducing approach. Another commonality between client and contractor is monitoring and the works. One other commonality is documentation between contractor and landlord, where more concise documentation and simplified design information would be recommended. The remaining recommended elements seem more dispersed, with one-to-one communication and the contractors' buried services strategy. The recommended strategy for institutionalising is SLT and PLF, and that this was a new approach to the TfL PITTA project and that it is a remarkable inclusion given its brief history.

FIGURE 19 - RECOMMENDED ELEMENTS FOR INSTITUTIONALISING

The penultimate enquiry to the stakeholders had to do with how well the strategies have been institutionalised in the organisation. Figure 20, depict the responses below. SLT seems to be a commonality between client and landlord. The remainder of the strategies are specific to each stakeholder group. The client group had a strong message about repeating the vision of the business for any strategy to be effective and adopted well. However, this is more of a recommendation than ease of adoption into the organisation and it is included here. Another point is the independent monitoring and review of the client team.

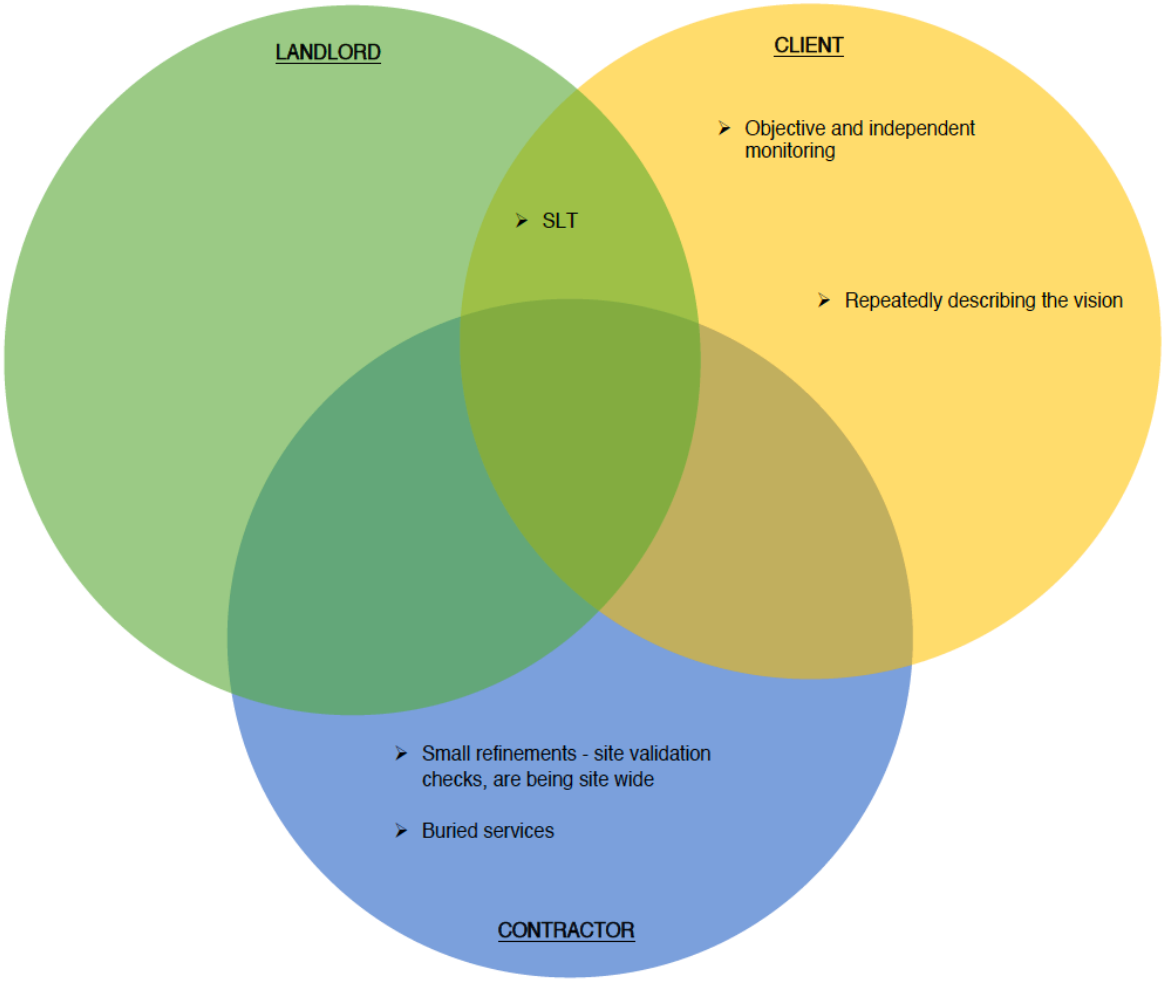


FIGURE 20 - EASE OF STRATEGIC ADOPTION INTO ORGANISATIONS

The final line of inquiry relates to strategies that would not be recommended for implementing in other areas of the organisation. Although no specific strategies were nominated as "not recommended", there is valuable information gleaned from this section. We can evidence that there are systemic barriers or challenges that we should highlight as areas where improvements could be made. The landlord elects that removing bureaucracy would improve the environment to apply safety strategies. The client points to an area where communication could be improved, and this has been noted previously in figure 14 above. The contractor reflects that when refusing to work or stopping works because they do not meet the minimum standards has come at a personal cost. Perhaps this area needs more reinforcing to encourage teams that this type of behaviour is encouraged and supported.

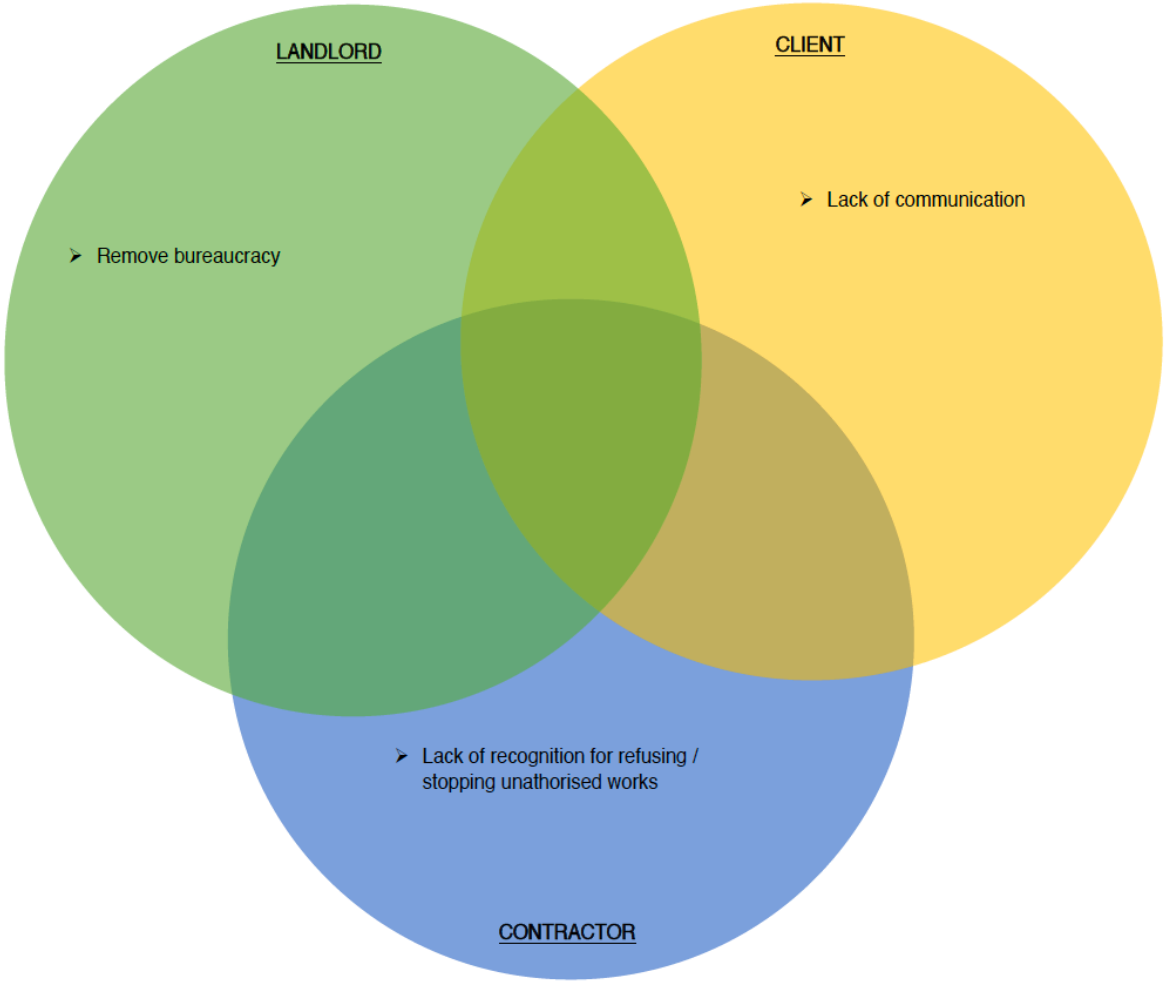


FIGURE 21 - INSTITUTIONAL BLOCKERS

Tabulated below in table 10, is a summary of the discussions this section. As previously depicted, the stakeholders are listed at the top of the table. On the left is the theoretical categories or second order themes. In the grey boxes across are the aggregate theoretical dimensions. Thus, under safety management systems, we have three second order themes, which capture the general safety system approaches for all stakeholders. We notice that these fall into the broad legislative, and governance approaches followed by the more detailed outputs that the contractor typically produces. Under safety planning or during the preconstruction phase, it is evident that stakeholders are engaged with their legal and contractual obligations. During the safety intervention category or the construction phase, we observe a synergy amongst the stakeholder strategies and a remarkable inclusion of SLT where AR based approach was adopted to solve specific safety risks.

The next aggregate theoretical dimension is strategy efficacy, where we investigate the stakeholders' perspectives of how effective the strategies have been during the pre-construction and construction phases. During planning efficacy or pre-construction phase, the strategies are perceived in a dispersed manner. These include competence and

training; pre-construction information, documentation, surveys and meetings; collaborative interaction and approaches and design risk assessments. However, under action and intervention efficacy we notice once again synergistic qualities emerging, and the inclusion of SLT, RAMS and monitoring of the works. Under enhancing efficacy or areas where improvements could be made to reduce safety incidents, improving project controls, reducing RAMS, and introducing qualitative data to enhance the AR based approach are noted.

The next aggregate theoretical dimension is implementation issues and barriers where the second order themes capture the general or systemic issues, followed by safety planning barriers during the pre-construction phase and finally the safety action and intervention barriers during the construction phase. Systemic issues arise from the lengthy TfL approval process, behavioural safety issues and stakeholder engagement. Safety planning barriers or issues encountered during the pre-construction phase are noted as the lengthy TfL approval process, the volume of documentation requirements, incident reporting issues, insufficient pre-construction information and the authorisation of unauthorised works. For the safety action and intervention barriers second order theme and during the construction phase we note that TFL time constraints, the physical delivery of assets to the workface and monitoring of the works caused challenges for the stakeholders.

The final aggregate theoretical dimension is institutional context and how well strategies have been applied in other areas of the stakeholder organisations. For second order theme, institutionalised strategies, we note that the contractor stakeholder has maintained the SLT approach, the incident reporting system and specific training for supervisor operatives. However, the other stakeholders did note that they would use SLT when the opportunity arose. Where the second order themes cover recommended elements for institutionalising, we note that SLT, PLF, monitoring the works, more concise documentation and repeating the vision to stakeholders are included. The next theme explores how well strategies have been institutionalised and SLT and an independent oversight approach emerges here. Finally, the institutional blockers highlight three distinct elements, namely, bureaucracy, poor communication and lack of support and recognition for stopping unauthorised works.

In this study I have used the existing safety data to support, suggest or discount some of the stakeholder perspectives regarding specific themes. It is not possible to include all the safety data as it would breach the word count of this thesis. As such I have included the summarised safety reports extracts in Appendix G

Below in table 10, the stakeholders' perspectives are highlighted. These are mapped against the second order themes and categorised into aggregate theoretical dimensions.

Stakeholder / Theoretical categories (2nd order themes)	Landlord	Client	Contractor
safety management systems			
safety system and approach	→ legislative → governance → the "nuts and bolts" of legislative and governance outputs		
safety planning	→ each stakeholder fulfils legal and contractual obligations in this phase		
safety interventions	→ synergy of strategies → remarkable inclusion of SLT/AR based approach		
strategy efficacy			
planning efficacy	→ stakeholders are dispersed in selections → competence & training → pre-construction information, documentation, surveys, meetings → collaborative interaction and approach → Designers Risk Assessments		
action and intervention efficacy	→ synergy of strategies → SLT → RAMS → Monitoring of works		
enhancing efficacy	→ Improve project controls on incremental design approvals method → Improving RAMS documents to more easily readable format and size → Introduce quantitative data to improve AR based decisions		
implementation issues and/or barriers			
systemic barriers	→ TfL lengthy approval process → behavioural safety issues (culture, mentality, people, complacency) → stakeholder engagement		
safety planning barriers	→ TfL approval process → Reducing documentation requirements → Incident reporting issues → pre-construction surveys and information → authorisation of unauthorised works		
safety action and intervention barriers	→ working on TfL - time constraints → physical delivery of assets to workface → monitoring the works		
Institutional context			
institutionalised strategies	→ SLT - contractor stakeholder only → incident reporting (Telsafe) - contractor stakeholder only → training for supervisors - contractor stakeholder only		
recommended elements for institutionalising	→ SLT and PLF → Monitoring of the works → more concise documentation approaches → Keep repeating the Vision		

ease of strategic adoption into broader organisational context	→ SLT → independent oversight
Institutional blockers	→ Bureaucracy → Poor communication → Lack of recognition and support for stopping unauthorised works

TABLE 10 - SUMMARY OF STAKEHOLDER PERSPECTIVES

As a practitioner-researcher I want to contribute towards solving practical construction problems and to create new knowledge that is valuable to organisations. It is important that future researchers have a map of how the decisions are made and what theoretical design supports them.

AR has distinctive a theory and practice by design and in application. AR is diagnostic, evaluative, action-based and learning capability when applied as noted in Azhar, Ahmad, and Sein, (2010). Table 10 above is an AR developed starting point for the TfL ISR team and it is developed from the practice of TfL PITTA team. In this sense exhibits a lessons-learnt component. It is not intended as a prescription for TfL ISR team, and it initiates the conceptual design for TfL ISR team. Schenkels and Jacobs (2018) notes that practitioner participation helps to join an assembly of ideas that creates the conceptual designs. Burns (1999) goes further with this notion by supporting the validity of the participation, and in measuring the involvement of all participants. All stakeholders' perspectives are considered in the development of table 10, because all perspectives seek to address the same issue within the research questions posed.

There is a distinction between internal TfL problems and collective delivery stakeholder problems within the TfL PITTA AR approach. Cognisant of this distinction, table 10 poses an initial proposal for discussion, but I am also aware that the delivery stakeholder perspectives may not entirely offer a best fit into the TFL ISR AR design as the initial AR applications are principally TfL participants. Baskerville, (1997) offers this distinction and it is worthy to note for this AR application.

AR is important in solving construction related problems and it offers a mechanism where often research lacks the development of recommendations to solve these issues. AlSehaimi, Koskela and Tzortzopoulos' (2013) study critiques the lack of recommendations made to solve the issue of the delay problems found in construction projects and furthermore finds that when recommendations are made, they are do not match findings.

AR does have weaknesses as noted in Azhar, Ahmad, and Sein, (2010). AR finds bespoke solutions for specific problems, which make the solutions less generalisable.

IMPLICATIONS FOR PRACTICE

The TfL PITTA project is coming to the end of its project phase, and the proposals developed here will be with the view to apply them to another area of TFL. Since we have already used an AR based approach within TfL PITTA project, we can draw some lessons from the interview data, from stakeholders that have been directly involved in the SLT, PLF and AR process. In addition, I use the existing safety data to develop a deeper understanding of what strategies were effective. Using the existing safety data, follow up interviews with the safety members of the contractor provide further meaning to the incident numbers and contribute towards lessons learnt within the TfL PITTA project team. I also describe the enabling factors and enacting behaviours that contribute towards the safety culture within TfL PITTA to provide the context of what assisted these strategies to have engaged team members and develop effective solutions to solve specific safety issues within TfL PITTA project.

With the above proposals the next phase of action research in this study is to propose these findings, and the context that enabled them to another department within TfL, namely the TfL In-Station retail team. The aim to find ways to institutionalise effective strategies within TfL, that reduce safety risks and thus, incident numbers. Proposing the lessons learnt in using AR strategies within the TfL PITTA project, the TfL In-Station project team will start another cycle of AR, to apply strategies that are effective in reducing safety risks.

Table 10 provides a reference to create a framework of existing methods and strategies noted on table 11. Table 11 is developed from the knowledge extracted from the TfL PITTA project. This table is the starting point for discussions with the TfL In-Station Retail (ISR) team as implications for practice. Aggregate theoretical dimensions are retained together with the second order themes. Aggregate theoretical dimensions are preceded with the codes 'A, B, C, and D' and strategies or methods are coded with the aggregate theoretical dimension prefix for referencing purposes later. The columns are divided into sections to do with implementation. Thus, the first column captures the implications for practice within the ISR project. The columns to the right capture strategies that should be retained, introduced, improved, or institutionally improved. Section A, where we have the aggregated theoretical dimension of safety management systems, I have listed out the elements that we are proposing to be retained as strategies that reduce safety incidents. A1, A2, A3 and A4 are legislative, governance, detailed legal and governance documents and stakeholder obligations are to be retained. These are all required to undertake project work for TfL as 'business as usual' elements. Items A5 and A6 are proposed as new introductory methods to reduce safety risks, given what we know from the TfL PITTA project.

Theoretical categories (2nd order themes)	Implications for practice In TfL ISR Retail	Retain strategies / methods	Introduce Strategy / methods	Improve strategy / methods	Institutional improvements
A - safety management systems					
safety system and approach	→ legislative → governance → the detailed "nuts and bolts" of legislative and governance outputs	→ A1 - legislative → A2 - governance → A3 - the detailed "nuts and bolts" of legislative and governance outputs			
safety planning	→ Stakeholders' contractual obligations	→ A4 - Stakeholders' contractual obligations			
safety interventions	→ SLT/PFL → AR specialist teams		→ A5 - SLT/PFL → A6 - AR specialist teams		
B - Effective Strategies and Areas for Improvement					
planning efficacy	→ Competence / training → pre-construction information, documentation, surveys, meetings → collaborative interaction and approach → Designers Risk Assessments	→ B1 - Competence / training → B2 - Designers Risk Assessments → B3 - pre-construction information, documentation, surveys, meetings → B4 - collaborative interaction and approach			

action and intervention efficacy	→ RAMS → Monitoring of Works	→ B5 – RAMS → B6 - Monitoring of Works			
enhancing efficacy	→ Incremental Design Approvals → RAMS → DATA collation		→ B8 - DATA Collation	→ B7 - Improve project controls on incremental design approvals method → B5- Improving RAMS documents to more easily readable format and size	
C - Efficacy Barriers to Address					
systemic barriers	→ TfL lengthy approval process behavioural safety issues (culture, mentality, people, complacency) → stakeholder engagement			→ C1- TfL lengthy approval process → C2 - behavioural safety issues (culture, mentality, people, complacency) → C3 - stakeholder engagement	
safety planning barriers	→ TfL approval process → Reducing documentation requirements → Incident reporting issues → pre-construction			→ C1 - TfL approval process → C4 - Reducing documentation requirements → C5 - Incident reporting → C6 - pre-construction	→ C1 - TfL approval process → C4 - Reducing documentation requirements

	surveys and information → authorisation of unauthorised works			surveys and information → C7 - authorisation of unauthorised works	
safety action and intervention barriers	→ working on TfL - time constraints → physical delivery of assets to workface → monitoring the works			→ C8 - working on TfL - time constraints → C9 - physical delivery of assets to workface → C10 - monitoring the works	→ C8 - working on TfL - time constraints
D - Institutional Implications					
institutionalised strategies	→ SLT → training for supervisors - contractor stakeholder				
recommended elements for institutionalising	→ SLT and PLF → Monitoring of the works → more concise documentation approaches → Keep repeating the Vision		→ D1 - SLT and PLF	→ D3 - Monitoring of the works → D4 - more concise documentation approaches	→ D7 - Keep repeating the Vision
ease of strategic adoption into broader organisational context	→ SLT → independent oversight				
Institutional blockers	→ Bureaucracy → Poor communication → Lack of recognition for stopping		→ D2 - Recognition for stopping unauthorised works	→ D5 - Bureaucracy → D6 - Communication	→ D5 - Bureaucracy → D6 - Communication

	unauthorised works				

TABLE 11 - IMPLICATIONS FOR PRACTICE

In the next aggregate theoretical dimension, section B, we list out the strategies that were found to be effective in reducing safety risks. These are categorised into three second order themes. Thus, for the preconstruction or planning phase, I retain the elements referenced as B1, B2, B3, and B4. During the construction phase, I have retained B5, B6 as important safety risk reducing methods. Improvements or refinements, B7 to improve the way we control incremental design approvals and B5, to improve the RAMS documents to a more readable and appropriate size are noted. The use the existing data captured through inspections, site reports and observations and develop a way to use this information to inform better decision making is listed.

Section C lists out elements that were perceived as barriers, blockers or have caused issues within the TfL PITTA project. These are valuable areas the TfL ISR Project to look at for areas for improvement, at project level and at an institutional level within this AR cycle. C1 is listed as an area that both project and wider TfL areas could address. This has to do with the lengthy TfL approval process. C2 related to behavioural safety, and we have listed it here as an area of potential improvement. C3 relates to stakeholder engagement and listed as an area to improve. The SLT and PLF are useful forums to enhance stakeholder engagement. Specific elements are listed out for planning or preconstruction and there is some overlap here with C1 appearing here too. C4, C5, C6 and C7 are all listed for improvement areas. C4 is related to B5, where it is perceived as an effective element and that it could be further enhanced by improvements in reducing the document to a more readable size. C5 relates to incident reporting and issues that have been experienced within the TfL PITTA project. The TfL incident reporting is a mature process but a recommended area to investigate would be how other stakeholders are informed and notified with our existing process, and how incidents are investigated and closed out.

C6 also appears as B3 also, because it is perceived as an effective element for safety risk reduction and that it would benefit further by improvements. B3 is perceived as an effective safety reducing element and that C6 places these document requirements in the spotlight where TfL could further enhance the use of these documents by ensuring up to date and accurate surveys are collated. C7 relates to unauthorised works and translates to pre-construction control processes that make explicit which element of design is authorised for construction. C7 is also related to B7 to do with project controls and listed as an effective strategy that could use some improvements to enhance efficacy. C8 investigates the notion of limited time constraints to undertake construction works on the TfL estate. Time limitations to work on site are an issue for safety related risks and potentially increase safety risks. TfL ISR project could explore ways to alleviate these limited time constraints and it is possible with special permissions to access TfL sites earlier using a risk-based approach. It is however an area where further improvements could be made. C9 related to the physical delivery of assets, and this is a common issue

on TfL projects, given the limited timescales to deliver the assets and the logistical challenges in accessing TfL stations. TfL PITTA project successfully developed bespoke solutions to transport media screens on the TfL station escalators using specialist equipment that was developed through the AR based approach within SLT.

This study proposes to use the same mechanism of SLT and the AR teams to tackle such safety related challenges. C10 explores how monitoring of the works could be better enhanced to reduce safety risks. We know that monitoring of the works is perceived by stakeholders as an effective strategy in reducing safety risks, as it appears in B6 on the previous aggregate theoretical dimension of effective strategies.

Section D lists the elements that have either been institutionalised in stakeholder organisations, recommended for institutionalising, and ease of adoption. The section also covers elements that were perceived as institutional blockers or strategies or methods that would not be recommended. D1 relates to the SLT and PLF that this study is proposing for introducing into the TfL ISR project. D3 indicates that monitoring of the work is recommended for institutionalising and improvement and is linked to C10 and B6. D4 offers similar outlook in that is an element that is recommended for use in other areas, and it could be improved. D4 is linked to C4 and B5. D7 informs us that for institutionalising safety reducing strategies, a clear vision should be developed, and it should be repeated often to enhance efficacy. The final section explores areas that were perceived as blockers and this study recommends that these could be areas of potential improvement. D2 relates to developing ways to recognise that stopping works averts potential injuries our workforce and it should be commended and supported. In my personal experience, stopping works is not a straightforward judgement call and it can attract financial consequences if it is eventually deemed unwarranted. D5 relates to bureaucracy and is not uncommon for public-sector organisations to exhibit such qualities (Niskanen, 1994). This study proposes that this is an area for potential improvement and refinement. This issue can be addressed at both ISR project level and TfL in a wider context. D6 relates to communication, and this is proposed as an area for improvement, especially in relation to how stakeholders communicate with each other but also internally within TfL. This study proposes to collectively develop communication protocols with stakeholders.

It is useful to tabulate the implications for practice in a simpler way for the TfL ISR project and table 12, below offers a less granular way of interpreting the implications abovementioned. The top row retains the aggregate theoretical dimensions from the previous section; thus, item A refers to safety management systems, B, refers to strategies which are perceived to have been effective in safety risk reduction, C, refer to barriers that affect efficacy of safety risk reducing strategies and D refers to institutional implications. On the left column we have listed what we would like to propose to the ISR project team. Therefore, strategies or methods can be retained, introduced, improved at project level or programme level improvements.

I must also include the findings from the TfL safety data so that the stakeholder perspectives are viewed in the context of this data. The safety data suggests that AR solutions did not indicate any incidents, so we know that these solutions did work, we

also know that the safety risk was eliminated in the manual handling and reduced in the working at height solution. In addition, the safety data suggests more work was needed to improve the communication and briefing of the RAMS to operatives. The total number of incidents in total was low for the person hours that were undertaken and so the strategies that are implemented within the TfL safety process are effective.

Description	A - safety management systems	B - Effective Strategies for Safety Risks	C - Efficacy Barriers to Address	D - Institutional Implications
Retain strategies /methods	A1 - legislative A2 - governance A3 - the detailed "nuts and bolts" of legislative and governance outputs A4 - Stakeholders' contractual obligations	B1 - Competence / training B2 - Designers Risk Assessments B3 - pre-construction information, documentation, surveys, meetings B4 - collaborative interaction and approach B5 - RAMS B6 - Monitoring of Works B7 - Incremental Design Approvals		
Introduce strategy / methods	A5 - SLT/PFL A6 - AR specialist teams	B8 - DATA Collation		D1 – Rollout of SLT and PLF D2 - Recognition for stopping unauthorised works
Improve strategy / methods		B7 - Improve project controls on incremental design approvals method B5- Improving RAMS documents to more easily readable format and size	C1- TfL lengthy approval process C2 - behavioural safety issues (culture, mentality, people, complacency) C3 - stakeholder engagement C4 - Reducing documentation requirements C5 - Incident reporting C6 - pre-construction surveys and information C7 - authorisation of unauthorised works C8 - working on TfL - time constraints C9 - physical delivery of assets to workface C10 - monitoring the works	D3 - Improve Monitoring of the works D4 - more concise documentation approaches
Institutional Level improvements				D5 - Reduce Bureaucracy D6 - Improve Communication D7 - Repeating the Vision

TABLE 12 - IMPLICATIONS FOR PRACTICE FOR TFL ISR PROJECT

Another point to note is the safety culture that enabled the TfL PITTA team to engage with these safety strategies. Without these enabling factors and enacting behaviours, the

AR approach and the SLT and PLF would not have delivered solutions to solve the safety risks identified.

First Round of Action Research for ISR

The first action taken with the TfL In-Station (ISR) retail team was to engage the business development manager and the safety manager. The TfL ISR team is a newly formed and growing team that was formed in 2020 and given the COVID pandemic, the team has not been fully developed yet. Some of the existing team members are new to the TfL business. The business development manager has been involved in helping shape the team that is required to deliver the retail projects. It was important to involve them early so that any proposed changes would be integrated with the overall change plan for ISR. Both the safety manager and the business development manager welcomed a safety framework and approach that was based on a previous project's lessons learnt. More work was required from me to develop a process map so that it could be integrated into the ISR change plan. The main outcomes of the first AR session were to ensure the initially proposed implications for practice had a strong link to the overall change plan for ISR. The safety manager supported the initial implications for practice and specifically noted the commitment required for the introduction of an SLT within the ISR team. Thus, resource and time were items that needed to be addressed for the successful implementation of the SLT.

Second Round of Action Research for ISR

The second step of action was to propose the initial findings with the ISR leadership team as a starting point for discussion and a plan for future actions. The various categories were presented as per table 12. The initial discussions focused on what ISR are currently doing and undertake a gap analysis of what we should be including to address safety risks. As previously stated, TfL has a strong safety management system and all the strategies noted for retaining were acknowledged as approaches that are currently being implemented and will be retained. I introduced the concept of AR and how this strategy helped to solve some complex safety risks for the TfL PITTA project. The initial discussions were concerned with how to resource the SLT, PLF and AR teams. My view was that the existing stakeholders would fill these roles, but there was concern about how burdening the existing resources further. The resource issue is initially noted from the first round of AR and thus supported in this second AR session. The ISR leadership team was not opposed to the AR strategy. I drew attention to the way the PLF, SLT and the AR team was formed within TfL PITTA team. The SLT was formed first, followed by the PLF and then the AR teams followed last. The TfL ISR team offered a different approach to engage the wider leadership team, and that was to form the AR teams first and solve some existing safety issues, followed by the formation of the SLT and the PLF. My view was that the SLT was important in the early diagnostic elements of existing problems, but this early diagnostic exercise could be incorporated in the AR team, because it is a required function

of the AR process. Thus, the order of formation within ISR team was proposed to be developed in a different sequence to the PITTA team.

The discussions led on to the safety culture elements that were found within the TfL PITTA team. I presented the findings on the enabling factors and enacting behaviours that contributed to the engagement of stakeholders in the application of the strategies. This opened a valuable discussion with the ISR team, in that it was perceived as a higher priority especially when introducing a new strategy to reduce safety risks. The consensus was to discuss the enabling and enacting factors and to highlight the areas where more development is required so that the safety culture can help support the new safety initiatives better. The grouped enabling factors were explored, and the organisational enabling factors was assessed as adequate, in that leadership commitment and existing TfL safety polices were strong. Group enabling factors such as cohesion and psychological safety are assessed as requiring more time to develop. This is predominantly due to the short time the team have had to work together and develop cohesion. As individual enablers, where safety skills, sense of control and individual commitment, the ISR team assessed these to be needing more development, especially in the introduction of more safety skills.

With regards to the enacting behaviours, the ISR team identified the incident reporting to be the most developed. Communication and information exchange, collaboration and fair rewarding and punishing behaviours are identified as areas that need improving. Given the short time teams have been formed within ISR, these are areas that need a little more time to develop.

The initial decisions arising from the group were to identify an area of safety risk that needed immediate improvement or solutions and to form an AR team to develop solutions for this safety issue. I suggested that the ISR fit out tenants' area posed the greatest safety threat for safety incidents and proposed a team of three for the AR group to be formed. These three persons are members of the construction team and AR work has already commenced in developing a training and induction course for all ISR tenants that are going to work on the TfL estate. This training course material is currently being developed with the view to develop it to be a certified CITB (Construction Industry Training Board) course that is provided in the future to anyone needing to work on the TfL estate. The first step is to develop this course in-house, as the TfL team are experts in the delivery of construction works within the TfL environment, and then to roll out the CITB course.

The second course of action is to develop a plan to enhance the enabling factors and enacting behaviours so that the safety culture within ISR is strengthened. The ISR leadership team viewed the success experienced with TfL PITTA project was influenced by a strong safety culture, which enabled the safety strategies to be fully employed. As such the SLT, PLF and AR had a strong engagement because the safety culture was strong within TfL PITTA project. Thus, forming the SLT and PLF within ISR was perceived as premature, until the safety culture within ISR is strengthened. As identified above, specific elements to do with safety culture need to be enhanced, and another action team

is proposed to develop this. The safety manager and myself are two members proposed for this team, and more team members are required at this at present time.

SUBSEQUENT ROUNDS OF ACTION RESEARCH FOR ISR

Currently, we have two AR teams within ISR that are investigating the fit-out tenant safety issue through the development of a training course, and the AR team that is focusing on the enhancing the safety culture within ISR through developing the enabling factors and enacting behaviours. The SLT has been set up more recently and is meeting periodically to assess progress and diagnose safety problems.

The AR safety culture team has progressed and commenced specific safety initiative drives, namely getting to site more, safety reporting and safety skills development. All the ISR safety initiatives are championed by specific project managers and supported and facilitated by me and the SLT. The ISR team is now, recently become a part of a larger team called Transport Trading Limited Properties (TTLP) which is the total property development division of TfL. TTLP is a much larger team and the ISR SLT will now be integrated into the new structure to encompass all the property related activities for TfL.

LIMITATIONS AND RESEARCH DIRECTIONS

The stakeholders selected for the interviews were stakeholders of the TfL PITTA project and as such the findings are specific to the case study, which is the TfL PITTA project. Similarly, the lessons learnt are specific to the TfL PITTA project. Moreover, the case study focuses on a project within the TfL environment and as such there may be limitations as to its applicability on other transportation organisations. Given the actions arising from the second cycle of action research within the TfL ISR team, there are specific areas that need to be addressed first, before the roll-out of any new safety initiatives. Safety culture is a priority if safety strategies are to be fully engaged by all delivery stakeholders and TfL PITTA project has taught us this lesson. This becomes apparent in the assessment of the safety culture within the TfL PITTA team and in the co-construction of new approaches within the TfL ISR team. Simply applying the SLT, PLF and AR teams are not a recommend approach in institutionalising these strategies in other parts of TfL.

Future research could be broadened to more stakeholders. In this study I have used three, but this could expand to include the operatives on the ground and broaden further to include governmental bodies.

Deciding to include the safety data, is not a straightforward exercise. Careful deliberation took place to assess the content on this data and how this data could be interpreted. TfL does not have limitless safety resources to collect specific safety data to meet this study's needs and as such the safety reports are not directly measuring the effectiveness of specific safety strategies. Safety reports offer indirect safety observations with regards

to effectiveness. Incident levels offer an insight on safety trends and highlight repeat issues, like the RAMS and the lack of briefings. Future research may be better positioned to predefine specific data to collate and collect such data for a more quantitative approach. Future research could use a mixed methods or quantitative study to include this data and to explore if these findings are more generalisable.

The stakeholders interviewed are experts in their chosen fields, thus their perspectives have a validity in forming the initial view on safety strategies within TfL. In this study, I have used the safety data to form a backdrop to these perspectives, but future research may apply a mixed methods approach, given specific data is collated.

Extant literature could benefit with more AR based studies in the construction related sector. This study contributes towards that research space. AR based approaches can be effective in reducing safety related risks within the construction sector and this study is co-constructing ways to institutionalise this approach to other areas of TfL, with the view to developing actionable knowledge and further action research.

CONCLUSIONS

The aims of this study are to investigate what lessons can be learnt from the application of an AR based approach in reducing safety risks within TfL. Within TfL PITTA project, the AR based approach is applied to solve very specific safety issues. AR solutions are effective in addressing these specific safety risks and produce innovative solutions that addresse specific safety risks.

AR is not applied in isolation within TfL. The findings demonstrate that AR sits within the context of a safety management system and is underpinned by theoretical premise and is applied within compliance considerations. More broadly, safety management systems do not exist in isolation either, they are bordered by other concepts, namely, safety leadership and safety culture, all of which sit within a broader organisational culture. I have highlighted these specific concepts and explicated how these mechanisms play a vital role is safety outcomes.

One limitation of this study uses a small in-depth sample for interviews, and three delivery stakeholders. AR has shown effectiveness in solving safety issues and this study does progress into another area of TfL retail. However, without further research, and perhaps using a mixed methods or quantitative method, the findings cannot be generalisable. Future research directions could address this issue.

There are some AR studies noted in the literature review that are applied within the construction sector, but much more is needed in this sector. This study contributes towards that area. This study collates the strategies used in reducing safety risks, investigates how effective these have been and highlights the challenges faced by the specialists applying these strategies.

In this study I have provided an insight to how AR is applied in practice. Theoretical foundations are important; however, these do not relay the challenges of AR in practice. Innovative solutions found within AR have been shown to be effective, but these have not been without the careful navigation through organisational culture, safety culture and safety leadership considerations. Notwithstanding the numerous trails and tests that are required to secure viable solutions. At times, these, did not go to plan, and much deliberation and a return to the 'drawing board' was required. Appreciatively, the AR based method is a collaborative approach and at times when no solution seemed possible, the collective power of the team came to the rescue. AR seems to promote a strong collaborative environment, which has contributed to the AR solutions being developed and applied.

I am grateful to have had this opportunity to be involved as a researcher-practitioner with AR-based method. Safety is important to me; I have a duty of care to the workforce that I set out to work on our estate. AR is one such method that is effective in reducing safety risks and in turn reducing the risk to our workforce.

RESEARCHER'S REFLECTIONS FROM PRACTICE OF AR APPROACH

AR is not a strategy that is typically used within TfL. As a researcher-practitioner, there is adequate literature and theoretical support to propose the notion of AR within our TfL PITTA project using the SLT as a platform to launch this idea. There are several pitfalls that need to be avoided, one of which has to do with time constraints. Given that all proposed members of the AR team are also project team members with specific roles that need to be fulfilled, the AR strategy would require additional effort to be undertaken and over and above ones' normal duties. In addition, the programme of works cannot be delayed so taking action within AR has a time constraint in order to develop solutions, plan for action and test the proposals, before any solution was accepted as a feasible solution. The AR based approach requires a fully resourced team to action fully.

My initial approach in this research is to use the interview data to construct perspectives, but subsequent reconsiderations, based on the supervisors' inputs makes me reconsider this position. I am initially reluctant to include the safety data because effectiveness of strategies is difficult to support with the data. However, not including this data is also problematic because I am only left with stakeholders' perspectives and there is ethical considerations to make of not using data that is linked to incidents. Using the safety data to provide further meaning offers this research stronger validity and confidence in proposing a new starting point for the AR TfL ISR team. More specific safety data in the future, which can be isolated to provide a quantitative or a mixed methods approach, may be useful future research to pursue.

In my experience, proposing any change or new safety ideas to my organisation is not a straightforward exercise. New ideas are often met with scepticism, uncertainty, and resistance. I am aware that I have been studying and researching this problem area for several years, so there is a great deal of patience required to allow TfL colleagues to arrive at new ideas that have been developed over time.

As a researcher practitioner, I have learnt that the way change is implemented is complex. Stakeholders need to be engaged and how one goes about the execution of change requires skill. I have certainly developed within this area as a practitioner throughout the DBA process, and I still have a lot to learn.

This study provides me a platform to undertake further research in the future, where I could explore AR based approaches further within TfL and the wider construction environment.

The practice of action research has made me reconsider my role as a manager or a leader, and the responsibilities that entails. I feel a deep sense of responsibility towards solving our organisational challenges. I want to reduce and prevent injury to any person who undertakes work on our TfL estate. The practice of AR has provided a new way to reflect and address a complex organisational problem and to provide meaningful, and effective strategies to improve the way we operate. In addition, AR has also provided me

newfound and improved skills in reflective thinking, interviewing, listening, presenting, taking action and collaboration. I feel that I am a much more valuable member within our team and organisation today than before I started the DBA journey. I feel I can contribute in effective and meaningful ways. Critical reflection has offered me the opportunity to become a more freethinking, and responsible leader.

REFERENCES

Adams, E.E., (1976) 'Accident causation and the management system.' *Professional Safety* 21 (10), 26–29.

Aires, M.D.M., Gámez, M.C.R., and Gibb, A., (2010) 'Prevention through design: the effect of European Directives on construction workplace accidents.' *Safety Science* 2010;48:248–58.

AlSehaimi, A., Koskela, L., and Tzortzopoulos, P., (2013) 'Need for Alternative Research Approaches in Construction Management: Case of Delay Studies.' *Journal of Management in Engineering,* Vol. 29, No. 4, October 1, 2013.

Altayeb, S., (1992) 'Efficacy of drug testing programs implemented by contractors.' *Journal of Construction Engineering and Management* 1992;118(4):780-90.

Argyris, C., (1994) 'Good communication that blocks learning.' *Harvard Business Review*, 72(4), 77–85.

Argyris, C., and Schön, D., (1978) *Organizational learning: A theory of action perspective.* Addison-Wesley, Reading, Mass.

Atique, S., Zarour, A., Siddiqui, T., El-Menyar, A., Maull, K., Al Thani, H., et al., (2012) 'Trauma caused by falling objects at construction site.' *Journal of Trauma and Acute Care Surgery* 2012;73(3):704-8.

Azhar, S., Ahmad, I., and Sein, M.K., (2010) 'Action Research as a Proactive Research Method for Construction Engineering and Management.' *Journal of Construction Engineering and Management,* Vol. 136, No. 1, January 1, 2010.

Babbie, S., (2007) *The Practice of Social Research.* Belmont: Thomason Higher Education.

Bandura, A., (1986) *Social Foundations of Thought and Action: A Social Cognitive Theory.* Prentice-Hall, Englewood Cliffs, NJ.

Barney, J., (1991) Firm resources and sustained competitive advantage. *Journal of management,* 17(1), pp.99-120.

Baskerville, R.L., (1997) 'Distinguishing action research from participative case studies', *Journal of Systems and Information Technology*, Vol. 1 Issue: 1, p.24-43.

Baskerville, R.L., (1997) 'Distinguishing action research from participative case studies', *Journal of Systems and Information Technology,* Vol. 1 Issue: 1, p.24-43.

Bazerman, M.H. and Watkins, M.D., (2008) 'Cognitive roots: The role of human biases. In Predictable Surprises: The Disasters You Should Have Seen Coming and How to Prevent Them.' *Boston: Harvard Business Press.*

Beal, A., (2007) 'CDM Regulations: 12 years of pain but little gain.' *Institution of Civil Engineers: Civil Engineering, 2007, 160, No. CE2.* p.82-88.

Beal, D. J., Cohen, R. R., Burke, M. J., McLendon, C. L., (2003) 'Cohesion and performance in groups: A meta-analytic clarification of construct relations.' *Journal of Applied Psychology*, 88, p. 989–1004.

Bena, A., Berchialla, P., Coffano, M.E., Debernardi, M.L., and Icardi, L.G., (2009) 'Effectiveness of the Training Program for Workers at Construction Sites of the High-Speed Railway Line Between Torino and Novara: Impact on Injury Rates.' *American Journal Of Industrial Medicine* 52:965–972 (2009).

Bentley, T.A., Hide, S., Tappin, D., Moore, D., Legg, S., Ashby, L., et al., (2006) 'Investigating risk factors for slips, trips and falls in New Zealand residential construction using incident-centred and incident independent methods.' *Ergonomics* 2006;49(1):62-77.

Bird, F.E.J., (1974) 'Management Guide to Loss Control.' *Institute Press* (A Division of International Loss Control Institute), Loganville (GA).

Bisbey, T. M., Kilcullen, M. P., Thomas, E. J., Ottesen, M. J., Tsao, K., Salas, E., (2021) 'Safety Culture: An Integration of Existing Models and a Framework for Understanding Its Development' *Human Factors*, Vol. 63, No 1, p. 88-110.

Cabrera, D.D., Isla, R., (1998) 'The role of safety climate in a safety management system.' In: Hale, A., Baram, M. (Eds.), *Safety Management: The Challenge of Change. Elsevier Science, Oxford,* p. 93-105.

Clarkson, M.B.E., (1995) 'A stakeholder framework for analyzing and evaluating corporate social performance.' *Academy of Management Review*. 20 (1), 92–117.

combined perspective of supervisors and experienced workers.' *Journal of Safety*
Conchie, S. M. (2013). 'Transformational leadership, intrinsic motivation, and trust: A moderated-mediated model of workplace safety.' *Journal of occupational health psychology*, *18*(2), 198.

Conchie, S. M., Moon, S., & Duncan, M. (2013) 'Supervisors' engagement in safety leadership: Factors that help and hinder.' *Safety science*, *51*(1), 109-117.

Connaughton, J., & Weller, S. (2013) 'Improving collaboration in construction: an opportunity for action research.' *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 1125-1134.

Construction and Design Management (CDM) (2015) Available at: http://www.hse.gov.uk/pUbns/priced/l153.pdf (Downloaded: 7th May 2018).

Cooke, R.A., Rousseau, D.M., (1988) 'Behavioural norms and expectations: a quantitative approach to the assessment of organizational culture.' *Group and Organization Studies* 13, p.245-273.

Cooper, M.D., (2000) 'Towards a model of safety culture.' *Safety Science* 36, p.111-136.

Cooper, M.D., Phillips, R.A., (1995) 'Killing two birds with one stone: achieving total quality via total safety management.' *Leadership and Organization Development Journal* 16, p.3-9.

Creswell, J., (2013) *Qualitative inquiry and research design: choosing among five approaches.* 3rd ed. London: Sage. Chapters 1–5.

Davies, A., MacAulay, S., DeBarro, T., and Thurston, M., (2014) 'Making Innovation Happen in a Megaproject: London's Crossrail Suburban Railway System', *Project Management Journal*, Vol 45, No 6, p. 25-37.

Davies, G.F., Powell, W.W., (1992) 'Organisation - environment relations.' In: Dunnette, M.D., Hough, L.M. (Eds.), *Handbook of Industrial and Organizational Psychology*. p. 315-375.

Deming, W.E., (1950) *Elementary Principles of the Statistical Control of Quality*, JUSE

Donaldson, T. and Preston, L.E., (1995) 'The stakeholder theory of the corporation: Concepts, evidence, and implications.' *Academy of management Review*, 20(1), pp.65-91.

Dougherty, D., (1992) 'Interpretive barriers to successful product innovation in large firms.' *Organization Science*, 3, 179–202.

Dougherty, D., (2016) *Taking advantage of emergence. Productively Innovating in Complex Innovation Systems.* Oxford University Press.

Easterby-Smith, M., Thorpe, R., & Jackson, P., (2013) *Management research.* 4th ed. London: Sage.

Edmondson, A., (1999) 'Psychological safety and learning behavior in work teams.' *Administrative Science Quarterly*, 44, 350–383.

Fang, D., Wu, C., & Wu, H. (2015). 'Impact of the supervisor on worker safety behavior in construction projects.' *Journal of management in engineering*, *31*(6), 04015001.

Fouquet, N., Petitb, A., Descathac, A., and Roquelaureb, Y., (2018) 'Theoretical impact of workplace-based primary prevention of lumbar disc surgery in a French region: A pilot study', *IOS* Press, Work 62 (2019) 13–20.

Freeman, R. E., (1984) *Strategic management: A stakeholder approach.* Boston: Pitman.

Freeman, R. E., Harrison, J. S., & Wicks, A. C., (2007) *Managing for stakeholders: Survival, reputation, and success.* New Haven, CT: Yale University Press.

Gibb, A., Hide, S., Haslam, R., and Hastings, S., (2001) 'Identifying Root Causes of Construction Accidents', *Journal of Construction Management and Engineering,* July/August, p. 348-349.

Glendon, A. I., Stanton, N. A., (2000) 'Perspectives on safety culture.' *Safety Science*, 34, p. 193–214.

Goh, K.C., Goh, H.H., Omar, M.F., Toh, T.C., and Zin, A.A.M., (2016) 'Accidents Preventive Practice for High-Rise Construction' MATEC Web of Conferences, 47, 04004, (2016).

Granovetter, M.S., (1973) 'The strength of weak ties.' *American journal of sociology*, 78(6), pp.1360-1380.

Greenwood, D.J. & Levin, M., (2007). *Introduction to action research.* 2nd ed. Thousand Oaks, California: Sage. Chapter 1, 'Introduction: Action Research, Diversity, and Democracy'

Grill, M., Pousette, A., Nielsen, K., Grytnes, R., & Törner, M. (2017). 'Safety leadership at construction sites: the importance of rule-oriented and participative leadership.' *Scandinavian journal of work, environment & health*, 375-384.

Guba, E.G., & Lincoln, Y.S., (1981) *Effective evaluation.* Newbury Park, CA: Sage.

Guba, E.G., & Lincoln, Y.S., (1989) *Fourth generation evaluation.* Newbury Park, CA: Sage.

Guldenmund, F. W., (1998) 'The nature of safety culture: a review of theory and research.' Paper presented at the 24th *International Congress of Applied Psychology, Safety culture Symposium*, 9-14 August, San Francisco, CA, USA.

Guldenmund, F. W., (2000) 'The nature of safety culture: A review of theory and research.' *Safety Science*, 34, p. 215–257.

Guldenmund, F. W., (2007) 'The use of questionnaires in safety culture research—An evaluation.' *Safety Science*, 45, p. 723–743.

Habermas, J., (1974) *Theory and Practice,* trans. John Viertel. London: Heinemann.

Haddon Jr., W., (1973) 'Energy damage and the ten countermeasure strategies.' *Human Factors.: Journal of Human Factors and Ergonomics Society,* 15 (4), 355–366.

Hale, A. R. (2000) 'Railway safety management: The challenge of the new millennium.' *Safety Science Monitor*, 1, p. 1–15.

Hale, A.R., (2005) 'Safety Management, What do We Know, What do We Believe We Know, and What do We Overlook.' *Safety Science Group Delft University of Technology, Netherlands.*

Haslam, R.A., Hide, S.A., Gibb, A.G.F., Gyi, D.E., Pavitt, T., Atkinson, S., Duff, A.R., (2005) 'Contributing factors in construction accidents' *Applied Ergonomics* 36 (2005) p.401–415.

Health and Safety at Work etc. Act, (1974) Chapter 37 Available at: https://www.legislation.gov.uk/ukpga/1974/37 (Accessed 12th June 2020)

Health and Safety Executive, HSE, (2013) *Managing for health and safety (HSG65)*, 3rd Edition 2013.

Hoffmeister, K., Gibbons, A. M., Johnson, S. K., Cigularov, K. P., Chen, P. Y., & Rosecrance, J. C. (2014) 'The differential effects of transformational leadership facets on employee safety.' *Safety science*, 62, 68-78.

Hughes, A. M., Gregory, M. E., Joseph, D. L., Sonesh, S. C., Marlow, S. L., Lacerenza, C. N., Salas, E., (2016) 'Saving lives: A meta-analysis of team training in healthcare.' *Journal of Applied Psychology*, 101, p. 1266–1304.

Inyang, N., Han, S., Al-Hussein, M., El-Rich, M., (2012) 'A VR Model of Ergonomics and Productivity Assessment in Panelized Construction Production Line' *Construction Research Congress 2012.*

Ivan, J.N., Malenich, J., Pain, R., (2003) 'Safety management systems: A Synthesis of Highway Practice (Synthesis of highway practice 322).' Retrieved from *Transportation Research Board*, Washington, D.C.

Jensen, M.C. and Meckling, W.H., (1976) 'Theory of the firm: Managerial behavior, agency costs and ownership structure.' *Journal of financial economics*, 3(4), pp.305-360

Jensen, M.C., (1993) 'The modern industrial revolution, exit, and the failure of internal control systems.' *the Journal of Finance*, 48(3), pp.831-880

Kincl, L.D., Anton, D., Hess, J.A., and Weeks, D.L., (2016) 'Safety voice for ergonomics (SAVE) project: protocol for a workplace cluster randomized controlled trial to reduce musculoskeletal disorders in masonry apprentices.' *BMC Public Health* (2016) 16:362.

Li, Y., and Guldenmund, F.W., (2018) 'Safety Management Systems; A broad overview of the literature.' *Safety Science* 103 (2018) p.94-123.

Lowery, J.T., Borgerding, J.A., Zhen, B., Glazner, J.G., Bondy, J., and Kreiss, K., (1998) 'Risk Factors for Injury Among Construction Workers at Denver International Airport' *American Journal of Industrial Medicine* 34:113–120 (1998).

Marks, M. A., Mathieu, J. E., & Zaccaro, S. J., (2001) 'A temporally based framework and taxonomy of team processes.' *Academy of Management Review*, 26, p. 356–376.

Meyer, J.W. and Rowan, B., (1977) Institutionalized organizations: Formal structure as myth and ceremony. *American journal of sociology*, 83(2), pp.340-363.

Miller, R., and Lessard, D., (2001) 'Understanding and managing risks in large engineering projects.' *International Journal of Project Management* 19 (2001) p.437–443.

Mills, A., (2001) 'A systematic approach to risk management for construction.' *Structural Survey*, Volume 19 number 5 p. 245-252.

Mitchell, R.K., Agle, B.R. and Wood, D.J., (1997) 'Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts.' *Academy of management review*, 22(4), pp.853-886.

Naaranoja, M., Kähkönen, K. and Keinänen, M., (2014) 'Construction projects as research objects–different research approaches and possibilities.' *Procedia-Social and Behavioral Sciences*, 119, pp.237-246.

Naoum, S., Hemmings, B., Fong, D., (2011) 'Is there a correlation between contractor's health and safety performance and their profit margin?' *ISEC 2011 - 6th International Structural Engineering and Construction Conference*

Nielsen, D.S., (1974) 'Use of cause-consequence charts in practical systems analysis' (Risø-M-1743). *Paper presented at the Conference on Reliability and Fault Tree Analysis*, University of California, Berkeley (CA).

Niskanen, W. A., (1994) *Bureaucracy and Public Economics*, Books, Edward Elgar Publishing, number 333.

Nonaka, I., (1994) 'A Dynamic Theory of Organizational Knowledge Creation', Organization Science 5(1):14-37.

Office of Rail and Road, (2017) 'Strategy for Regulation of health and safety risks, Chapter 12: Health and Safety by Design.' Available at: https://www.orr.gov.uk/sites/default/files/om/strategic-chapter-12-health-and-safety-by-design.pdf (Accessed: October 2018).

Office of Rail and Road, (2019) '5210 Annual data of Health and Safety Performance on Britain's Railways' 2001-2020, issued 2020. Available at: https://www.orr.gov.uk/monitoring-regulation/rail/promoting-health-safety/annual-health-safety-report (Accessed: October 2018).

Office of Rail and Road, (2019) *RM3, The Risk Management Maturity Model,* 3rd edition: Crown. Available at: https://www.orr.gov.uk/sites/default/files/2020-09/risk-management-maturity-model-rm3-2019.pdf (Accessed at: October 2018).

Pawson, R., & Tilley, N., (1997) *Realist Evaluation.* London: Sage.

Phillips, R., (2003) *Stakeholder theory and organizational ethics.* San Francisco, CA: Berrett-Koehler.

Phillips, R., (2003) *Stakeholder theory and organizational ethics*. Berrett-Koehler Publishers.

Pilbeam, C., Doherty, N., Davidson, R., & Denyer, D. (2016) 'Safety leadership practices for organizational safety compliance: Developing a research agenda from a review of the literature.' *Safety science*, *86*, 110-121.

Reason, J., (1990) 'The contribution of latent human failures to the breakdown of complex systems.' *Philosophical Transactions of the Royal Society B: Biological Sciences,* 327 (1241), 475–484.

Reason, J., (1997) *Managing the Risks of Organizational Accidents.* Ashgate Publishing Ltd, Aldershot, Hants.

Reason, J., (1997) *Organizational accidents: The management of human and organizational factors in hazardous technologies*. Cambridge, UK: Cambridge University Press.

Reiman, T., Pietikäinen, E., Oedewald, P., (2010) 'Multilayered approach to patient safety culture.' *Quality and Safety in Health Care*, 19, e20.

Rubio-Romero, J.C., Carrillo-Castrillo, J.A., Gibb, A., (2015) 'Prevention of falls to a lower level: evaluation of an occupational health and safety intervention via subsidies for the replacement of scaffolding.' *International Journal of Injury Control and Safety Promotion* 2015;22(1):16-23.

Schein, E. H., (1984) 'Coming to a new awareness of organizational culture.' *Sloan Management Review*, 25(2), p. 3–16.

Schein, E., (1992) *Organisational Culture and Leadership,* 2nd Edition. Jossey-Bass, San Francisco CA.

Schenkels, A., and Jacobs, G., (2018) 'Designing the plane while flying it': concept co-construction in a collaborative action research project', *Educational Action Research.*

Smillie, R.J., Ayoub, M.A., (1976) 'Accident causation theories: a simulation approach.' *Journal of Occupational Accidents*, 1 (1), 47–68. http://dx.doi.org/10.1016/0376-6349(76)90007-9.

Sowah, D., Boyko, R., Antle, D., Miller, L., Zakhary, M., Straube S., (2018) 'Occupational interventions for the prevention of back pain: Overview of systematic reviews', *Journal of Safety Research* 66 (2018) 39–59.

Stiles, S., Ryan, B., & Golightly, D. (2018) 'Evaluating attitudes to safety leadership within rail construction projects.' *Safety science*, *110*, 134-144.

Strufflebeam, D. L., & Shinkfield, A. J., (2007) *Evaluation theory, models and applications.* San Francisco: Jossey-Bass.

Suraji, A., Duff, A.R., and Peckitt, S.J., (2001) 'Development of Causal Model of Construction Accident Causation', *Journal of Construction Engineering and Management,* July/August, p.337-344.

Tajfel, H., Turner, J., (1986) 'The social identity theory of intergroup behavior.' In S. I. Worchel & W. G. Austin (Eds.), *Psychology of intergroup relations* (p. 7–24). Chicago, IL: Nelson Hall.

Teece, D.J., Pisano, G. and Shuen, A., (1997) 'Dynamic capabilities and strategic management.' *Strategic management journal*, 18(7), pp.509-533.

TfL Health, Safety and Environment Annual Report (2016/17) Available at: http://content.tflTfL.gov.uk/board-20180130-item06-hse-annual-report.pdf (Downloaded: 20th October 2018).

TfL Pathway Guidance Product R0473, (2019) *Active Risk Manager Guidance Document* Rev A2. Internal TfL Document. Unpublished.

TfL Pathway Health and Safety Special Interest Group Product PD0225, (2017) *Construction Phase and Environmental Management Plan* Rev 5. Internal TfL Document. Unpublished.

TfL Process and Guidance Pathway Product H064, (2017) *Manging a Programme* Rev 2. Internal TfL Document. Unpublished.

TfL Process and Guidance Pathway Product H066, (2017) *Pathway Construction Handbook* Rev 4. Internal TfL Document. Unpublished.

TfL Process and Guidance Pathway Product H068, (2018) *Pathway Manual* Rev A3. Internal TfL Document. Unpublished.

The Cochrane Research Centre, (2020) Available at: https://www.cochrane.org/about-us (Accessed at: 1st March 2020).

The Railways and Other Guided Transport Systems (Safety) Regulations 2006, (2006) *United Kingdom Statutory Instruments.*

Thomas, M.J., (2011) 'A Systematic Review of the Effectiveness of Safety Management Systems' (AR-2011-148). Retrieved from *Australian Transport Safety Bureau*.

Törner, M., Pousette, A., (2009) 'Safety in construction–a comprehensive description of the characteristics of high safety standards in construction work, from the combined perspective of supervisors and experienced workers.' *Journal of safety research*, 40(6), pp.399-409.

Turner, J. C., (1999) 'Some current issues in research on social identity and self-categorization theories.' In N. Ellemers, R. Spears, & B. Doosje (Eds.), *Social identity: Context, commitment, content* (pp. 6–34). Oxford, UK: Blackwell.

Valente, T.W., (1996) 'Social network thresholds in the diffusion of innovations.' *Social networks*, 18(1), pp.69-89.

van der Molen, H.F., Basnet, P., Hoonakker, P.L.T., Lehtola, M.M., Lappalainen, J., Frings-Dresen, M.H.W., Haslam, R., Verbeek, J.H., (2018) 'Interventions to prevent injuries in construction workers.' *Cochrane Database of Systematic Reviews* 2018, Issue 2.

van der Molen, H.F., Sluiter, J.K., Hulshof, C.T.J., Vink, P., van Duivenbooden, C., Holman, R., Frings-Dresen, M.H.W., (2005) 'Implementation of participatory ergonomics intervention in construction companies.' *Scandinavian Journal of Work, Environment & Health* 2005; 31(3): p.191–204.

Vogus, T. J., Sutcliffe, K. M., Weick, K. E., (2010) 'Doing no harm: Enabling, enacting, and elaborating a culture of safety in health care.' *Academy of Management Perspectives*, 24(4), p. 60–77.

Wickizer, T.M., Kopjar, B., Franklin, G., Joesch, J., (2004) 'Do drugfree workplace programs prevent occupational injuries? Evidence from Washington State.' *Health Services Research* 2004;39(1):91-110.

Williams Jr., Q., Ochsner, M., Marshall, E., Kimmel, L., Martino, C., (2010) 'The impact of a peer-led participatory health and safety training program for Latino day laborers in construction', *Journal of Safety Research* 41 (2010) 253–261.

Wu, C., Li, N., & Fang, D. (2017) 'Leadership improvement and its impact on workplace safety in construction projects: A conceptual model and action research.' *International Journal of Project Management*, 35(8), 1495-1511

Xia, N., Zhong, R., Wu, C., Wang, X., Wang, S., (2017). 'Assessment of stakeholder-related risks in construction projects: integrated analyses of risk attributes and stakeholder influences.' *Journal of Construction Engineering and Management*. 143 (8), 04017030.

Xia, N., Zou, P. X., Griffin, M. A., Wang, X., & Zhong, R. (2018). 'Towards integrating construction risk management and stakeholder management: A systematic literature review and future research agendas.' *International Journal of Project Management*, *36*(5), 701-715.

Yang, R.J., Wang, Y., Jin, X.H., (2014). 'Stakeholders' attributes, behaviors, and decision–making strategies in construction projects: importance and correlations in practice.' *Project Management Journal*. 45 (3), 74–90.

Yin, R.K., (2014) *Case Study Research*, 5th Edition: Sage.

Yin, R.K., (2016) *Qualitative Research from Start to Finish*, 2nd Edition: The Guilford Press.

Yoe, C., (2011) 'Primer on Risk Analysis: Decision Making Under Uncertainty.' *CRC Press*, New York (NY).

Zavadskas, E., Vainiūnas, P., Turskis, Z., & Tamošaitienė, J., (2012) 'Multiple Criteria Decision Support System for Assessment of Projects Managers in Construction', *International Journal of Information Technology & Decision Making*, 11, 2, P. 501.

Zucker, L.G., (1983) 'Organizations as institutions.' *Research in the Sociology of Organizations*, 2: 1-42. Greenwich, CT: JAIPress.

APPENDICES

APPENDIX A – INTERVIEW QUESTIONS

Interview Questions		
	question	category
1	What was your involvement with the Programme Leadership Forum (PLF) OR Safety Leadership Team (SLT)?	involvement/ context/ stakeholder
2	What strategies did you implement in order to reduce workplace incidents?	strategies used to reduce workplace incidents
3	Which of these strategies were done during pre-construction phase?	
4	Which strategies were used during the construction phase?	
5	Of the strategies used during the pre-construction phase, which of these strategies do you feel were more effective ones in relation to safety related risks?	effectiveness of strategies used
6	Of the strategies used during the construction phase, which of these strategies do you feel were more effective in relation to safety related risks?	
7	Of these strategies, where do you think improvements or refinements could be used to improve the strategies?	
8	What challenges were experienced in implementing these strategies?	challenges encountered using strategies
9	Were there specific challenges in the pre-construction phase strategies that you can highlight and how were they addressed?	
10	Were there specific challenges in the construction phase strategies that you can highlight and how were they addressed?	
11	Which of these strategies, have you used in other parts of the organisation or other projects that you are involved in?	institutionalising of strategies
12	Which of these strategies would you recommend in implementing into other areas or industries you are involved in and why?	
13	How well have these strategies been institutionalised into other areas of your organisation?	
14	Which of these strategies would you NOT recommend in implementing into other areas or industries you are involved with and why?	

APPENDIX B – ETHICS APPROVAL LETTER

Dear Christos,

I am pleased to inform you that the DBA Research Ethics Committee has approved the revisions to the ethical approval for your study. These revisions were due to the impact of Covid-19 and informed by the guidelines for social distancing from the World Health Organisation (WHO) and University of Liverpool (UoL). Details and conditions of the approval can be found below:

Committee Name: DBA Research Ethics Committee

Title of Study:

A Case Study into how Action Research may be used to Diagnose and Solve TfL Construction Safety Risks

Student Investigator: Christos Savva

School/Institute: School of Management

Approval Date: 14.05.2020.

The application was APPROVED subject to the following conditions:

1. The researchers must obtain ethical approval from a local research ethics committee if this is an international study

2. University of Liverpool approval is subject to compliance with all relevant national legislative requirements if this this is an international study.

3. All serious adverse events must be reported to the Sub-Committee within 24 hours of their occurrence, via the Research Integrity and Governance Officer (ethics@liv.ac.uk)

4. If it is proposed to make an amendment to the research, you should notify the Committee of the amendment.

This approval applies to the duration of the research. If it is proposed to extend the duration of the study as specified in the application form, the Committee should be notified.

Kind regards,

Alison

Dr Alison Hollinrake
Faculty Reviewer

APPENDIX C – PARTICIPANT CONSENT FORM

UNIVERSITY OF LIVERPOOL

Committee on Research Ethics

PARTICIPANT CONSENT FORM

Title of Research Project: **A Case Study into Reducing Workplace Accidents on TfL projects**

Researcher(s): Christos Savva

Please initial box

1. I confirm that I have had a minimum of two weeks to read and have understood the information sheet dated [August 2019] for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my rights being affected. In addition, should I not wish to answer any particular question or questions, I am free to decline. ☐

3. I understand that, under the Data Protection Act, I can at any time ask for access to the information I provide and I can also request the destruction of that information if I wish. ☐

4. I agree to take part in the above study. ☐

5. I agree to take part in the above study via remote interview and accept that an electronic signature or a confirmation email shall be required due to the covid19 pandemic. ☐

Participant Name	Date	Signature

Researcher	Date	Signature
Christos Savva		

Student Researcher:
Name: Christos Savva
Work Address: 14 Pier Walk, 3rd Floor, North Greenwich, London, SE10 0ES
Mobile: +44 (0) 7746387583
Work Email: christos.savva@liverpool.ac.uk

[Version 01 _ Date: Nov 2017]

UNIVERSITY OF LIVERPOOL

Optional Statements

- The information you have submitted will be published as a report; please indicate whether you would like to receive a copy. ☐
- I understand that confidentiality and anonymity will be maintained, and it will not be possible to identify me in any publications. ☐
- I agree for the data collected from me to be used in future research and understand that any such use of identifiable data would be reviewed and approved by a research ethics committee. ☐
- I understand and agree that my participation will be audio recorded and I am aware of and consent to your use of these recordings for the purposes of transcription ☐
- I agree for the data collected from me may be used in relevant future research. ☐
- I would like my name used and I understand and agree that what I have said or written as part of this study will be used in reports, publications and other research outputs so that anything I have contributed to this project can be recognised. ☐

APPENDIX D – PARTICIPANT INFORMATION SHEET

UNIVERSITY OF LIVERPOOL

Committee on Research Ethics

Participant Information Sheet

1. **Title of Study**

   A Case Study into Reducing Workplace Accidents on TfL projects

2. **Version Number and Date**

   Version 01: August 2019

3. **Invitation to Participants**

   You are being invited to participate in a research study. Before you decide whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and feel free to ask us if you would like more information or if there is anything that you do not understand. Please also feel free to discuss this with your friends and/or relatives if you wish. We would like to stress that you do not have to accept this invitation and should only agree to take part if you want to.

   Thank you for reading this.

4. **What is the purpose of the study?**

   This study explores how an action research strategy may be used to address project risks within TfL projects. This case study explores how action research may contribute towards reducing workplace injuries.

   The potential benefit of this research is that new insights and information about the mitigation of project risks, in applying an action research approach, may inform future TfL projects and contribute towards reducing future workplace injuries. In addition, evaluations shall be undertaken to explore the benefits of applying an action research approach in problem-solving, and how this approach may improve the cohesiveness of teams or groups in problem-solving and contribute toward improving collaboration and accountability.

5. **Why have I been chosen to take part?**

   You have been chosen because you are person who has a direct connection, link and/or influence over this project or have been impacted by the projects' decisions relating to reducing project risks. You have also been chosen with the researchers' intention to have a diverse sample of managers or operatives within the whole supply chain, from client to supplier. You may have also been chosen as a comparative project to corollate or contrast the findings of this specific case being studied.

6. **Do I have to take part?**

   Participation is voluntary and participants are free to withdraw at anytime without explanation and without incurring a disadvantage.

7. **What will happen if I take part?**

Participant Information Sheet

UNIVERSITY OF LIVERPOOL

Below is an explanation of exactly what will be asked of you and what will happen during the research:

- You should expect a one-to-one interview with the researcher. This may be undertaken remotely using telephone or video at a pre-agreed time, given the covid19 circumstances.
- The researcher carrying out the interviews is Christos Savva.
- The supervisor for this study is Alen Badal.
- The interviews are expected to last for approximately one hour
- As a participant, you are responsible to notify the researcher if there are specific requirements you will need to undertake the interview.

Please note that this research interview will involve an audio recording. Your consent of this is included in the consent form. If the interview is conducted remotely due to Covid19, you will need to consent remotely by acceptance via electronic signature or confirmation email on the consent form. This is listed as item 5 on the consent form.
Post-interview, there may be some further clarification and/or verification required by you about the data collected from your interview. This serves as a quality control measure and also a time for you to clarify specific points.

8. Expenses and / or payments

If any specific travel expenses have been incurred that relate to participation of this study, then these expenses will be fully compensated. There are no payments, thank you gifts or other compensations to be made.

9. Are there any risks in taking part?

There is a potential, minimal reputational and/or psychological risk when highlighting failures within a business unit and when such failures are perceived negatively. If adverse information comes to light, this may affect people who are responsible for specific areas where failures have been identified. All specific personal details and reference that have the potential to identify persons, directly or indirectly within the organisation will be protected within the case study report by the use of a less granular narration by the author. The risk will be kept to a minimum by increasing the granularity of the narrative within the study. Personal data will be stored on password protected personal computers, where it will be anonymised for this study, therefore, the risk of personal data protection being breached is kept an a minimum.
If the participant should experience any discomfort or disadvantage as part of the research, this should be made known to the researcher(s) immediately.

10. Are there any benefits in taking part?

The potential benefit of taking part in this research is that you may contribute towards discovering new insights and information about mitigation of project risks, by using an action research approach. This may inform future TfL projects and contribute towards reducing workplace injuries. There is also the potential of evaluating other benefits of applying an action research approach in problem solving, by enhancing and improving the cohesiveness of teams in problem-solving and contributing towards improving collaboration and accountability within teams.

11. What if I am unhappy or if there is a problem?

If you are unhappy, or if there is a problem, please feel free to let us know by contacting **Alen Badal - 00 1 209 380 7215** and we will try to help. If you remain unhappy or have a complaint which you feel you cannot come to us with then you should contact the Research Governance Officer at ethics@liv.ac.uk. When contacting the Research Governance Officer, please provide details of the name or

description of the study, the researcher(s) involved, and the details of the complaint you wish to make.
You may also contact the **University Research Participant Advocate**, (USA number 001-612-312-1210 or email address liverpoolethics@ohecampus.com)

12. Will my participation be kept confidential?

Data is to be collected using audio equipment that will be stored securely on the PIs' (Principal Investigators) personal computers and backed up on UoL (University of Liverpool) data storage systems, which are password protected. The PIs personal computer is password and fingerprint protected. The interview data will be transcribed and analysed. Data will be anonymised, unless otherwise requested within the consent form. Data will be used to investigate the mechanisms and context of decisions made to minimise project risks and the outcome on workplace injuries. Other aspects such as collaboration, team cohesiveness and behaviours may be evaluated. Only the principal researcher and supervisor will have access to this data, and it will be stored for five years after the study is completed on the PIs personal computer and backed up at UoL data systems, which are password protected and accessible only to the principal researcher and supervisor. No data will be stored on work computers. Transcripts and audio recordings will be shredded and deleted respectively. Only electronic copies for the duration for research purposes will be retained in safekeeping.

13. What will happen to the results of the study?

If requested, the results may be made available electronically to the participants. Participants will not be identifiable from the results unless they have consented to being so.

14. What will happen if I want to stop taking part?

Participants should be informed that they can withdraw at any time, without explanation. Results up to the period of withdrawal may be used if consent has been given. Participants may request that results are destroyed, and no further use is made of them. If results are anonymised results may only be withdrawn prior to anonymisation.

15. Who can I contact if I have further questions?

Christos Savva
Principal Investigator
14 Pier Walk
3rd Floor
North Greenwich
London
SE10 0ES
Mobile: +44 (0) 7746387583
Email: christos.savva@liverpool.ac.uk

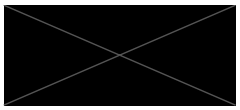
Mobile +44 7746387583

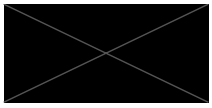
16. Conflict of Interest

This study is kept independent from the researcher's professional role. A potential conflict of interest arising from the duality of roles of the principal researcher as a researcher and a professional manager shall be managed through the initial reporting of such conflict to the primary supervisor. The principal view is to safeguard the objectivity of this case study research.

APPENDIX E – EXISTING SAFETY REPORTS (EXTRACT ONLY OF P13_2018 AND P7_2019)

(Redacted copies)





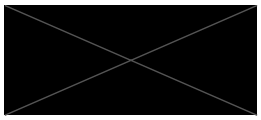
QEHS / PITTA / PERFORMANCE REPORT

RAIL LONDON PROJECTS BUSINESS AREA

March P13 2018/19

Authority	Name	Signature	Date
Author -	[redacted]		
Reviewer	[redacted]		
Approved -	[redacted]		

2



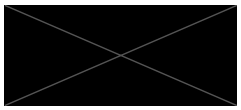
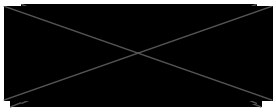
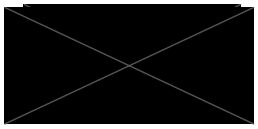


Table of Contents

1. Executive Summary....3
2. Project highlights....3
3. Hours Worked....4
4. Site Safety Inspections and Safety Tours....5
5. Loss Triangles....6
6. Incidents reported in a period....7
7. Significant DWB reported in a period....9
8. Assets recoverd....10

3





1. Executive Summary

There were No Reported RIDDOR or Lost Time Incidents in this period .There were two near misses reported within the period which are detailed in section 7 .

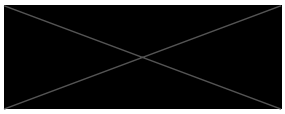
In this period there were eight safety inspections and safety tours completed on the PITTA project , the outstanding planned inspections and tours will be rescheduled

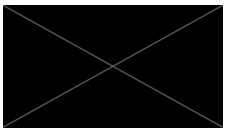
2. 2018/19 PITTA Project QEHS Performance

For reporting Period (13) 03th March 2019 – 31st March 2019

PITTA PROJECT	
Total Number of Near Miss	2
Total Number of Injuries	0
Total Number of DWB reported this Period	10
Total Number of RTA	0
Total Number of DWB (P1 – P 13(2018-2019))	189
Total Injury Free hours (site based hours only)	262,376

4





3. Total Project Hours worked in Period 13

15,776 total hours inclusive of none site hours worked on the project

Site Hours worked on Programme 3-4, 5,7, 8, 9,10

Programme	Hours Worked
3/4	3.120
5	1,704
7	9,744
8	592
9	616
Total	15,776

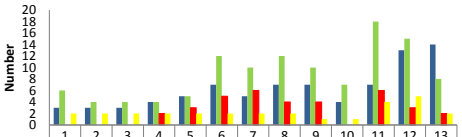
4. Number of PGI/Tours by Programme Completed this Period.

Programme	Completed
3/4	2
5	2
7	2
8	-
9	2
Total	8

5

[redacted] [redacted]

PITTA Project QEHS Workforce Site Engagements P13 2018/19



	1	2	3	4	5	6	7	8	9	10	11	12	13
Planned PGI/Tours	3	3	3	4	5	7	5	7	7	4	7	13	14
No Comp	6	4	4	4	5	12	10	12	10	7	18	15	8
-ve findings	0	0	0	2	3	5	6	4	4	0	6	3	2
+ve findings (GP)	2	2	2	2	2	2	2	2	1	1	4	5	2

Missed inspections will be rescheduled

6

[redacted] [redacted]

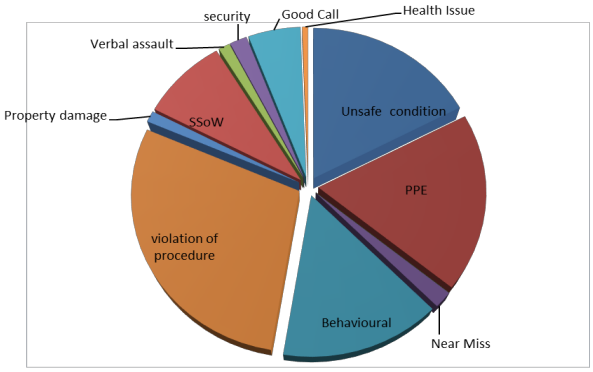
5. Loss Triangles

The following Heinrich Loss Triangle details the number Don't Walk By's reported on the PITTA Project worksites form Period 1 to Period 13 2018/19

7

[redacted] [redacted]

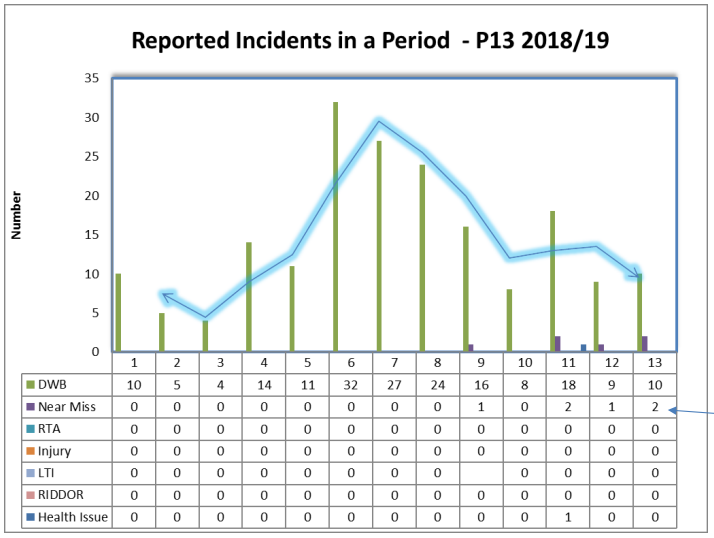
6. Period 13 2019/20 Category of Reported DWB



Note: The reported unsafe conditions are issues observed by our site staff relating to LU assets and or other contractors note: [redacted]

8

[redacted] [redacted]



	1	2	3	4	5	6	7	8	9	10	11	12	13
DWB	10	5	4	14	11	32	27	24	16	8	18	9	10
Near Miss	0	0	0	0	0	0	0	0	1	0	2	1	2
RTA	0	0	0	0	0	0	0	0	0	0	0	0	0
Injury	0	0	0	0	0	0	0	0	0	0	0	0	0
LTI	0	0	0	0	0	0	0	0		0	0	0	0
RIDDOR	0	0	0	0	0	0	0	0	0	0	0	0	0
Health Issue	0	0	0	0	0	0	0	0	0	0	1	0	0

See near misses highlighted in the table below

9

[redacted] [redacted]

7. List of Significant DWB Reported in P13 2018/2019

Date	Location	Project	Description	Action Taken	Status
05.03.19	London Bridge	P5	Engineer denied permission to erect hoarding	The site file pre-check list has now been amended to contain all the relevant site documentation .	Ongoing monitoring
05.03.19	Victoria Station	P3	Subcontractor attended site with no authorization	Subcontractors to only attend sites that are on the planned works.	Ongoing monitoring of planned works
21.03.19	Oxford Circus	P7	Damage to comb plate on Escalator number 4 caused by missed M8 nut during pre-inspection before starting up of the Escalator.	Investigation completed with recommendations to address the failings	Ongoing
16.03.19	TCR	P5	Asset protection not installed correctly	this deficiency has been raised with the sub-contractor which will be monitored to ensure compliance	Ongoing

DWB = Don't Walk By An event of someone challenging, resolving (where possible) and reporting an unsafe act / condition

RTA = Road Traffic Accident

10

[redacted] [redacted]

8. [redacted] Assets recovered from site.

615 redundant assets recovered from various sites P3 (339), P4 (60) P7 (216)

We aim to provide more information in future reports

(Data provided [redacted] QEHS team)

Note: [redacted] ***will review the request received from*** [redacted] ***for reporting on addition KPI's.***

11

QEHS / PITTA / PERFORMANCE REPORT

RAIL LONDON PROJECTS BUSINESS AREA

Period 7 - 2019/20

Authority	Name
Author	[redacted]
Reviewer	[redacted]
Approved	[redacted]
Reporting Period 7	16/09/19 - 12/10/19
Published date	18 October 2019 V1

Table of Contents

Section	Title	Page
1	Summary	3
2	Previously unreported incident	3
3	Hours worked and site safety inspections / tours	4
4	PITTA Project performance for the last 13 Periods.	5
5	PITTA – Accumulative telSAFEs/ close call breakdown for P1-P7 (2019/20)	6
6	List of Significant Close Calls Reported	6
7	[redacted] Assets recovered from site	6

1. **Summary - Reporting period 7 (16/09/19 - 12/10/19)**

Since the commencement of PITTA project (November 2016) we have had a total of 385,878 hours worked with no Lost Time injury

- There were no reported RIDDOR or Lost Time Incidents in Period 7
- There were 6 safety inspections / safety tours completed
- 8 t[redacted] including 3 close calls reported. The three close calls reported this period are detailed in Section 6

2. **Previously unreported incident** (minor injury)

One minor injury previously unreported has been identified in Period 13 (07/03/2019)

- **EM_NOTIFY009079**-Euston Station-Escalator 6-Holding the edge of a panel - got finger caught between the panel - a little bit swollen.

The contractor was not made aware of the incident by the operative concerned and the incident was identified during a review of [redacted]

Since the [redacted] the following additional information has been received.

> Minor accident on site, whilst removing the back panel for the dep screens operative trapped his finger.
>
> The IP trapped his finger (middle finger on right hand) between the edge of the panel being removed and the fixed panel next to it, causing some bruising and swelling to the finger, please note that he was wearing gloves, so the skin remained intact and unbroken, we applied first aid by bandaging one finger to the other to temporarily immobilize use of the swollen finger, seeing as it is only bruising, he did not wish to go to hospital.

The contractor has been contacted and asked to carry out an investigation into the incident and include any recommendations / actions to prevent a similar incident happening again.

3. Hours worked and site safety inspections / tours

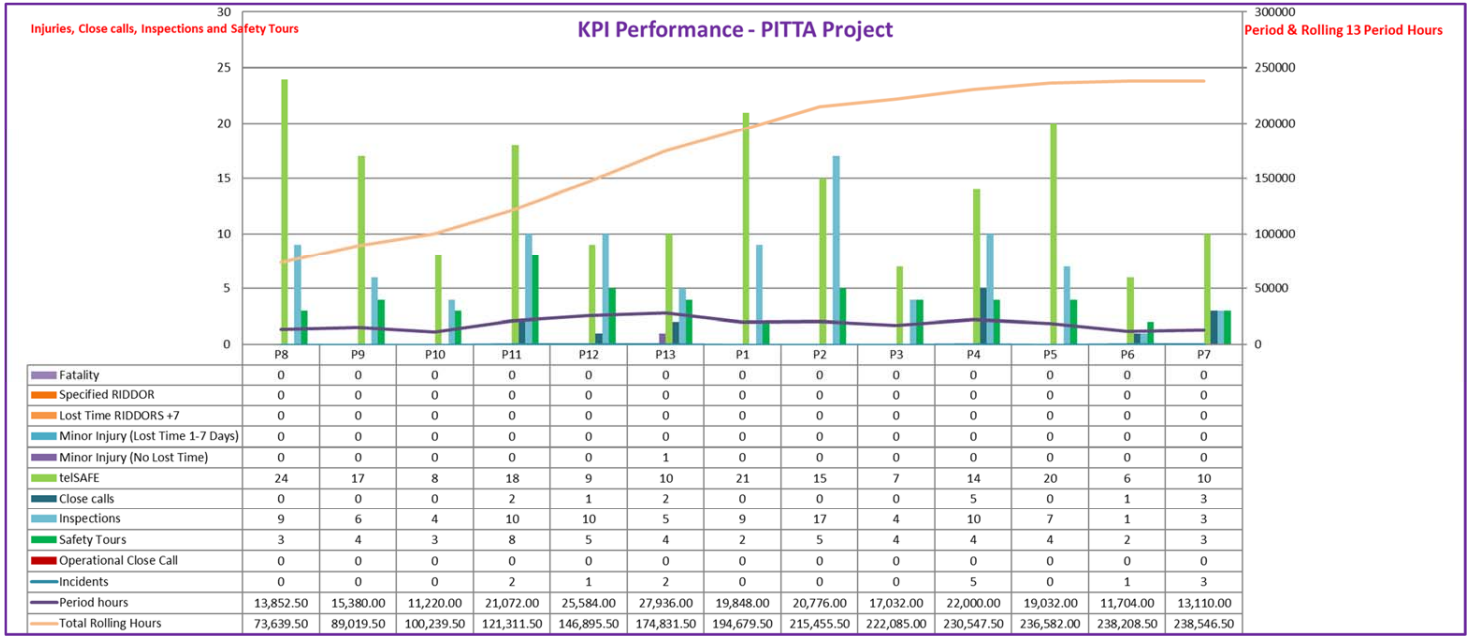
The total hours worked in **P7 2019 was 13,110** This figure is inclusive of non-site hours worked on the project. Site hours worked were 6,360

Site hours worked on Programme 3-4, 5, 7, 8, 9 and site safety inspections and tours are detailed below:

Programme	Site hours worked	Site safety inspections /Tours completed	telSAFEs
3/4	704	0	3
5	760	1	1
7	3,272	2	2
8	0	0	0
9	1,624	3	3
Cody Road Office	n/a	0	1
Total	6,360	6	10

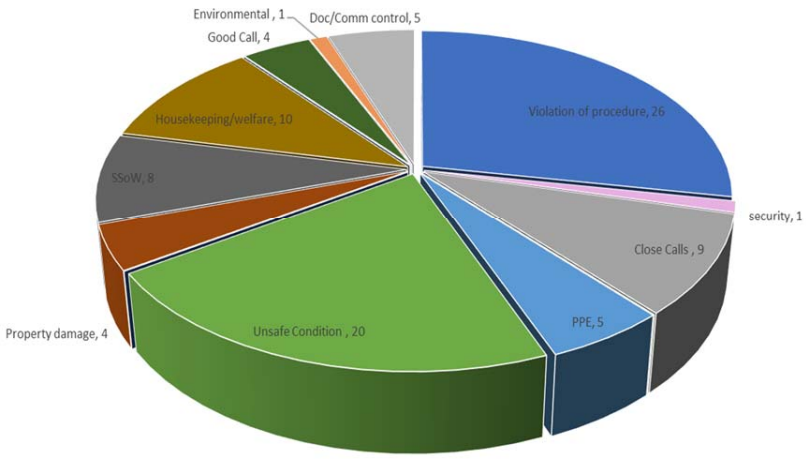
Site inspections number were reduced due to reduced site works and low-risk activity.

4. PITTA Project performance for the last 13 Periods.



	P8	P9	P10	P11	P12	P13	P1	P2	P3	P4	P5	P6	P7
Fatality	0	0	0	0	0	0	0	0	0	0	0	0	0
Specified RIDDOR	0	0	0	0	0	0	0	0	0	0	0	0	0
Lost Time RIDDORS +7	0	0	0	0	0	0	0	0	0	0	0	0	0
Minor Injury (Lost Time 1-7 Days)	0	0	0	0	0	0	0	0	0	0	0	0	0
Minor Injury (No Lost Time)	0	0	0	0	0	1	0	0	0	0	0	0	0
telSAFE	24	17	8	18	9	10	21	15	7	14	20	6	10
Close calls	0	0	0	2	1	2	0	0	0	5	0	1	3
Inspections	9	6	4	10	10	5	9	17	4	10	7	1	3
Safety Tours	3	4	3	8	5	4	2	5	4	4	4	2	3
Operational Close Call	0	0	0	0	0	0	0	0	0	0	0	0	0
Incidents	0	0	0	2	1	2	0	0	0	5	0	1	3
Period hours	13,852.50	15,380.00	11,220.00	21,072.00	25,584.00	27,936.00	19,848.00	20,776.00	17,032.00	22,000.00	19,032.00	11,704.00	13,110.00
Total Rolling Hours	73,639.50	89,019.50	100,239.50	121,311.50	146,895.50	174,831.50	194,679.50	215,455.50	222,085.00	230,547.50	236,582.00	238,208.50	238,546.50

5. PITTA – Accumulative telSAFEs Breakdown for P1-P7; including close calls (2019/20)



Total number of accumulative [redacted] for P1-P7 2019/20 is 93.

Note: The reported unsafe conditions include issues observed by our staff relating to LU assets and/or other contractors (not all reported incidents are [redacted] controlled matters to 'close out').

6. List of significant Close Calls reported in period 7

Date	Project	Description	Action Taken	Status
16.10 .19 (**Close call)**	P9	During a site inspection, operative was undertaking physical work while accessing site using a "visitor" pass	Operative was removed from site. Safety / Operations have requested a local investigation report from the Supplier.	Closed
11.10.19 **(Close call)**	P9	Sub-contractor worked without a valid permit. Sub-contractor changed his plans without notifying the construction manager hence no permit was raised for the contractor.	Local investigation underway	Open
18.09.19 **(Close call)**	P3	Faulty Isolator handle on Escalator 9 at Waterloo Underground Station.	The issue was reported to the station supervisor for TFL to address	Closed

7. EM Assets recovered from site. There were 448 redundant assets recovered. Project 7: 3; Project 4: 62; Project 3:383

APPENDIX F – TOTAL WORD COUNT

Total Word Count Calculation

Total body word count	55548
References work count	-2952
Total word count	**52,596**