Creation of a Confidential Incident Reporting System to Enhance Korea's Railway Safety Culture

by

Beomjoon Park

A thesis submitted to the University of Birmingham
for the degree of MASTER OF PHILOSOPHY

Department of Civil Engineering
School of Engineering
College of Engineering and Physical Sciences
University of Birmingham
September 2017

Abstract

Historically, catastrophic accidents have been important drivers for the development of safety systems in the railway industry. The railway industry is becoming safer than ever, but catastrophic accidents still happen. This may be because, as a society becomes more complex and complicated, the causes of accidents also become more complex and complicated. Many railway accidents are caused by organisational failures, which are compounded by human error and inadequate organisational cultures. Among the various approaches that have been tried to reduce the risk of complication and complexity related accidents, establishing a good safety culture is considered an effective solution. Although safety culture is influenced by various factors inside and outside of an organisation, it is thought to be closely related to an informed culture. Thus, developing effective reporting channels is very important to improve an organisation's safety culture. However, many safety events have not been reported due to a perceived blame culture or fear of disciplinary action. To overcome this 'under-reporting', so-called confidential incident reporting systems (CIRSs) have been adopted in some industries, to ensure confidentiality of 'reporters' to facilitate reporting of safety events.

The aim of this research is to improve Korea's railway safety culture by changing the reporting culture. Since most research into railway safety culture has concentrated on the railway operations sector, this author researched the railway construction field, which has not yet been studied. Through this research, the author assessed the actual safety culture of Korean construction sites and investigated the feasibility of implementing a CIRS for Korea's railways. As a result of the research, the author suggests a tailor-made CIRS model.

To meet the aims of the research, the author needed quantitative data to generalise the safety culture and qualitative data, to understand the underlying issues and opinions of frontline staff. In this regard, a mixed methods research approach was used, which includes both quantitative and qualitative data. Based on the methodology, the author conducted a series of case studies, questionnaire surveys and interviews.

The case studies were performed on two themes: The author assessed the levels of safety and of safety culture of Korea's railway, and identified the characteristics and effectiveness of CIRSs. The safety performance of Korean railways has improved steadily and has reached a similar level to that of major EU countries, however, the safety culture has remained at a relatively low level. The case study of CIRSs was conducted by looking at actual practice in the UK (CIRAS) and US (C^3RS).

Both systems have worked well to secure confidentiality. During the case studies, the author identified that CIRAS is proven to have value as a complementary reporting channel by providing solutions that had not been identified by existing reporting channels, and C³RS proved to be effective for safety and safety culture through a comprehensive evaluation programme.

The questionnaire surveys were conducted in two phases: In the preliminary questionnaire survey, the author captured that Korean railway construction workers had a very positive safety culture (mean value was 4.440 out of 5.000), but the possibility of under-reporting was also identified. In the main survey, again, a positive safety culture (mean value was 4.413 out of 5.000) was detected; however, a gap in the safety culture amongst managers and amongst manual workers was identified. Severe fear of being punished was an important clue to understanding the real safety culture in Korean railways.

Interviews were conducted in two categories. In the interviews with workers on Korean railway construction sites, the author identified that they have a fairly positive safety culture but deficiencies in safety also existed. There was a lack of perception of safety culture and frontline staff did not participate voluntarily in the interviews. Most of all, they had a serious level of fear of being punished. In the interviews related to CIRAS, the author identified that CIRAS has in place many countermeasures to secure confidentiality. In particular, the author recognised its value as a contemporary reporting channel for which the issues in existing reporting channels have been solved.

The author developed the Korean Confidential Incident Reporting System (KCIRS) model for the Korean railway industry, based on the existing CIRS cases and issues found during the research.
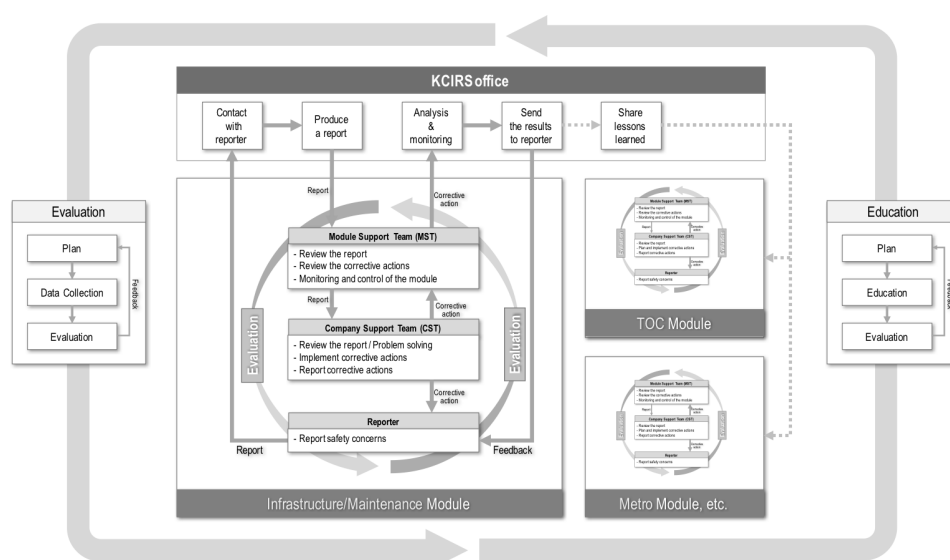
The author adopted a modular structure to create the KCIRS model in a functional manner. This approach is different from CIRAS, in which an institution manages the whole railway industry, or C^{3}RS, in which each railway company operates its own system. KCIRS's modular architecture makes it easy to adopt progressively and to standardise the CIRSs. This suits the structure of the Korean railway industry, where only a small number of institutions are responsible for operation, maintenance and construction.

For efficient operation of the KCIRS model, the author also presents the concept for the reporting process and the roles and responsibilities of the KCIRS entities comprising the KCIRS Office (KCO), Module Support Team (MST) and Company Support Team (CST). In addition, the author establishes and presents various strategies for efficient operation of KCIRS, e.g., securing confidentiality, evaluation and improvement, systematic education and adoption of KCIRS.

In the future, if further research on evaluation, standardisation and modular structures is conducted, the KCIRS model will be more applicable to Korean railways.

Acknowledgement

I would like to express gratitude to my supervisors Prof. Felix Schmid and Prof. Anson Jack. They gave me a lot of patience, guidance and motivation during my studies that enabled me to complete my research. In particular, Prof. Schmid has shown immense knowledge, passion and love for the railways always that have inspired me throughout my time in Birmingham.

I would like to thank Mr Chris Langer who offered me ideas and information regarding this thesis and Dr Hongsin Kim who always gave me helpful advice during my research period. In addition, I would like to thank all the members of the Birmingham Centre for Railway Research and Education (BCRRE).

It is thanks to the support of Korea Rail Network Authority (KRNA) that I have had significant time in Birmingham for two years. I would like to thank KRNA for providing funding for my research.

Last but not least, I would like to thank my family: my wife, Hye-kyeong, and two daughters, Seongeun and Seoyeon, for their constant love and support.

Table of Contents

List of Figures

List of Tables

Glossary of Terms / List of Abbreviations

Term	Explanation / Meaning / Definition
C³RS	Confidential Close Call Reporting System
CCS	Close Call System
CHIRP	Confidential Human Factor Incident Reporting Programme
CIRAS	Confidential Incident Reporting and Analysis System
CIRS	Confidential Incident Reporting System
CP	Canadian Pacific
CR	Conventional Railways
CSI	Common Safety Indicator
CST	Company Support Team
ERA	European Union Agency for Railways
ERAIL	European Railway Accident Information Links
EU	European Union
FRA	Federal Railroad Administration
FRAM	Functional Resonance Accident Model
GB	Great Britain (England, Scotland and Wales)
HSC	Health and Safety Commission
HSE	Health and Safety Executive
HSR	High-Speed Railways
IAEA	International Atomic Energy Agency
IM	Infrastructure Manager
INSAG	International Nuclear Safety Advisory Group
KCIRS	Korea Confidential Incident Reporting System
KCO	KCIRS Office
KR	Korea Rail Network Authority
KRRI	Korea Railroad Research Institute
KTSA	Korea Transportation Safety Authority
LRT	Light Railway Transit
MOLIT	Korean government of Ministry of Land, Infrastructure and Transportation
MOR	Mandatory Occurrence Reporting
MOU	Memorandum of Understanding
MST	Module Support Team

Term	Explanation / Meaning / Definition
NASA	National Aeronautics and Space Administration
NJT	New Jersey Transit
NR	Network Rail
ORR	Office of Rail and Road
PRT	Peer Review Team
Reporter	Person who reports safety issues (Chapter 1)
RMS	Railway Maintenance System
RSIS	Rail Safety Information System
RSSB	Railway Safety and Standards Board
S.D.	Standard Deviation
SMIS	Safety Management Information System
SMS	Safety Management System
SOP	Standard Operating Procedure
TLA	Three Letter Acronym
TOC	Train Operating company
TOS	Train Operating System
UK	United Kingdom (Great Britain and Northern Ireland)
UP	Union Pacific
US	United States

1 Introduction

1.1 Background

1.1.1 Safety and Accidents

Safety is a very commonly used term. In the Oxford Dictionary, safety is defined as "the condition of being protected from or unlikely to cause danger, risk, or injury". People have always been anxious about safety. Nevertheless, many catastrophic accidents have been causing people concern. Paradoxically, catastrophic accidents have been a major driver for the development of safety systems in the railway industry. Thus, catastrophic accidents accelerate the development of better safety systems, and the railway industry has become much safer than before (Wallace, et al., 2003).

Even though the railway industry is becoming safer, catastrophic accidents still happen around the world. Typical examples are the Amagasaki derailment (2005) in Japan, the Santiago de Compostela derailment (2013) in Spain, the Eckwersheim derailment (2015) in France, the Bad Aibling train collision (2016) in Germany and the Croydon tram derailment (2016) in the UK. Such large accidents occurred despite the high level of safety systems in those countries. Therefore, further effort is required to ensure safety.

Hollnagel (2014) argues that there are three approaches in safety thinking, the age of technology (until 1979), the age of human factors (until 1986) and the age of safety management (after 1986). In the age of safety management, organisational factors and safety culture are considered as important factors to secure safety.

However, even the most efficient safety management systems (SMSs), which measure the risk of accidents and remove the causes of accidents before they happen, cannot completely prevent accidents. Even a perfect SMS could be breached by 'human error'. The Amagasaki derailment (2005) in Japan, Santiago de Compostela derailment (2013) in Spain and Eckwersheim derailment (2015) in France were typical accidents caused by organisational failure that was compounded by human error and organisational culture in the railway industry.

1.1.2 Safety Culture

The Health and Safety Executive (HSE) focuses on human errors, which are regarded as an important factor that contributes to accidents and incidents (HSE, 1999). Human error has received substantial attention in research as a causal factor for a long time. Among the various approaches which have been tried to reduce the risk associated with human error,

constructing a good safety culture is considered an effective solution to prevent harmful events.

Safety culture is defined as "the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviours" (HSC, 1993). Currently, the concept of safety culture is widely used in various industries, e.g., railway, aviation, nuclear power plant and healthcare, etc. A poor safety culture in an organisation can cause serious outcomes. Since the issue of safety culture first appeared in the International Atomic Energy Agency's (IAEA's) reports about the Chernobyl nuclear accident, safety culture has been counted as an important factor in the accident (IAEA, 1986), and a poor safety culture has frequently turned out to be an underlying cause in many serious accidents.

In Britain's railway industry, the concept of safety culture began to receive attention in the context of ensuring the safety of railways after the Clapham Junction collision in 1988 and the Ladbroke Grove collision in 1999 (Clarke, 1998; Cullen, 2001; Hidden, 1989). Deficiencies in the safety culture were identified as an underlying cause of the accidents (Clarke, 1998). Thereafter, Britain's railway industry has been interested in the good safety culture in organisations, and has begun to work towards improving safety culture. An organisation's safety culture is influenced by various factors from inside and outside the organisation. In general, safety culture is thought to be closely related to an informed culture. Reason (1997) equates safety culture with informed culture. Thus, developing effective reporting channels to collect safety knowledge from safety events is very important to improve an organisation's safety culture (Reason, 1997; 1998).

1.1.3 Safety Concern Reporting Scheme

Reporting of accidents has been regarded as an important feedback method that provides clues to why accidents occur and how they can be prevented (Benn, et al., 2009). However, in some industries, including the railway industry, where the accident rate has fallen to a very low level, it is difficult to collect enough information from accidents. To solve the situation, safety information is collected from incidents as well. Analysis of reported incidents can provide useful information to prevent future accidents and improve the safety of organisations (Benn, et al., 2009; Wallace, et al., 2003). In many cases, similar patterns of incipient failures precede both accidents and incidents. Therefore, analysing sufficient incident data may provide more valuable support than focusing on a small number of isolated accidents. However, many incidents are not reported through official reporting channels due to a perceived blame culture or fear of disciplinary action (Davies, et al., 2000). 'Under-reporting' of safety-related incidents is said to be a common problem in many industries

(Clarke, 1998). To overcome under-reporting, so-called confidential incident reporting systems (CIRSs), which ensure confidentiality of the so-called 'reporters' who report safety issues, have been adopted in some industries (Barach & Small, 2000; Davies, et al., 2000; Wallace, et al., 2003). Ensuring confidentiality promotes reporting of safety events because it reduces concerns about revealing the identity of those involved and the fear of being punished in relation to the incidents reported. Thus, CIRSs are operated in some industries, e.g., aviation, railways, nuclear power plants and healthcare. In particular, in the aviation industry, many countries have effectively operated CIRSs for a long time.

1.1.4 Research Motivation

In Britain's railway industry, CIRSs have been recognised as an essential tool to improve railway safety. The Confidential Incident Reporting and Analysis System (CIRAS) is the main CIRS in the UK railway industry, and complements other reporting systems, e.g., the Safety Management Information System (SMIS) and the Close Call System (CCS) which are designed and controlled by the Rail Safety and Standards Board (RSSB).

Despite this advantage, many countries have not yet adopted CIRSs in their railway industry because most of them are already operating other reporting channels. In the Korean railway industry, usually accidents are promptly reported through the internet, and systematic SMSs are in operation already. However, reporting of incidents is not that popular and CIRSs have not yet been adopted. The importance of perception of good safety culture is still at a relatively lower level than the overall safety level.

So far, Korea's railway industry has shown good performance in terms of railway operation and safety. However, assessment of safety culture is in the early stages in only a few train operating companies (TOCs), and infrastructure managers have not assessed the level of safety culture. Although concerns over under-reporting have continued to exist, the introduction of a CIRS has yet to be realised.

Construction sites adjacent to operating railways have more risks than normal construction sites, and influence train operation.

Thus, this thesis concentrated on Korea's railway construction sites, which have not yet been researched.

1.2   Aim and Objectives

The aim of the thesis is to improve Korea's railway safety culture by changing the reporting culture. Currently, Korea's railway shows good performance both in the quality and quantity of railway operation, and safety performance is also relatively good even compared with the 28 European countries and various countries around the world. However, to further enhance the current level of safety, it is necessary to supplement the weaknesses of the existing safety system and strengthen the strengths. In this regard, research into the application of safety culture is necessary because people in Korea's railway industry are not familiar with safety culture even though they have good SMSs. Therefore, the theme of this thesis will focus on safety culture.

Currently, the concept of safety culture is not popular and is not even being emphasised in Korea's railway industry. A measurement tool for railway safety culture was developed only in 2011 and has been applied only to several companies every year since then. The measurement of safety culture has been concentrated in the TOCs, and has not been conducted with railway infrastructure managers (IMs). Therefore, this thesis will focus on the railway construction field, which has not yet been subjected to measurement of safety culture.

The author will conduct an assessment of the safety culture on railway construction sites. This aims to diagnose the level of safety culture and identify the need for improvements, and propose a practical way to improve railway safety culture. Innovation of reporting culture is necessary to develop safety culture. This is because the knowledge acquired through past experience becomes a powerful means of preventing future accidents. For this purpose, safety events are reported and analysed through various reporting systems. However, there are many cases where safety events are not reported because people are reluctant to report safety for many reasons. For example, these events might adversely affect their performance evaluations, or people might be concerned about being punished, etc.

Therefore, measures should be taken to prevent from this happening. The author will review the need for the adoption of a CIRS, which is considered one of the most effective methods introduced to date for dealing with under-reporting.

This will allow Korea's railway industry to determine if a CIRS needs to be introduced separately from the existing reporting channels.

Also, the author intends to design a CIRS model suitable for the Korean railway industry. The model aims to facilitate the smooth introduction of a CIRS for the Koran railways.

These are the detailed objectives of the thesis:

- Review the concept of accidents and understand their causation. Distinguish between accident, incident and near miss, and find preventive measures;

- Investigate safety culture by looking at the concept, origin, definition, components and assessment tools of safety culture, and find efficient methods;

- Review the concepts and effectiveness of CIRSs, and research effective application of CIRSs;

- Conduct case studies on the safety performance and safety culture of Korea's railway, and on CIRSs in the UK and US;

- Assess the perception of safety culture in Korea's railway industry and review the necessity of adopting a CIRS as an additional reporting channel in Korea's railway industry;

- Analyse the strengths and weaknesses of the safety culture in Korea's railway industry and examine the need to adopt a CIRS;

- Identify important information about the operation of a CIRS;

- Propose a CIRS model for Korea's railway industry based on the results of literature reviews, case studies, questionnaire surveys and interviews.

1.3 Scope

This thesis concerns the introduction of a CIRS to improve railway safety in Korea. To do this, the author covers the safety culture necessary to improve the safety of railways, and includes a review of the reasons for the adaptation of a CIRS.

The railway industry consists of various sectors, for example, construction, maintenance and operations. Much of the research on safety culture has been linked to railway operations, but research into the construction field is insufficient. Therefore, the scope of this thesis focuses on the railway construction sector.

Currently, many railway constructions are being built near operating railways, and have a lot of influence on actual train operation, but there is insufficient research into this.

Therefore, this thesis focuses on the railway construction sites of the Korea Rail Network Authority (KR), which is responsible for construction and management of railway infrastructure for high-speed and conventional railways. The questionnaire survey and interviews were conducted at railway construction sites managed by KR; sites were selected only if adjacent to the operating railway and closely related to the railway operation.

In particular, the questionnaire survey targets were chosen evenly by railway field, i.e., civil, track, building, electric power, communication, signals, etc., to obtain representative results.

The scope of the CIRS model presented in accordance with the findings of this thesis covers the entire area of the Korean railway industry, but gives concrete details only for the railway construction sector, providing only a minimal conceptual structure of the CIRS model for operations and other sectors in order to be consistent with the CIRS structure of the whole railway industry of Korea. Even though they are not significantly different from the construction sector, some adjustment may be required to consider the characteristics and circumstances of other sectors. These are to be left for future works.

The scope of this thesis is to reflect the research methodology to harmonise it and thus work efficiently. However, this thesis does not include practical implementation and testing of the CIRS model developed for Korea's railway industry.

1.4 Methodology

The research methodology of this thesis was determined through the process shown in Figure 1.
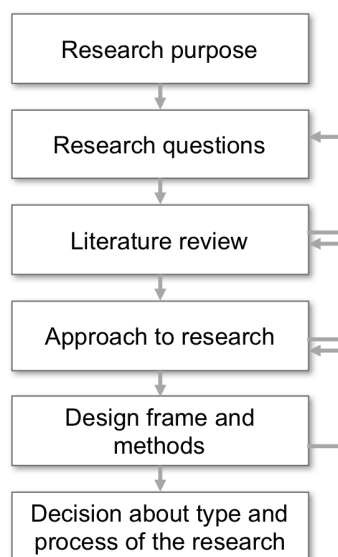
Figure 1. Process of designing research methodology

Through the process, the author selected research questions regarding the research purpose by conducting literature reviews. After designing the framework and methodology for research, the type and process of research methods were determined.

The author developed a specific research model for this research, which follows the simplified research model of Punch (2014).

As shown in Figure 2, the author conducted a literature review on the author's research area of railway safety culture. Through the literature reviews, the author chose CIRSs as the research topic, an important factor in improving safety culture.

The research topic was refined to create research questions be key to the research. Thus, the research methodology was designed to resolve the research questions.

The research for the thesis used a mixed methods research approach to meet the aim and objectives of the research. Mixed methods research is a type of research which uses both quantitative and qualitative research approaches cohesively (Johnson, et al., 2007).
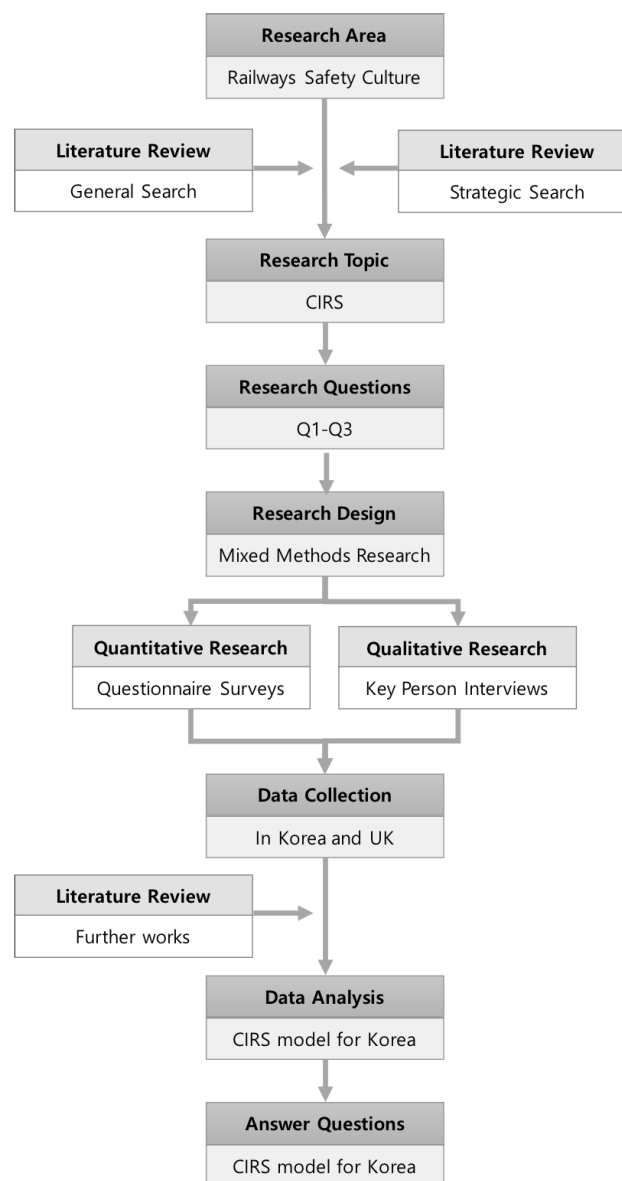
Figure 2. Research model of the thesis (adapted from Punch (2014))

Johnson and Onwuegbuzie (2004) argue that combining quantitative and qualitative methods complements the strengths of each and overcomes weaknesses. To achieve the aim and objectives of the research, the author had to collect a wide range of numerical data on safety culture, which enabled quantification and generalisation of the safety culture level of organisations. Qualitative data was necessary to help to understand the underlying issues and opinions of frontline staff, enabling a deeper dive into the core of the research subject. Therefore, this thesis combined quantitative and qualitative data to optimise the strengths and mitigate the weaknesses of the methods.

Based on the methodology, the UK, US and Korea were chosen to collect research data on while conducting the research. Korea was chosen as a data collection target because the main objective of this research was to enhance the railway safety culture of Korea. The UK was selected because the concepts of safety culture and CIRS are widely applied. The author selected the US as a research target because the US has introduced a CIRS to the railway sector systematically, though it has not yet been applied to the whole railway industry.

After the data collection phase, further literature reviews were conducted to reinforce the information related to research subject.

The subsequent phase involved comprehensive analysis of the information collected. In this phase, the information collected through case studies, interviews and questionnaire surveys was analysed to determine the matters necessary to configure the CIRS model for the Korean railway industry.

The last phase was designed to address the research questions and to present the CIRS model through analysis of the information collected. Through these phases, data was collected and analysed which produced the answers to the research questions.

1.5 Structure of Thesis

Each chapter of this thesis contributes to achieve the purpose of the research.

Each chapter was classified to effectively analyse the information acquired in the research process, and is composed of the following:

- In Chapter 1, the author explains the background of the research topic, and sets the research aim and objectives. The methodology to effectively implement the research is presented;

- Chapter 2 deals with accidents and causation, and discusses preventive measures necessary to prevent accidents. As the definition of safety means no accident or hazard, it is first reviewed in this thesis;

- Chapter 3 deals with safety culture. As safety culture is not yet widely used in the Korean railway industry, the basic matters, origin, concept and definitions are comprehensively addressed. Furthermore, safety culture components and measurement techniques are presented;

- Chapter 4 explains about CIRSs. There is a discussion of why information gained from accidents and incidents is useful, and the author presents important points of the concept and operation of CIRSs that can effectively handle this. Furthermore, it contains the accomplishments after CIRSs are introduced and the need to introduce a CIRS in the railway industry;

- Chapter 5 provides the research questions of this thesis. The research questions to be posed are collected through a literature review;

- Chapters 6 to 8 present the results of the research methods performed in order to resolve the research questions. Chapter 6 presents the result of the case studies. Safety performance and safety culture evaluation are reviewed, and the results of case studies of CIRAS in the UK and C^3RS in the US, successful CIRSs in the world, are presented;

- Chapter 7 is used to describe the questionnaire surveys conducted on railway construction sites in Korea. Through the preliminary survey and the results of the main survey, the author reviews the status of safety culture in Korea's railway industry and the need to introduce a CIRS;

- Chapter 8 deals with interviews. The author selected a few sites and conducted interviews with people working in Korea's railway industry to obtain a qualitative assessment of safety culture. The results of interviews with people in CIRAS are also presented. The results of the interviews were utilised when the author developed a CIRS model, and to find out important factors in the introduction and operation phase of CIRAS;

- Chapter 9 is used to describe the Korea Confidential Incident Reporting System (KCIRS), a model for Korea's railway industry. To establish the KCIRS model, important facets of KCIRS are presented, e.g., a framework for developing the KCIRS model, the scope of data collection, data process and securing confidentiality;

- Chapter 10 is used to summarise the results of the research.

2   Accidents and Their Causation

2.1 Definition of Accident, Incident and Near Miss

'Accident' and 'incident' are words that are commonly used in everyday life. People read these words everyday through newspapers, TV programmes or the internet. Sometimes, the two words are used interchangeably and sometimes they are used with separate meanings. According to the Oxford Dictionary, the definitions of accident and incident are as follows:

"Accident is an unfortunate incident that happens unexpectedly and unintentionally, typically resulting in damage or injury" (Oxford University Press, 2017)

"Incident is an instance of something happening" (Oxford University Press, 2017)

However, HSE uses slightly different definitions to those of the dictionary. It defines 'accident' as "an event that results in injury or ill health" and 'incident' includes the concept of 'near miss' and 'undesired circumstance'. A 'near miss' is defined as "an event that, while not causing harm, has the potential to cause injury or ill health". And 'undesired circumstance' is defined as "a set of conditions or circumstances that have the potential to cause injury or ill health" (HSE, 2004, p. 4).

Usually, the terms 'incident' and 'near miss' are used with the same meaning. Reason (1997, p. 118) defines 'near miss' as "any event that could have had bad consequences, but did not" and uses this as a term for 'incident'.

Sometimes the term 'close call' is also used, which means that it is similar to the terms 'near miss' and 'incident'. The Oxford Dictionary defines close call as "a narrow escape from danger or disaster" (Oxford University Press, 2017). In the US, the term 'close call' is used interchangeably with 'incident', e.g., as in the Confidential Close Call Reporting System (C^3RS) (NASA, 2017). In the UK, Network Rail uses the term 'close call' and operates a CCS (RSSB, 2017). In this, a close call "could be any unsafe act or unsafe condition that in different circumstances could have led to an accident or personal injury, or could have resulted in damage to property or equipment, but could not introduced risk to the railway infrastructure" (Network Rail, 2017).

Although there are various terms and definitions, the author intends to use the terms and definitions of HSE in this thesis.

Often, near misses and close calls are viewed as precursors to serious incidents and accidents (Barach & Small, 2000; Benn, et al., 2009; Clarke, 1998; Davies, et al., 2000; Langer, 2014; Reason, 1997; Wallace, et al., 2003).

2.2   Individual and Organisational Accidents

Accidents can be classified according to different criteria. They can be divided into categories of causation and magnitude of damage. The diversity of these classifications is due to the different perspectives applied to accidents, as shown in Table 1 (Reason, 1998). However, sometimes it is not easy to distinguish between individual and organisational accidents because some accidents may have features of both types. One of the most important things is that organisational accidents have multiple causes associated with many people at different levels. On the other hand, individual accidents are caused by an individual or a limited group. These differences relate to the impact of an accident. While individual accidents have limited impact, organisational accidents can have far-reaching implications. Therefore, it is natural that Reason (1997) pays more attention to organisational accidents.

Reason (1997) argues that organisational accidents are a product of recent times and technical innovations. This means that organisational accidents are influenced greatly by the ambient environment and conditions, i.e., organisational accidents are more complicated and more difficult to control than individual accidents, which have properties that have changed relatively little over time.

Table 1. Characteristics of individual and organisational accidents (Reason, 1998)

Distinction	Individual accidents	Organisation accidents
Frequency	Frequent	Rare
Consequence	Limited	Widespread
Defences	Few or no defences	Many defences
Cause	Limited	Multiple
Occurrence	Slips, trips and lapses	Product of new technology
History	Short	Long

These days, safety systems are highly developed, and safety-related information is provided to people actively. Furthermore, as people become more aware of safety, individual accidents tend to decline significantly. However, although organisational accidents are less likely to occur, as the effects are still consistent, continuous research and response is still necessary. Therefore, the author focused on organisational accidents in this thesis.

2.3   Models of Accident Causation

There has been a lot of research about why and how accidents and incidents happen (Heinrich, 1980; Hollnagel, 2016; Reason, 1997). Perceptions about why accidents occur have been presented through various accident models.

Hollnagel et al. (2006) classifies accident models into three categories, i.e., simple linear accident models, complex linear accident models and complex non-linear accident models.

Simple Linear Accident Model

A typical simple linear accident model is Heinrich's domino model (Hollnagel, et al., 2006). Heinrich's domino model explains accident causation through a linear relation of causes and effects in accidents, as shown in Figure 3.
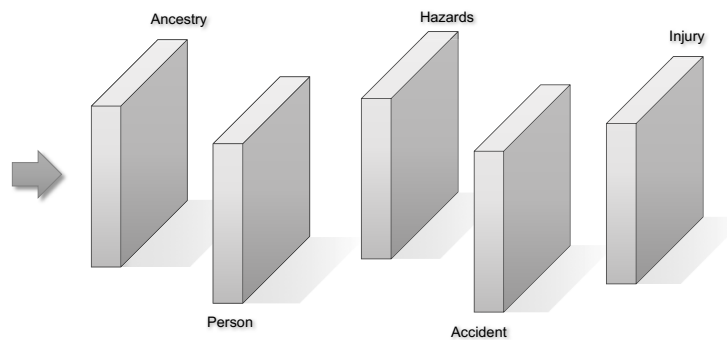
Figure 3. Simple linear accident model: domino model (Hollnagel, et al., 2006)

The domino model highlights a linear relationship between cause and effect, and includes the notion that investigation of accidents can lead to better safety by identifying the root cause and removing it. This means that the safety of a system can be improved by removing dominoes or extending the space between the dominoes in Figure 3 (Hollnagel, et al., 2006).

Complex Linear Accident Model

Hollnagel et al. (2006) present the Swiss cheese model as a typical example of a complex linear model, as shown in Figure 4. There are slices of cheese between the 'Hazards' and 'Losses', and each slice of cheese represents a layer of defence. And each defence has holes which are the fault of each layer and which are generated by 'active failure' or 'latent condition'. The Swiss cheese model is quite helpful to understand a mechanism of accidents simply.
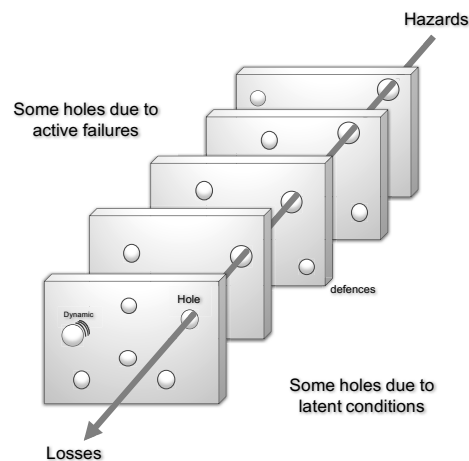
Figure 4. Complex linear accident model: Swiss cheese model (Reason, 1998)

The Swiss cheese model describes that accidents occur when the weaknesses (holes) in each layer align. In this case, the defects (holes) are dynamic and the holes are constantly moving, and the holes are opened and closed continuously, depending on the ambient conditions. At this time, the defects (holes) caused by active failure exist over a short period of time, while the defects (holes) caused by latent conditions exist over the longer term.

Therefore, although safety systems are well constructed, accidents may occur due to various surrounding situations even though the frequency is not high. Reason (1998) demonstrated that high-tech systems with multiple layers of defence are more highly influenced by safety culture. This is because multiple barriers reduce the incidence of accidents, but are a stumbling block for operators of the systems to understand the overall system.

Reason (1998) argues that only culture can affect all the barriers and their associated holes in the Swiss cheese model. Indeed, the Swiss cheese model shows an organisational aspect of accidents.

Complex Non-Linear Accident Model

Complex non-linear accident models were developed for accidents that cannot be explained by linear accident models. The Functional Resonance Accident Model (FRAM) is a recent representative model among complex non-linear models that takes a three-dimensional approach to highly complex accidents (Toft, et al., 2012) .

Hollnagel (2016) explains that contemporary systems have become tightly coupled and linked to each other, which causes the systems to have little or no tolerance for the slightest disturbance, thus resulting in undetectable and unwanted consequences which are a result of functional resonance.
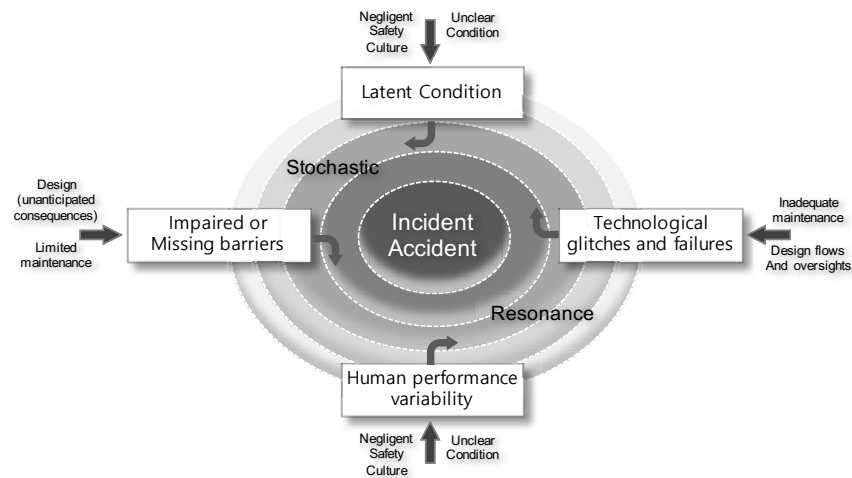
Figure 5. Functional Resonance Accidents Model (Toft, et al., 2012)

Hollnagel's FRAM model is a new approach to explain how functions are linked or coupled to other functions within systems; it describes the complexity of modern accidents that is completely different from those of linear causation models of accidents, and how it can be managed.

2.4   Recent Approaches to the Analysis of Accidents and Safety

Nowadays, systems are so complex and complicated, and work situations not always underspecified and unpredictable as they were in the past. As such, approaches to safety have also changed.

Hollnagel (2014) explains that the perception of safety has evolved into three stages, i.e., the age of technology, the age of human factors and the age of safety management, and argues that the next approach is the perspective of complex systems.

In complex systems, components are tightly coupled to each other, making them closely affected. If systems cannot tolerate system variances, accidents happen. Therefore, the safety of the systems is guaranteed by controlling variability.

In order to achieve this, procedures and tools should be adjusted appropriately according to these circumstances, and systems should absorb the variance.

However, due to limited time and information, precise adjustments are always not made, which causes threats to safety (Hollnagel, 2016; Toft, et al., 2012).

Hollnagel (2014) argues that the situations of the current complex systems are difficult to explain in existing approaches to safety, and explains this from the perspectives of Safety-I and Safety-II. Safety-I is the previous view of safety. The premise for Safety-I is the need to

understand why accidents happen. It is the perspective that safety reduces the number of adverse events, and tries to eliminate causes and improve barriers.

On the contrary, Safety-II is interested in normal conditions, i.e., everyday work. It is the perspective that safety is the ability to succeed under changing conditions and uses most of the data available for learning (Hollnagel, 2014).

The differences between Safety-I and Safety-II are shown below in Table 2.

Hollnagel et al. (2015) present the methods for transition to Safety-II as follows:

- Look for what goes right;
- Focus on frequent events;
- Remain sensitive to the possibility of failure;
- Be thorough as well as efficient;
- Invest in safety, focus on the gains from safety.

Table 2. Comparison of Safety-I and Safety-II (Hollnagel, 2014)

Item	Safety-I	Safety-II
Definition of safety	As few things as possible go wrong.	As many things as possible go right.
Safety management principle	Reactive, respond when something happens, or is categorised as an unacceptable risk.	Proactive, continuously trying to anticipate developments and events.
Explanations of accidents	Accidents are caused by failure and malfunctions. The purpose of an investigation is to identify causes and contributory factors.	Things basically happen in the same way, regardless of the outcome. The purpose of an investigation is to understand how things usually go right as basis for explaining how things occasionally go wrong.
Attitude to the human factor	Humans are predominantly seen as a liability or a hazard.	Humans are seen as a resource necessary for system flexibility and resilience.
Role of performance variability	Harmful, should be prevented as far as possible.	Inevitable but also useful. Should be monitored and managed.

However, Hollnagel et al. (2015) emphasise that Safety-I should not be completely replaced by Safety-II, but they should be combined. Because lots of harmful events are simple, they can be solved by the concept of Safety-I. If the concept of Safety-I does not work, it is necessary to adopt the concept of Safety-II (Hollnagel, et al., 2015).

The concept of Safety-I and Safety-II gives a new direction to how to design safety systems. The concept of Safety-I and Safety-II expands the scope and opportunities of safety systems.

In this regard, although existing safety systems were designed with the view of Safety-I, it is obvious that new safety systems should be designed with the view of Safety-II as well as Safety-I.

3 Safety Culture

3.1 Organisational Culture

There have been many studies of industrial accidents which show that particular characteristics of an organisation influence the occurrence of accidents. Among them, safety culture has received much attention. Safety culture, as a sub-facet of organisational culture, has a significant influence on people's behaviours and attitudes and thus influences the safety performance of organisations (Reason, 1997; Cooper, 2000; Guldenmund, 2000).

Organisational culture has been studied by many researchers in general, but it has also been studied as an approach to reduce accidents and to improve safety in workplaces (Pidgeon & O'Leary, 2000; Silva, et al., 2004). As most human beings work in an organisation rather than on their own, improving safety performance requires that they accept their responsibilities to the organisation because its policies, conventions, etc., affect all individuals associated with its activities.

In the Oxford Dictionary, culture is defined as "the ideas, customs, and sociology of society" (Oxford University Press, 2017). Although the term 'culture' is widely used in various fields, the understanding commonly used by anthropologists is different from that used by organisational specialists (Choudhry, et al., 2007).

The definition of organisational culture has not been established clearly, but many researchers associate it with "shared behaviours, beliefs, attitudes and values" (Guldenmund, 2000; Hudson, 2003; Reason, 1997). Schein (2004) uses the term organisational culture as "a pattern of basic assumptions invented, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration". Organisational culture is gradually associated with a single group but is created by all members of the organisation (Glendon & Stanton, 2000). However, although an organisation has a dominating culture, internally it can be expressed in various ways. In other words, there may be various subcultures. Many researchers argue that several different subcultures build up or appear in different functional groups, hierarchical levels and organisational roles in an organisation. These different subcultures can provide various perspectives and understanding of the different themes. Safety culture is also a subcomponent of organisational culture, which describes a safety level of organisations well (Clarke, 1999; Cooper, 2000; Harvey, et al., 2002; Hudson, 2007; Pidgeon, 1998).

Many major accidents have been caused by complicated and unpredictable interactions among socio-technical components (Hollnagel, 2016; Toft, et al., 2012). Thus, a socio-cultural

perspective should be considered along with the technological perspective to avoid major accidents (Choudhry, et al., 2007; McDonald & Ryan, 1992; Pidgeon & O'Leary, 2000).

Organisational safety culture is one of the expressions and characteristics of a company's overall culture. Thus, the concept of safety culture is a useful method by which to judge an organisation's position in terms of safety (McDonald & Ryan, 1992; Pidgeon, 1998).

3.2   Concept of Safety Culture

The concept of safety culture has existed since the 1980s. However, the term safety culture is known to have been used for the first time in the summary report of the International Nuclear Safety Advisory Group (INSAG) on the Chernobyl disaster in 1986 by the IAEA, and it was expanded in the Basic Safety Principles for Nuclear Power Plants Safety series N75-INSAG-3 in 1998 (IAEA, 1991; Cooper, 2000; Choudhry, et al., 2007).

The Chernobyl disaster occurred during experiments period to test the design operation of the independent power supply in the case of the loss of external power sources (IAEA, 1986). At the time of the accident, many people died, and subsequent exposure to radioactive fallout resulted in the occurrence of various cancers in people who lived near the site. The IAEA cited poor safety culture as one of the reasons for the disastrous accident (IAEA, 1986).

The concept of safety culture is that causes of accidents do not originate only from human errors, casual environmental conditions or technological failures, but also originate from more underlying issues in organisations, e.g., organisational policies, practices, etc.

Since then, the concept of safety culture has been used in many areas, mainly centred on high-risk industries such as nuclear power plants, petroleum drilling, chemical plants, aviation and railways. Later, the notion of safety culture was adopted in the healthcare domain, which is also a high-risk and high-impact sector. The safety culture approach has also been actively introduced in the UK railway industry (Choudhry, et al., 2007; Cooper, 2000; Flin, 2007; Guldenmund, 2000; McDonald & Ryan, 1992; Reason, 1998).

Thus, the concept of safety culture has regarded as a good tool with which to judge the dominance of organisations from a safety point of view (McDonald & Ryan, 1992).

3.3   Definition of Safety Culture

There are many definitions of safety culture in the literature. However, there is not yet an agreed definition, although most of the definitions are pretty similar to each other.

The definition of safety culture which was presented by HSC's Advisory Committee on the Safety of Nuclear Installations is one of most widely used definitions (HSE, 2005):

> *"The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, and patterns of behaviour that determine the commitment to, and the style and proficiency of, and organisation's health and safety management. Organisations with a positive safety culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures."*
> (HSC, 1993)

Also, many researchers have defined safety culture in various ways. Hale (2000) defines safety culture as "the attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems." Guldenmund (2000) defines it as "those aspects of the organisational culture which will impact on attitudes and behaviour related to increasing or decreasing risk." And Choudhry et al. (2007) explain that safety culture is "embedded in the organisation's practices and safety management system."

Thus, although there are various views on the definition of what a safety culture is, it is certain that most of them focus on the thinking and behaviour related to safety, and safety culture is consistently coupled with the reality of organisations. Sometimes, the terms of safety culture and safety climate have been used interchangeably.

However, at first, their meanings were different. The term safety climate appeared earlier than the term safety culture; the concept of safety climate was defined as "a summary of the workers' perception about their safety and surroundings" (Zohar, 1980). Many researchers have noted that a safety climate relates to employees' psychological shared perception of safety, and tends to be temporal and changeable (Zohar, 1980; Williamson, et al., 1997; Diaz & Cabrera, 1997).

Other researchers explained that safety culture is concerned with real observable behaviours and it is unchangeable (Flin, 2007; Harvey, et al., 2002). However, a safety climate can be considered as one of measurable aspects of safety culture which is commonly measured by questionnaire survey and represents an important aspect of safety culture (Flin, 2007; Fang & Wu, 2013).

Therefore, in this thesis the author intends to use the HSC definition (1993), which represents the characteristics of safety culture in this power.

3.4   Components of Safety Culture

Reason (1997) explains that the function of safety culture is critical in safety management, and in order to acquire a positive safety culture, collecting, synthesising and utilising the right data is very important. To illustrate this, Reason (1997) divides safety culture into five subcomponents: informed culture, reporting culture, just culture, flexible culture and learning culture.

Reason (1997) asserts that the focus of safety culture is in the building of safety information systems and all activities related to safety information, such as collecting, analysing, disseminating and utilising data; systems are connected with informed culture, i.e., he equates safety culture with informed culture.

In addition, Reason (1997) presents four subcomponents to create an informed culture: reporting culture, just culture, flexible culture and learning culture.

A reporting culture is defined by Reason as "*an organisational climate where people are prepared to report their errors and near misses*" (1997), which is an important factor in operating safety information systems effectively. To construct an effective reporting culture, management of blame is important. Blame has a profound effect on reporting rate. If blame is not managed, under-reporting will prevail. Under-reporting has been a matter of constant concern in many industries. Therefore, Reason (1997) asserts that just culture is necessary. A just culture is an atmosphere that encourages people to provide the right data related to safety. Reason (1997) stresses that there should be a clear standard to judge whether behaviour is acceptable or not.

The term flexible culture is defined as an ability to adapt to changing circumstances (Reason, 1997).

Lastly, a learning culture is defined as "the willingness and competence to derive a proper conclusion from safety information systems and the will to implement large changes when it is needed." Hence, Reason (1997) explains safety culture through safety information systems. Safety culture is composed of informed culture and four subcultures which are related to and interact with each other to create informed culture (Reason, 1997).

Thus, safety culture is not intended to achieve any level of objectives that these subcultures are aiming to achieve, but is a continuously ongoing process. Reason (1997) explains that "safety culture is something that is striven for but rarely attained."

Indeed, Reason's perception on safety culture is consistent with the fact that the highest level in the safety culture maturity model of HSE is 'continually improving'.

3.5   Measurement of Safety Culture

It is difficult to improve the safety culture of organisations; however, people have successfully improved safety culture through careful management. Halligan and Zecevic (2011) explain that safety culture has been improved via interventions, and present the following steps to engineer safety:

- Step 1: Evaluate safety culture;
- Step 2: Educate safety science;
- Step 3: Identify safety concerns;
- Step 4: Create partnerships between management and units;
- Step 5: Continuously learn from safety deficiencies;
- Step 6: Re-evaluate safety culture.

Indeed, measurement of safety culture is important in improving safety culture. So far, various assessment tools have been adopted to evaluate safety cultures and safety climates. Some of them are specific assessment tools for particular industries; there are also general-purpose tools for industries.

HSE has reviewed safety culture measuring tools to create a safety culture measurement toolkit for ORR, which is intended to measure the safety culture of railways in the UK; the results are shown below in Table 3.

As shown in Table 3, many tools are designed in questionnaire form and use a rating scale; the tools evaluate safety culture and have very similar indicators without distinction of industry: offshore, gas, nuclear power and railway industries.

In the healthcare industry, Sammer et al. (2010) synthesised properties of safety culture from various works in the literature, grouped by the following seven items: leadership, teamwork, evidence-based, communication, learning, just and patient-centred.

Indeed, many measurement tools of safety culture have very similar indicators without distinction of industry; in particular, emphasis on the indicators of leadership, reporting and communication has been highlighted in many aspects.

Table 3. Safety culture and climate measurement tools (HSE (2005))

Culture /climate	Structure		Usage
HSE Health and Safety Climate Survey Tool			
Safety climate	Questionnaire (71 items) - Organisational commitment and communication - Line manager commitment - Supervisor's role - Personal role - Workmates' influence - Competence	- Risk-taking behaviour and some contributory influences - Some obstacles to safe behaviour - Permit-to-work systems - Reporting of accidents and near misses	All industry
Aberdeen University Offshore Safety Questionnaire			
Safety climate	Questionnaire (80 items) - General information - Communication - Involvement in safety	- Satisfaction with safety activity - Safety behaviour	Offshore, gas, power-generating industry
Occupational Psychology Centre Safety Culture Questionnaire			
Safety culture	Questionnaire - Communications about safety - Profile of safety within the organisation - Access to safety within the organisation - Recognition and openness about safety issues - Control over safety	- Attitudes to safety - Safety information - Learning from safety issues - Perceptions of safety performance - Investment in safety - Other factors	Railway industry
Quest Evaluations and Databases Ltd Safety Climate Questionnaire			
Safety climate	Questionnaire (319 items) - Safety priorities - Communication - Training - Environment - Procedures - Design of work/people	- Design of things/equipment - Management/structural - Investigation/evaluation - Emergencies - Maintenance	Offshore drilling environment

Culture /climate	Structure		Usage
Rail Safety and Standard Board (RSSB) Safety Culture Tool			
Safety culture	Questionnaire (66 items) - Positive organisational attributes - Management commitment to safety - Strategic flexibility - Participation and involvement	- Training - Communication - Reinforcement and incentives - Individual ownership - Individual perceptions	Railway industry
Robert Gordon University Computerised Safety Climate Questionnaire			
Safety climate	Questionnaire (49 items) - General information - Job (measuring self-reported risk-taking behaviour) - Safety attitudes (confidence in safety management; pressure for production; supervision and management; rules and regulations; safety on installation)		Offshore industry
The Loughborough University Safety Climate Assessment Toolkit (LSCAT)			
Safety climate	Questionnaire (47 items) - Organisational content - Social environment - Individual appreciation - Work environment - Organisation specific factors	Discussions Focus group meeting Examination Document analysis	Offshore industry
Serco Assurance Safety Culture Assessment Tool			
Safety culture	Questionnaire - Management & organisational factors - Enabling activities - Individual factors	Interview	Nuclear, railway
ORR's HMRI Safety Culture Inspection Toolkit			
Safety culture	Interview (6 scenarios) - Leadership - Two-way communication - Attitude towards blame	- Employee involvement - Learning culture	Railway industry

4   Confidential Incident Reporting Systems (CIRSs)

4.1   Safety Information from Accidents and Incidents

Reason (1997) equates safety culture and informed culture; he asserts that developing a safety information system is crucial to maintain a status of considerable wariness which gathers, analyses and shares information on safety events. Therefore, developing effective reporting channel is very important to improve an organisation's safety culture. The reporting of accidents has been regarded as an important feedback channel that can provide insights into why accidents occur and how they can be prevented (Barach & Small, 2000; Davies, et al., 2000; Hudson, 2003; Wallace, et al., 2003; Benn, et al., 2009; Langer, 2014).

In some industries, as the accident rate has fallen to very low levels, it is difficult to collect sufficient safety information from investigation of accidents. In response, a different type of safety information management system was created. An Incident reporting system seeks to obtain more safety data through the management of incidents that is more frequent than accidents (Clarke, 1998; Barach & Small, 2000; Wallace, et al., 2003).

4.2   Concept of CIRSs

Learning lessons from reported accidents and incidents within an organisational context depends entirely upon the continuous input of accidents and incidents data through voluntary submission of reports by frontline workers (Benn, et al., 2009). In many cases, major accidents are reported well, but minor accidents or incidents are often not reported (Clarke, 1998; Davies, et al., 2000). In order to prevent future accidents, it is required to collect the sufficient information not only major accidents but also minor accidents and incidents, which have been less reported. Barach and Small (2000) concludes that lack of information on accidents and incidents cause more severe consequence due to the fact that the risks cannot be mitigated by countermeasures. Therefore, focusing on incident data may add more valuable support to safety improvement than solely focusing on accidents.

Many researchers have found out various reasons that restrain reporting incidents and accidents, e.g., blame culture, apathy, time constraints, etc. Above all things, it is difficult to encourage people to confess their own mistakes. Hence under-reporting is a common problem in many industries (Clarke, 1998; Benn, et al., 2009). To overcome under-reporting, some industries have adopted CIRSs which ensure confidentiality of the people who report safety issues, the so-called reporters. Ensuring confidentiality facilitates incident reporting; it diminishes concerns about revealing the identity of those involved and being punished in

connection with the incidents. Therefore, ensuring the confidentiality of reporters is critical in the operation of CIRSs; if a CIRS does not guarantee the confidentiality of reporters, the number of received reports decreases and the CIRS will be less used (Davies, et al., 2000). To ensure confidentiality of reporters, CIRSs are designed as anonymous or confidential systems with reporters. Of those, confidential systems are more common, because anonymity is not always possible or necessary (Barach & Small, 2000).

4.3   Confidentiality and Anonymity

Till now, various factors have been presented as facilitating reporting systems in many works in the literature. Among them, confidentiality is regarded as an exceedingly important element to promote reporting of incidents and to keep the system sustainable (Barach & Small, 2000; Benn, et al., 2009; Reason, 1997; 1998; Sexton, et al., 2000; Vincent, et al., 1999).

Davies et al. (2000) demonstrate that incident reporting systems can be compromised by even a single event that betrays the confidence of the system, and the number of reports submitted could plummet. And Lucas (1991) argues if an incident reporting system does not secure anonymity, the system will quickly collapse. Moreover, Wallace et al. (2003) argue that CIRSs are more effective for collecting reports than non-confidential systems. Thus, confidentiality has a tremendous impact on the operation of incident reporting systems.

For this reason, many reporting systems guarantee being either confidential or anonymous for reporters. According to the analysis of Barach and Small (2000), 10 of 12 incident reporting systems they reviewed guarantee confidentiality, and two systems provide anonymity. Among them, only one system does not provide confidentiality or anonymity. Thus, guaranteeing confidentiality is popular and provides anonymity.

However, Barach and Small (2000) suggest that providing anonymity to reporters is only valid in the initial stages of incident reporting systems where it is needed to build trust, because it is difficult to guarantee anonymity and it is disadvantageous if additional information is needed on reports. Moreover, considering that there is a possibility that anonymity can be used for other purposes, such as harming a particular person or organisation, the application of anonymity should be considered prudently. Hudson (2003) demonstrates that the aviation industry found out that confidentiality is more important than anonymity for incident reporting systems.

Therefore, providing confidentiality for reporters is essential for any incident reporting system, because every system needs a degree of follow-up control. However, it is sensible

that anonymity for reporters should be introduced only in specific cases, such as in the case of a reporting culture which has not been established.

4.4   Introduction of CIRSs

Nowadays, many incident reporting systems are being operated across various industries. CIRSs were first introduced in the aviation industry and were later expanded into other areas. In addition to the aviation industry, they are currently being operated in the railways, healthcare industry and so on.

4.4.1 Aviation Industry

In the aviation industry, many countries are operating a CIRS, including the UK's Confidential Human Factor Incident Reporting Programme (CHIRP) and Mandatory Occurrence Reporting (MOR). The quality of incident reporting is excellent in the aviation industry. Incident reporting data has been used effectively to improve the efficiency of air traffic control, airport operation, pilot and attendant training and so on (Barach & Small, 2000; Davies, et al., 2000). Barach and Small (2000) argue that the immunity system for non-criminal offences had the greatest effect on facilitating the incident reporting process in the aviation industry.

4.4.2 Healthcare Industry

Although the healthcare industry was late in adopting CIRSs compared to other industries, i.e., aviation and railways, the operation of CIRSs is continuing to expand in the healthcare industry. Annually, a substantial number of patients are killed by preventable medical errors in hospitals; therefore, the safety regulator recommends the use of complementary mandatory and voluntary incident reporting systems to promote using lessons learned. Reporting incidents results in effective interventions, and decreases the possibility of future accidents (Barach & Small, 2000; Benn, et al., 2009; Itoh, et al., 2002).

4.4.3 Railway Industry

In the railway industry, safety information is collected, analysed and utilised systematically. Investigation into accidents and analysis of incidents have been conducted complementarily in a successful effort to improve railway safety. In the UK railway, reporting of safety-related information is mandated by means of the SMIS based on Railway Group Standard GE/RT8047 'Reporting of Safety Related Information' to collect and analyse reliable safety data for use in risk management (Clarke, 1998; Davies, et al., 2000; Wallace, et al., 2003; Langer, 2014).

The CCS is another reporting system used to collect a wider range of safety information. The term close call means 'an unsafe act or an unsafe condition' that can potentially cause injury

or damage (Network Rail, 2016). More precursors to potential accidents can be identified through the CCS. The 'number of close calls' and 'close calls closed ratio within 28 days' are used as performance indicators by Network Rail (2016).

In addition, CIRAS complements SMIS and CCS. CIRAS started as a pilot programme by ScotRail in 1996 (Davies, et al., 2000; Langer, 2014). After the Ladbroke Grove collision (1999), CIRAS was expanded to all UK Railway Group members. Now, it deals with long standing safety issues on the whole railway industry in the UK (Langer, 2014).

5 Research Problem and Research Questions

5.1 The Research Problem

The purpose of this research is to eventually improve the safety of Korean railways. The author looked at the items necessary to improve the safety of the Korean railway industry through literature reviews. The Korean railway has continued to grow since its first railways in 1899, and since the opening of the world's fifth high-speed railway in 2004, it operates an excellent railway system in qualitative and quantitative terms. The safety level of the Korean railway industry is relatively high, and the safety system is also systematically equipped.

However, the author identified deficiencies in the safety sector through literature reviews. Most importantly, there is a lack of a strategic approach to safety culture.

In developing safety, the Korean railway industry has focused on the systematisation and enhancement of SMSs. The government has introduced a national recognition system for SMSs to represent the technical level of SMSs in the country and to ensure that each railway company constructs an SMS beyond this standard.

However, in this technical standard for railway safety, consideration of safety culture is not considered important. A strategic approach to safety culture is not being achieved.

The measurement of safety culture is in the early stages of introduction, and railway workers are still unsure of the concept of safety culture. Also, improvements to the reporting system are needed, which is the most important factor in improving safety culture.

Currently, various reporting systems are in use, but most reporting systems are focused on accidents. However, the current trend of safety culture is that safety systems take lessons not only from accidents but also from small safety concerns occurring every day.

To do this, the support of a systematic reporting system is essential, but the Korean railway industry lacks measures to encourage reporting safety concerns and prevent under-reporting of accidents.

Overall, the problems of safety management in Korea's railway industry identified by the author are as follows:

- Lack of awareness of safety culture, and safety culture level was yet not accurately evaluated for frontline staff;
- Lack of strategic awareness of safety culture through measurement and supplementation of safety culture;

- Even though various kinds of reporting system for preventing future accidents have already been developed, they only focus on major accidents and are not interested in daily safety concerns;
- It is not clear if the reporting systems are being operated efficiently;
- The developmental direction of safety level is only intended to strengthen the SMSs.

Together, these issues formed the research problem.

5.2 Research Questions

To develop research questions, the author carried out the following review on the problems listed above. There are several fields within the railway industry, and every field needs research into safety. However, the author limited the scope of this research to the railway construction sector because the scope of problem was wide and limits were unclear.

Currently, even though there is much railway construction work near railways, affecting railway safety, research into the safety culture of the railway construction sector in Korea has not been conducted until now. This research will be the first investigation into the railway construction sites of Korea.

The author expected the research to discover practical perceptions about the safety culture of Korea's railway industry and to develop a standardised CIRS model which can be referred to in countries that do not yet operate CIRSs.

To achieve these objectives, the author developed the following research questions to solve the research problems:

- What are the Korean railway construction workers' perceptions of safety culture?
- Does the Korean railway industry need an additional reporting system?
- What is the appropriate CIRS model for the Korean railway industry?

6 Case Studies

Case study is a method suitable for treating an empirical situation or problem, as a method for analysing and understanding current real-life practice (Noor, 2008; Yin, 2013). The author conducted case studies on two subjects in conjunction with this research, i.e., railway safety culture and CIRSs. Regarding railway safety culture, Korea's railway safety culture was selected as a case. For CIRSs, CIRAS in the UK and C^{3}RS in the US were chosen as cases to research.

6.1 Safety Performance and Safety Culture of Korea's Railway Industry

Korea's railway industry is expanding its investments to increase the efficiency of railway operation and to promote high-speed movement between major hub cities. Thus, along with strengthening of railway safety standards, safety indicators are continuously improving.

6.1.1 Structure of Korea's Railway Industry

In Korea, most railway facilities are owned and operated by central and local government. The structure and operational entities of Korea's railway industry are shown below in Figure 6.
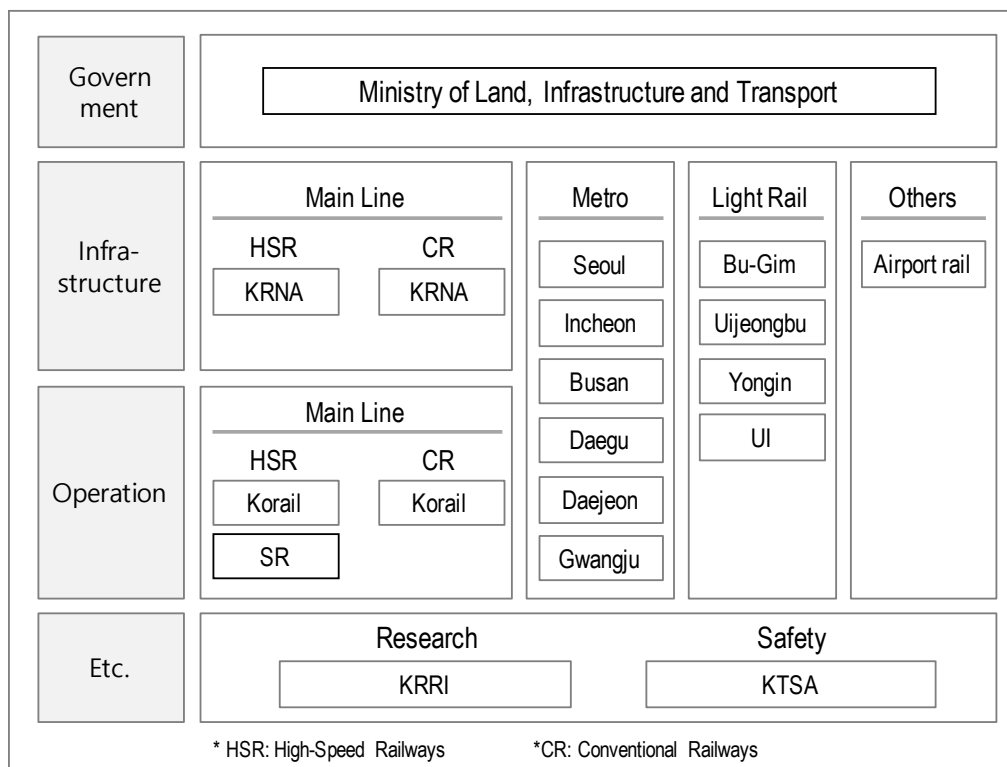
Figure 6. Structure of Korea's railway industry (The author)

The overall policies of the railway industry, including railway investments, are the responsibility of the Ministry of Land, Infrastructure and Transport. In 2004, the Korean government implemented a structural reform of the railway system which separated railway facilities and operation. Thus, two monopolistic public corporations were established: KR, which is in charge of construction, improvements and asset management, and Korail, which is responsible for passengers, freight and maintenance. And, with the opening of the new high-speed railway, a new TOC, named SR, was established, which is a kind of public company as all shareholders are public entities. Therefore, all mainline railways are owned and operated by government-led public companies.

Metros are being operated in six major cities in Korea, and they are owned and operated by public companies under the local governments. Light railway transits (LRTs) have been constructed recently to supplement the operation of the mainline railways and metros in urban areas. Though the LRTs are led by the local governments, they are built and operated by private operators, but this part of the network is far smaller than the mainline railways or metros.

In addition, there are special-purpose railways, such as the airport railway for accessing Incheon Airport outside of Seoul, which separate independent entities operate independently of the private sector.

The Korea Railroad Research Institute (KRRI) conducts railway research projects, and the Korea Transportation Safety Authority (KTSA) is in charge of railway safety.

Railway standards are not handled by a specific institution like RSSB in the UK, but are divided separately into several institutions according to each role in the railway industry.

As a result, the Korean railway industry consists of a simple structure with only small numbers of public institutions responsible for facilities, operations and metros.

6.1.2 Analysis of Safety Performance of Korea's Railway Industry

There are several ways to evaluate the safety performance of railways. While many indicators related to safety have been developed and used, there are not many indicators commonly applied on the railway industries across the world.

The author would like to compare Korea's railway safety performance with European countries that have a high level of railway safety performance. In order to do so, it is necessary to use safety indicators widely used in railway industries.

The European Union Agency for Railways (ERA) issues the biennial Railway Safety Performance Report that is intended to monitor the safety performance of the railways of the European Union (ERA, 2016). In the report, ERA uses Common Safety Indicators (CSIs), i.e., significant accidents, deaths and serious injuries, precursors of accidents, economic impact of accidents, etc., to collect information, which makes comparative analysis possible. Among them, the author will use 'fatalities per million train-km' and 'accidents per million train-km' in this thesis, because those indicators are the most widely used and are relatively simple to compare (ERA, 2016). The actual data for these indicators can be obtained from the European Railway Accident Information Link (ERAIL) system which is operated by ERA (ERA, 2017). The KTSA provides railway safety performance data through the Railway Accident and Safety Performance Report which is the annual safety analysis report including these indicators (KTSA, 2014; 2016).

The author compared the railway safety performance of Korea and eight European countries, i.e., UK, Germany, France, Italy, Spain, Austria, Sweden and Switzerland, using two safety indicators: 'fatalities per million train-km' and 'accidents per million train-km'. The author chose the eight countries with a high level of safety in the railway industry among the 28 countries of the European Union (EU).

Data was obtained from ERA's ERAIL system and KTSA's Railway Accident and Safety Performance Report. Although the ERAIL system provides various performance indicators for safety, the KTSA Safety Performance Report provides fewer safety indicators, and the criteria for classifying data are different from each other, thus the author only chose the two indicators.

6.1.2.1   Accidents on Railways

Accidents per million train-km is an objective indicator to represent the safety level of railways. For the indicator, Korea and the eight EU countries showed a relatively high level of safety. In particular, the numbers in Korea have dropped dramatically over the past 7 years, as shown in Figure 7.

Korea's accidents per million train-km dropped from 1.390 in 2009 to 0.520 in 2015. All eight EU countries showed a lower incidence of accidents than Korea. Though Austria showed a relatively higher accident rate than the other selected EU countries and the figures continue to fluctuate, the accident rate in Austria (0.504) was lower than that in Korea (0.520) in 2015.

In 2015, the other seven EU countries had fewer than half the figure for Korea, ranging from 0.07 to 0.304.
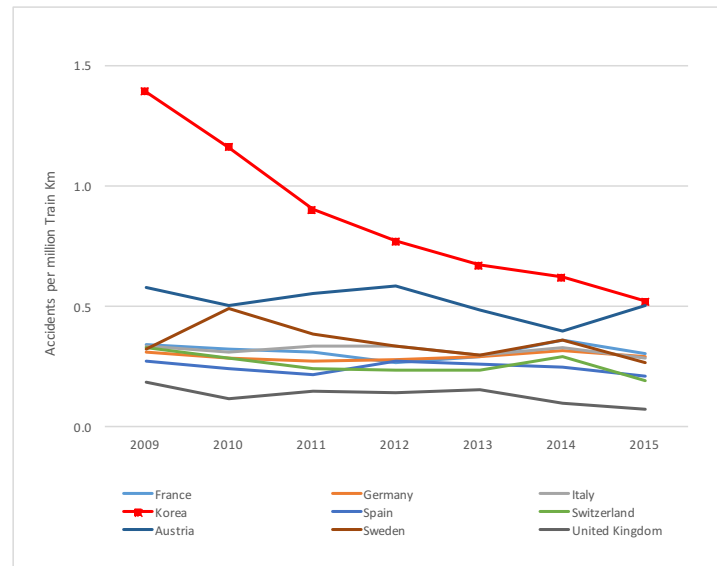
Figure 7. Accidents per million train-km (adapted from ERA (2017) and KTSA (2014; 2016))

As a result, Korea's railway industry has been seen as having had a significant improvement in accident rate, but it is still necessary to improve it to the EU level.

6.1.2.2   Fatalities on Railways

The indicator of fatalities per million train-km represents the severity of railway accidents. If a fatality occurs in a railway accident, it can be classified as a serious accident.

Korea's railway industry showed a slightly different trend for the indicator of fatalities per million train-km to that for the indicator of accidents per million train-km, as shown in Figure 8.
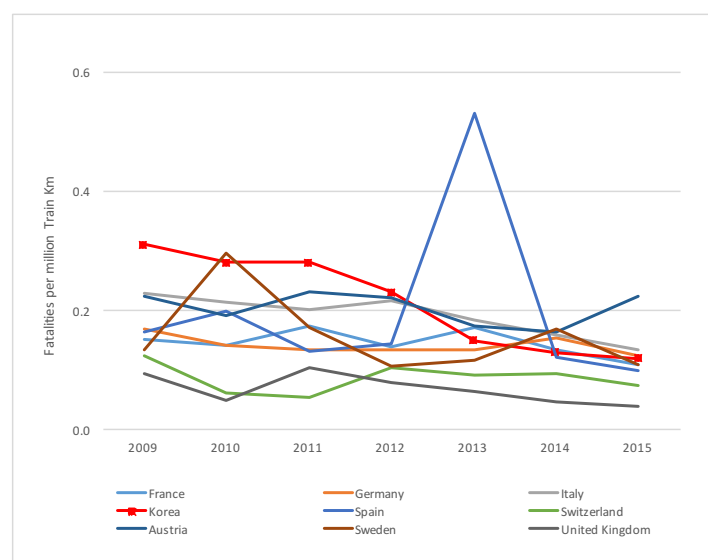
Figure 8. Fatalities per million train-km (adapted from ERA (2017) and KTSA (2014; 2016))

Although Korea's railway posted very similar values to the eight EU countries for fatalities per million train-km, it showed much higher values for accidents per million train-km.

Korea's number of fatalities per million train-km has decreased continuously from 0.310 in 2009 to 0.120 in 2015, as shown in Figure 8.

In 2015, the figure for Korea was lower than those for Germany (0.125), Italy (0.135) and Austria (0.223); however, it was still high compared to those for the UK (0.073) and Switzerland (0.040). The other six countries maintained similar levels in the same period, because they had already reached the highest level of railway safety among all 28 EU countries.

In Figure 8, it can be seen that the value for Spain rose significantly in 2013, reflecting the impact of the Santiago Compostela derailment accident in which 79 people were killed.

Normally, although there are a relatively low number of fatalities in the railway industry, it is one of the high-risk industries. There are always fears that catastrophic accidents like the one in Spain will happen at any time.

Therefore, while Korea's railway industry has a relatively low incidence of fatalities, it is necessary to improve safety levels in order to reduce the risk of serious accidents, considering the incidence of high accidents.

6.1.3 Safety Culture of Korea's Railway Industry

The concept of safety culture has recently been adopted by the Korean industry. Initially, it was applied to high-risk industries e.g., nuclear power plants and chemical plants, and then it began to be applied to the railway and healthcare industries (Lee, et al., 2014). Through this case study, the author conducted research about adoption and measurement of safety culture in Korea's railway industry.

6.1.3.1   Adoption of Safety Culture in Korea's Railway Industry

The concept of safety culture has not yet been properly established in Korea's railway industry. However, the Korean government included the concept of safety culture when it developed the approval process for railway SMSs (Lee, et al., 2011).

Legislation for the approval process for railway SMSs was imposed on IMs and TOCs for the systematic safety management of railways in 2014. In order to implement the legislation, the Korean government established safety management structure technical standards (MOLIT, 2014).

Since then, every railway IM and TOC in Korea operates under the government's approval for its SMS, based on the safety management structure technical standards. Through the legislation, the overall level of SMSs has been enhanced because all railway companies have established systematic SMSs that go further than the technical standards proposed by the Korean government.

According to the technical standards (MOLIT, 2016), the railway safety management structure is composed of three parts: railway SMS, train operating system (TOS) and railway maintenance system (RMS). SMS is again subdivided into 10 detailed areas as shown in Table 4.

Table 4. Safety management structure technical standards (MOLIT, 2016)

Structure	Element	Details
Railway safety management system (SMS)	Safety management	SMS, management policy, safety objective, safety plan, review of safety management, roll and responsibility
	Documentation	Documentation and management
	Risk management	Risk evaluation and management, countermeasures, change management
	Requirement management	Requirement elicitation, change management, compliance
	Accident investigation	Reporting, investigation, countermeasures
	Internal inspection	Evaluation, inspection and monitoring, result management
	Emergency response	Emergency response plan, training, cyber terror
	Education and training	Human resources programme, education and training
	Safety information	Management of safety information, safety assurance programme
	Safety culture	Safety leadership, improvement of safety culture
Train operating system (TOS)	Operation safety management	Train operation management system
Railway maintenance system (RMS)	Maintenance	Maintenance management system

The technical standards recommend the creation and implementation of executive safety leadership, and require companies to establish and to implement safety culture improvement programmes (MOLIT, 2016). However, since the policy is in its early stage, measurement and improvement activities for the railway safety culture have not been yet actively implemented.

The interest in safety culture emerged much earlier than the legislation for the approval process of railway SMSs. Actually, in 2011, KTSA launched a research programme to develop a railway safety culture assessment tool which is composed of five indicators and measures safety culture by means of a questionnaire survey (Lee, et al., 2011).

The questionnaire survey comprises six scenarios and links to five safety culture indicators as shown in Table 5. The scenarios are designed to help ensure that safety culture is accurately measured through familiar events or processes in the workplace (Lee, et al., 2014; Lee, et al., 2011).

Table 5. Relationship between KTSA's scenarios and indicators (Lee, et al. (2011))

Scenario of KTSA's questionnaire survey	Indicators of safety culture
1. Safety management	1. Safety policy and safety leadership 2. Communication between concerned parties 5. Safety responsibility mind
2. Occurrence of safety concerns	2. Communication between concerned parties 4. Learning culture 5. Safety responsibility mind
3. Change management	2. Communication between concerned parties 3. Change management and self-diagnosis
4. Transfer of information relating to shift duties	2. Communication between concerned parties 5. Safety responsibility mind
5. Time-critical and degraded situations	1. Safety policy and safety leadership 3. Change management and self-diagnosis 4. Learning culture 5. Safety responsibility mind
6. Accident management	1. Safety policy and safety leadership 4. Learning culture 5. Safety responsibility mind

KSTA's questionnaire survey consists of 43 questions and each answer is calculated to quantify the safety culture by awarding it a score based on a five-point Likert scale (1 to 5) (Son, et al., 2015).

The results of the survey are ranked into five categories as shown in Table 6.

Measurement of safety culture in Korea's railway industry has been carried out once a year by KTSA across the whole railway industry in Korea. Usually, KTSA gets replies from fewer than 200 people which is quite a small number considering the scale of Korea's railway industry. Furthermore, KTSA does not differentiate between sites or companies when analysing the results (Lee, et al., 2016; Lim & Kim, 2014; Son, et al., 2015).

Table 6. KTSA's decision criteria for safety culture level (Lee, et al., 2011)

Category	Description of category	Description of company attitudes
Level 1	Not yet	Only carries out mandatory requirements, responses to laws, and transfers all responsibilities to the safety departments
Level 2	Safety operation procedure (SOP) only	Safety norms and procedures are established but not distributed to all employees
Level 3	SOP & education/communication	Safety norms and procedures are established and education is provided for employees, but compliance is not ensured
Level 4	SOP & practice/promotion	Safety norms and procedures and established and complied with, incentive and punishments an applied, but safety education is not provided to employees
Level 5	SOP, education/communication & practice/promotion	All put importance on safety management, consider peer safety, safety norms and procedures run well, safety education is provided properly, and employees comply with requirement

6.1.3.2 *Measurement of Safety Culture in Korea's Railway Industry*

Measurement of the safety culture in Korea's railway industry has been conducted once a year by KTSA since it developed the measurement tool in 2011 (Lee, et al., 2014; Lee, et al., 2011; Lee, et al., 2016; Son, et al., 2015). Measurement is conducted using a web-based tool with workers in about ten train TOCs in Korea.

KTSA uses a questionnaire survey system in the Rail Safety Information System (RSIS). However, despite the operational convenience of the electronic survey system, the number of survey respondents is extremely limited. In the measurement of Korea's railway safety culture in 2015, only 184 people took part in the survey out of the 677 people targeted.

Among the respondents, 67.4% were frontline workers and the rest worked at headquarters. The biggest group of respondents worked as drivers (28.8%), the next biggest in safety areas (14.1%) (Lee, et al., 2016). The number of respondents was too small to be representative of the whole Korean railway industry. It is necessary to increase the reliability of measurement by increasing the number of measurement targets.

Table 7 illustrates all the results of safety culture measurement for Korea's railway industry since 2011 (Lee, et al., 2016; Son, et al., 2015).

Table 7. Results for Korea's railway safety culture (Lee, et al., 2016; Son, et al., 2015)

Indicator	2011		2012		2013		2014		2015	
	Positive answer	Average point	Positive answer	Average point	Positive answer	Average point	Positive answer	Average point	Positive answer	Average point
Safety policy and safety leadership	69.7%*	76.7%*	71.9%*	80.7%*	75.1%*	78.9%*	79.2%*	81.0%*	70.1%	80.0%
Communication between concerned parties	71.7%	77.4%	87.1%	84.4%	83.2%	83.4%	89.0%	86.4%**	76.4%	83.0%
Change management and self-diagnosis	70.1%	76.9%	83.1%	81.8%	79.3%	81.6%	83.0%	83.2%	74.7%	81.2%
Learning culture	73.2%	78.3%	82.2%	81.8%	76.0%	79.1%	81.8%	82.4%	69.2%*	79.7%*
Safety responsibility mind	75.6%**	79.6%**	88.6%**	84.8%**	86.2%**	84.2%**	89.4%**	86.1%	79.1%**	83.3%**
Total	**73.0%**	**78.8%**	**84.1%**	**82.7%**	**79.9%**	**81.4%**	**84.5%**	**83.9%**	**74.8%**	**81.7%**

* Minimum value; ** maximum value

As seen in Table 7, the results for safety culture are calculated in two ways, according to both 'positive answer' and 'average point'. Although all the indicators fluctuated, the lowest indicators were always 'safety policy and safety leadership' and 'learning culture'.

Figure 9 and Figure 10 show graphs using the total values from Table 7.

As shown in Figure 9 and Figure 10, Korea's railway safety culture was slightly increased in 2015 compared to the first measurement in 2011.

However, it is difficult to say conclusively that safety culture has improved in Korea's railway industry. During the measurement period, the values continued to fluctuate, as shown in Figure 9 and Figure 10.
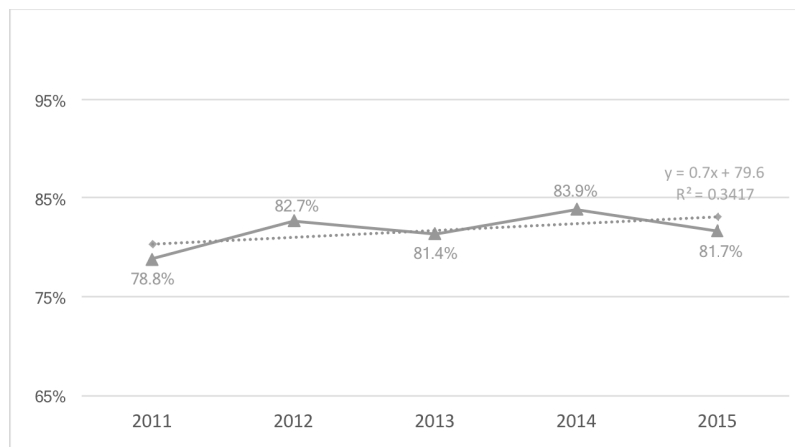
Figure 9. Safety culture in Korea by average point (adapted from Lee, et al. (2016))
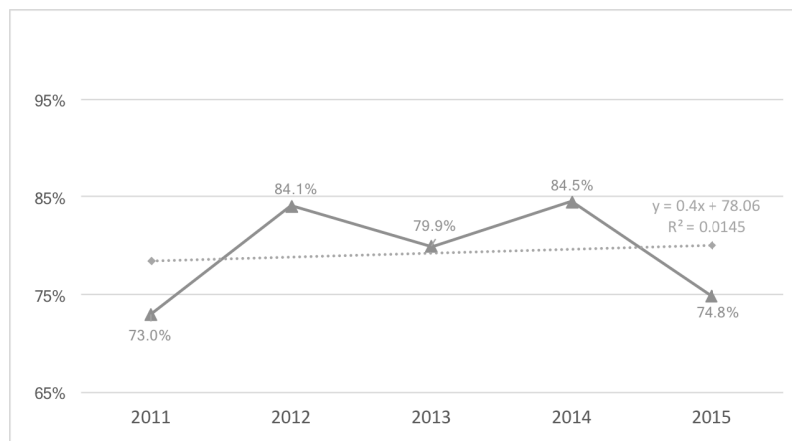
Figure 10. Safety culture in Korea by positive answer (adapted from Lee, et al. (2016))

Lee et al. (2016)show that the value for safety culture of Korea's railway industry was 81.7% in 2015, which corresponds to safety culture level 4 out of five levels.

Level 4 safety culture means that the Korean railway industry is set to be prepared and implement practices in accordance with the procedures and regulations for securing safety of employees, and the criteria for punishment are effectively established; however, the

management lacks a sufficient safety mindset, and the incentives for enhancing safety activities are not sufficient (Lee, et al., 2016).

Figure 11 and Figure 12 show the variation in safety culture indicators for Korea's railway industry.
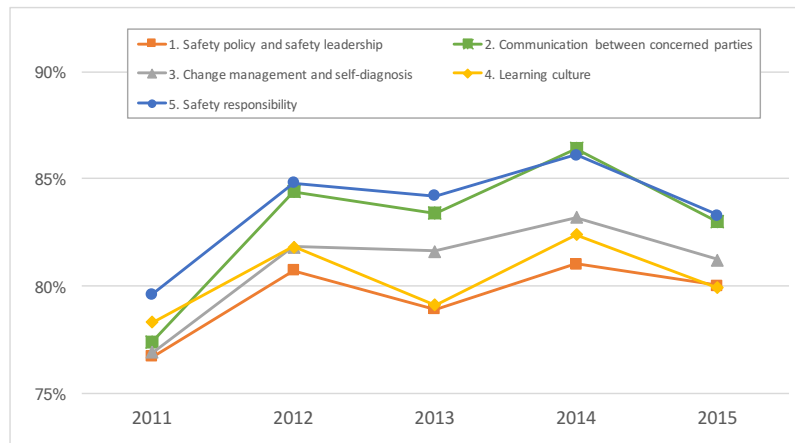
Figure 11. Average point by indicator for safety culture in Korea (Lee, et al. (2016))
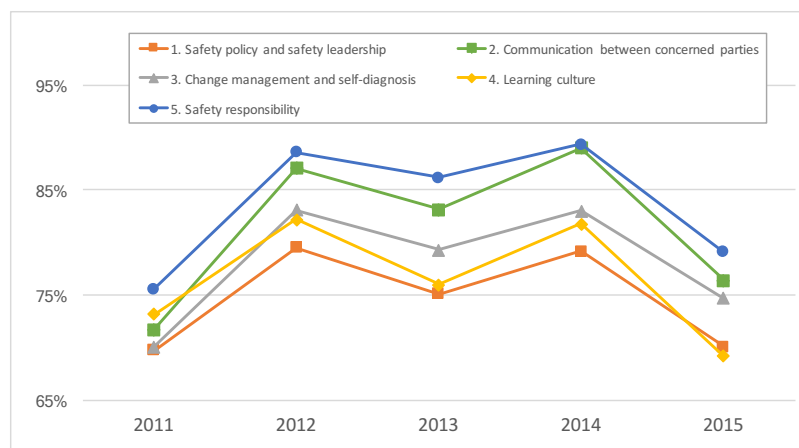
Figure 12. Positive answer by indicator for safety culture in Korea (Lee, et al. (2016))

Among the five indicators of railway safety culture, 'safety responsibility' represented the highest value for each year, and 'safety policy and safety leadership' represented the lowest values every year.

However, in 2015, 'learning culture' dropped sharply compared to the previous year. Although all indicators decreased, 'learning culture' still had the lowest value of the indicators. This means that learning culture must be urgently improved.

Despite these annual measurements, it is difficult to ascertain whether Korea's railway safety culture is properly evaluated, because the number of people participating in the

questionnaire survey has been very small compared to the number working in Korea's railway industry.

Indeed, the number is insufficient to represent the tens of thousands of employees in Korea's railway industry. Furthermore, many of the respondents' working disciplines were concentrated in certain areas, e.g., train driver, safety management, maintenance of infrastructure, etc. Also, the subculture of individual companies or sites has not yet been studied, and there has been a lack of research into the differences between the results and the actual level of safety culture at sites.

However, KTSA first measured Korea's railway safety culture and has continued to accumulate data related to safety culture (Lee, et al., 2014; Lee, et al., 2011; Lee, et al., 2016; Son, et al., 2015).

Thus, it is certain that it will help to identify vulnerable areas and to improve the overall railway safety culture of Korea through improvements of those areas.

From this point of view, 'safety policy and safety leadership', which has shown relatively low values compared to other indicators in the measurements, and 'learning culture', which sharply declined in the recent measurement, must be improved as soon as possible.

6.1.4 Findings for Korea's Railway Safety Performance and Safety Culture

The case study for Korea's railway industry was carried out to identify the actual level of safety performance and safety culture.

The safety performance level of Korea's railway industry was found to have a similar level of safety compared to the eight major European countries in terms of accidents and fatalities. In particular, it is positive that the safety performance has continually improved:

- Although Korea's accident per million train-km dropped sharply from 1.390 in 2009 to 0.520 in 2015, the value was slightly higher than major EU countries;

- Korea's fatalities per million train-km dropped from 0.310 in 2009 to 0.120 in 2015; the value was similar to those of major EU countries.

However, there was a lot of lack of respect for safety culture. There was not only a lack of awareness about safety culture, but also a lack of measurement and utilisation of safety culture. The results for safety culture measurement were relatively low and have fluctuated continually:

- The average point for Korea's safety culture increased from 78.8% in 2011 to 81.7% in 2015, but the values fluctuated in the process;

- Positive answers about Korea's safety culture increased from 73.0% in 2011 to 74.8% in 2015, but the values fluctuated much more than the average point;

- Korea's safety level was level 4 out of five levels in 2015.

Therefore, improvement of safety culture is necessary to secure railway safety in Korea. As a result of the case study for Korea's railway safety performance and safety culture, the following lessons were found:

- Safety performance has steadily improved and has approached a similar level of safety to that of major EU countries;

- Safety culture needs continuous efforts to be improved because the results were not at a good level and have fluctuated recently;

- There was a lack of awareness about safety culture;

- The safety culture indicators of 'safety policy and safety leadership' and 'learning culture' need to be improved in particular.

6.2   CIRS in the UK: CIRAS

6.2.1 Background

CIRAS began as a two-year pilot programme in the UK in 1996. The University of Strathclyde developed a confidential reporting system for ScotRail, and later other railway organisations in Scotland participated in the system. As a result of the Ladbroke Grove rail collision (1999), CIRAS was expanded to apply to all mainline railways in Great Britain (Davies, et al., 2000). Currently, membership of CIRAS stands at thousands of companies, as subcontractors of Network Rail participate in CIRAS (Langer, 2014).

The purpose of CIRAS is to promote ongoing safety improvements by collecting safety information and issues from the railway industry, analysing and resolving them, and sharing the lessons learned from the processes with all people involved.

In this scheme, it is key that people are able to provide more information and report issues without fear of being punished by ensuring confidentiality of 'reporters' who report safety issues. CIRAS has various defences at every part of the process to secure confidentiality, because confidentiality can determine its success. For this reason, CIRAS is being operated independently. CIRAS was designed to solve the issue that people did not want to report human factor problems through official channels because of a fear of blame or punishment, and many people who are disappointed with their internal reporting system use CIRAS as well.

6.2.2 Safety Concerns to Report

CIRAS handles various safety concerns related to the transportation industry, which is wide open. Any concerns about health and safety in the workplace can be reported to CIRAS.

CIRAS (2017) describes that the following safety concerns are treated:

- Unsafe practices;
- Work environment issues;
- Failure to follow procedures;
- Lack of training or qualifications to do a particular task;
- Lack of safety briefings;
- Community safety;
- Fatigue;
- Vandalism and trespassing.

The scope of reporting for CIRAS is advantageous to enlarge the range because CIRAS complements the existing reporting systems, thereby accumulating and sharing diverse lessons and experiences related to safety.

6.2.3 Operational Process

CIRAS's operational process is relatively simple. However, since the most important thing in implementing the process is securing confidentiality, it is necessary to ensure thorough preparation for confidentiality in each phase of operation (CIRAS, 2017; Davies, et al., 2000; Langer, 2014; Wallace, et al., 2003).

Ensuring confidentiality is very demanding. As only one breach of confidentiality for reporters can affect CIRSs severely, the reporting process must be organised reliably.

Figure 13 shows the operational processes of CIRAS.
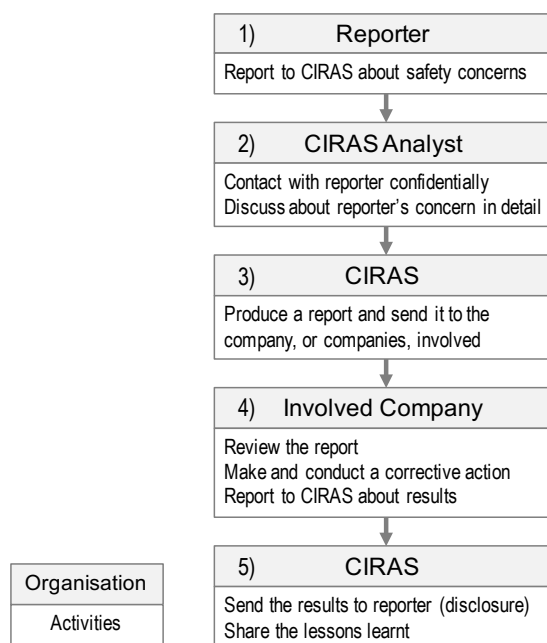
Figure 13. Operational process of CIRAS (adapted from CIRAS (2017))

As shown in Figure 13, the operational processes of the CIRAS are:

1) People voluntarily report safety concerns to CIRAS;

2) A CIRAS analyst contacts the reporter and discusses safety concerns;

3) The analyst produces a report and sends it to relevant companies and people;

4) Relevant companies or people review the report, make and implement corrective actions, and report the results of the corrective actions to CIRAS;

5) CIRAS sends the results to the reporter and shares the information.

As mentioned above, confidentiality is a top priority; CIRAS includes measures to protect confidentiality at each step of processes, e.g.:

- Limits report access to two persons;
- Sanitises identifying information in the reports;
- Reviews the sanitised reports before sending them to relevant companies.

Thus, CIRAS ensures confidentiality for reporters and achieves continuous improvement through the information from reporters.

6.2.4 Organisation of CIRAS

Currently, over 1,000 companies subscribe to the CIRAS scheme, and the number continues to grow as coverage extends to outside the railways (Langer, 2014).

The organisation of CIRAS to manage the companies is shown in Figure 14.

The CIRAS organisational structure comprises managers, analysts and administrators but only 15 members of staff.
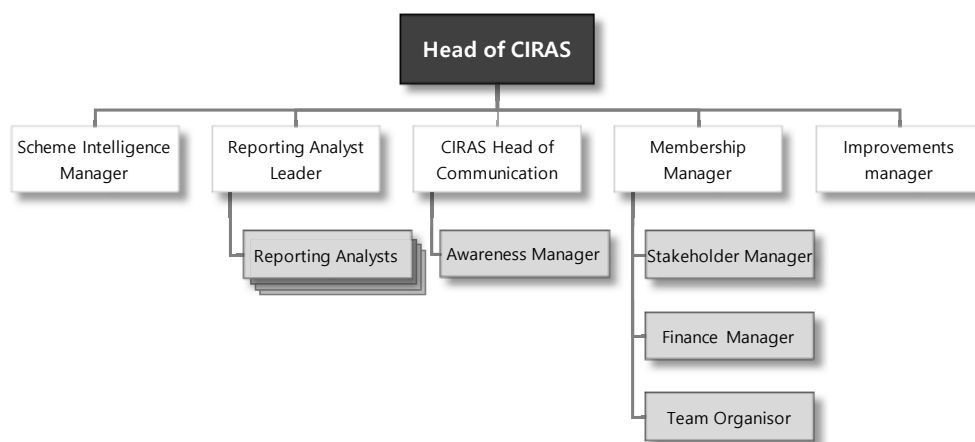
Figure 14. Organisation of CIRAS (adapted from CIRAS)

Most staff work in the reporting analysis and membership management sectors. There are also people in charge of communication, education, improvement, etc. CIRAS is being operated very efficiently as the number of staff is relatively small compared to the number of companies subscribing to the CIRAS scheme.

6.2.5 Effectiveness of CIRAS

Confidential reporting schemes like CIRAS help improve safety and safety culture. Langer (2014) argues that it is very difficult to calculate how many accidents CIRAS has prevented,

but it is obvious that CIRAS makes the railway safer than before, and calculates effectiveness in an indirect manner.

Langer (2014) demonstrates that the majority of safety concerns reported (81%) have already been reported through internal reporting channels, but are reported to CIRAS due to unsatisfactory results. Among them, 55% of reporters thought that results were inadequate and 23% of people thought they were adequate but prevention measures had not been implemented, as shown in Figure 15.
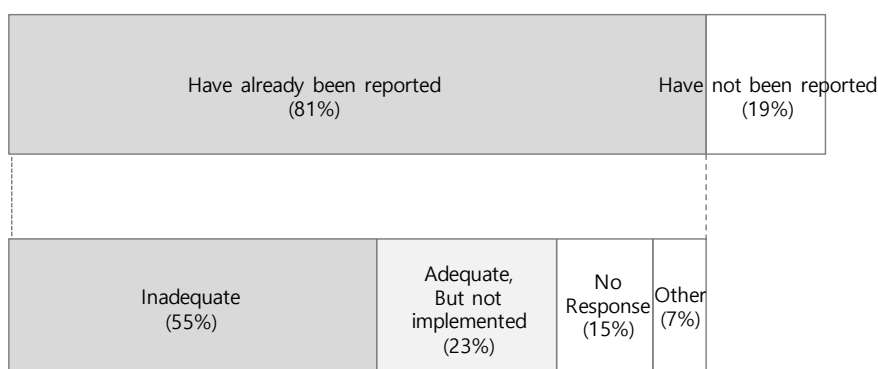
Figure 15. Perception of internal response to safety concerns (Langer (2014))

Indeed, this means that existing reporting systems are often not functioning properly, and such defects can be complemented by confidential reporting schemes such as CIRAS.

6.2.6 Findings from the Case Study of CIRAS

The case study for CIRAS was conducted to identify the overview and functionalities of CIRAS, and to find out the key points in the operation process.

CIRAS began in 1996 as a two-year pilot project and has been successfully applied throughout the UK's railway industry as a result of the Ladbroke Grove rail collision (1999). Currently, CIRAS continues to expand its coverage of buses, trams, ships and more.

CIRAS highlights ensuring confidentiality for reporters, thus it can solve many safety concerns related to problems unsolved by internal reporting channels. CIRAS's analysis showed the following:

- Majority of reported safety concerns (81%) have already been reported through internal reporting channels;
- 78% of results of the internal reporting were inadequate or unimplemented;
- CIRAS can complement such defects in internal reporting channels.

CIRAS demands the reporting of a wide range of topics, to acquire and share safety-related knowledge on various topics. Key lessons learned through the case study are:

- CIRAS handles a wide range of safety topics related to the transportation industry, including any concerns about health and safety in the workplace;

- Confidentiality has been the most important value of CIRAS and is ensured by various methods in the operation processes;

- As a complementary reporting channel, CIRAS has solved many issues that had not been solved by existing reporting channels.

6.3 CIRS in the US: C³RS

6.3.1 Background

In 2002, the Federal Railroad Administration (FRA) noted that there had been no improvement in human factor-caused accident level at that time, and decided to introduce a new approach to safety in 2003 that had already proven to be successfully in the aviation, nuclear power and chemical industries. After two years, FRA signed a memorandum of understanding with stakeholders for the pilot programme of C³RS (Morell, et al., 2006; Ranney, et al., 2015).

After preparation, C³RS started at the first site in 2007. Overall, four companies participated in the pilot programme: Union Pacific (UP), Canadian Pacific (CP), New Jersey Transit (NJT) and Amtrak. Currently, eight companies participate in the C³RS programme, and over 21,000 employees are eligible to report safety concerns through it (Morell, et al., 2006; Ranney, et al., 2015) .

From the start, FRA has conducted evaluations of the C³RS programme to assess outcomes. Its applicability to the entire US railway industry will depend on the outcome of this assessment (Ranney & Raslear, 2012; 2013; 2015; Ranney, et al., 2015).

6.3.2 Close Call Events

C³RS deals with close call events confidentially using a Peer Review Team (PRT). The term close call is defined as "an opportunity to improve safety practices in a situation or incident that has a potential for more serious consequence" (FRA, 2005; Ranney, et al., 2015).

FRA (2005) demonstrated examples of close calls as:

- Events of high frequency but minor consequence;
- Events of low frequency but which have potentially major consequences;
- Events that are below the FRA reporting threshold;
- Events that are above the FRA reporting threshold where the potential exists.

However, C³RS is only applicable to sites signing up with FRA, and it is not applicable to other sites.

6.3.3 Protection for Reporters

C³RS operates a protective system to ensure that reports are not missed due to concerns about punishment. Under this system, reporters can be exempted from discipline even though they are related to close calls.

For protection, FRA (2005) provides that the following conditions should be met:

- The employee did not intend to cause damage;
- The employee reported the unsafe condition within time limits (48 hours).

However, not all reports are subject to protection. FRA (2005) says that no protection is provided for workers in the following conditions:

- The employee's action was intended to damage;
- The employee's action involved a criminal offence;
- The employee's action was related to substance abuse;
- The report contains falsified information;
- Railroad accidents/incidents;
- The events resulted in identifiable release of hazardous material;
- The event was observed in real time and reported.

Even if workers have safety concerns, sometimes they do not report them because of inconvenience, indifference or fear of being punished. Therefore, the protection system for reporters is considered a very positive measure to help activate reporting of safety concerns.

6.3.4 Operational Process

Ensuring confidentiality of reporters is the first priority in the C^3RS operating process. To do this, a neutral third party, i.e., NASA, is involved between reporters and PRTs.

While operating C^3RS, NASA provides PRTs with 'balanced reports'; all personal information is removed from data to prevent leakage of personal information after the issue is solved.

The detailed operating process of C^3RS is shown in Figure 16.

The C^3RS process comprises six stages (Ranney, et al., 2015):

1) If a worker observes a close call event, he or she reports it to C^3RS via website or mail;
2) A C^3RS analyst interviews the worker by call to clarify or obtain additional information, and sanitises identifying data from the report to ensure confidentiality;
3) C^3RS sends the de-identified report to the PRT;
4) PRT reviews the report, determines the root causes and recommends corrective actions to the Support Team;
5) Corrective actions are reviewed, evaluated and implemented;
6) The implementation progress is tracked and original reports are destroyed.
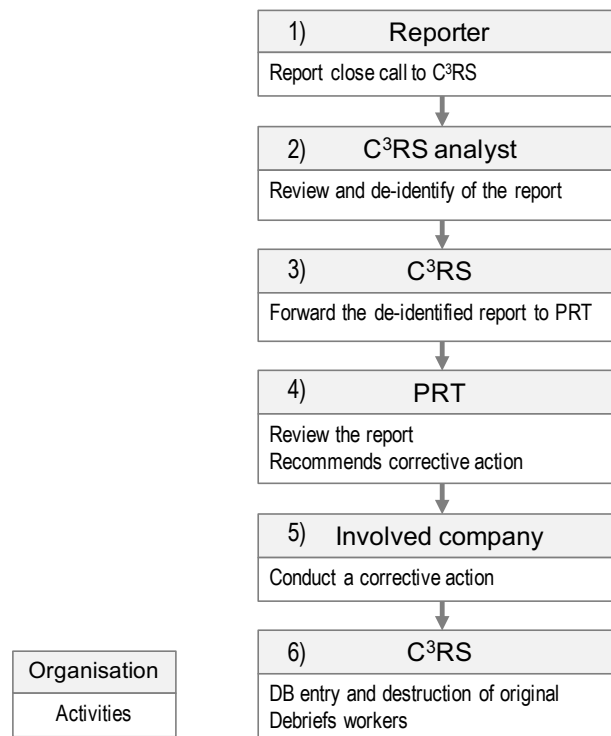
Figure 16. Operational process of C[3]RS (adapted from Ranney, et al. (2015))

6.3.5 Peer Review Team

The PRT is a group of experts which reviews the reports, selects the root causes of the close calls and develops corrective actions to recommend to the Support Team (FRA, 2005).

PRTs have an important role in presenting solutions to the reported close calls, a unique characteristic of C[3]RS. PRTs are usually organised on a regional basis and have a regular meeting each month to review the reports of close calls (FRA, 2005; Ranney, et al., 2015).

PRTs comprise specialists from carriers, labour organisations and FRA. The PRT members are trained to conduct multiple-cause-analysis problem solving. Although PRTs are not full time and solve problems by periodic meeting, they allow systematic operation of the CIRS (Ranney, et al., 2015).

Thus, training to enhance the competence of PRT members could be implemented through a prearranged plan.

6.3.6 Evaluation of C[3]RS

In the US railway industry, it is planned to conduct a pilot C[3]RS project before applying it to the entire US railway industry at the same time. After evaluation of the results it will be decided whether C[3]RS will be expanded or not (Ranney, et al., 2015).

Thus, a systematic evaluation was prepared to assess the effectiveness of C^{3}RS, and was conducted by the Volpe National Transportation System Center.

6.3.6.1   Purpose of the Evaluation

Raslear et al. (2008)and Ranney et al. (2015) demonstrated the purpose of the evaluation of C^{3}RS. It comprises three aspects:

- Implementation Evaluation evaluates how well it is being implemented;

- Outcome Evaluation evaluates the influence of C^{3}RS on safety and safety culture;

- Sustainability Evaluation evaluates how to maintain the programme in the long term.

6.3.6.2   Methods of Evaluation

For the systematic evaluation of C^{3}RS, Ranney et al. (2015) use an evaluation methodology to accomplish the purpose of evaluation, as shown in Table 8.

For every company adopting C^{3}RS, a C^{3}RS site and a non-C^{3}RS site were chosen together as evaluation targets to evaluate the effectiveness of C^{3}RS by comparison.

The evaluation is designed to be executed according to the progress of the programme, i.e., baseline, midterm and final points of the programme. Since a measurement was conducted as a baseline prior to the application of the C^{3}RS, it is possible to compare it with the subsequent measurements.

Table 8. Evaluation methodology (adapted from Ranney, et al. (2015))

Type	Company	Site	Programme Phase
Freight	UP	C^{3}RS site	Baseline, Midterm, Final
		Non-C^{3}RS site	Baseline, Midterm, Final
	CP	C^{3}RS site	Baseline, Midterm, Final
		Non-C^{3}RS site	Baseline, Midterm, Final
Passenger	NJT	C^{3}RS site (whole sites)	Baseline, Midterm, Final
	Amtrak	C^{3}RS site	Baseline, Midterm, Final
		Non-C^{3}RS site	Baseline, Midterm, Final

6.3.6.3   Data Collection for Evaluations

The following qualitative and quantitative data is used for evaluation of C³RS (Ranney, et al., 2015):

- Railway safety culture survey: evaluation of implementation and outcomes;
- Interviews: implementation, outcome, sustainability;
- C³RS reporting rates: implementation, sustainability;
- Project records: implementation, outcome, sustainability;
- Field notes: implementation, outcome, sustainability;
- Corporate safety data: outcome.

6.3.6.4   Results of Evaluations

The Volpe centre have conducted the evaluation process since the adoption of C³RS in 2007, and most evaluation results were positive (Ranney & Raslear, 2012; 2013; 2015; Ranney, et al., 2015).

The results of the evaluations are as follows:

Site A:

Ranney and Raslear (2012) show the evaluation results for a site 2 years after adoption of C³RS as below:

- Car movement between incidents improved about 31%;
- Labour–management relationships and peer-to-peer relationships improved;
- Discipline cases were dramatically decreased by over 90%.

Site B:

Ranney and Raslear (2013) demonstrated the evaluation results for another site 2 years after adoption of C³RS as shown below:

- Derailments caused by run-through switches decreased by 50%;
- Labour–management relationships improved.

Site C:

Ranney and Raslear (2015) revealed the evaluation results for another site 4.75 years after adoption of C³RS as shown below:

- Human-factored derailment decreased by 31%;

- Decertification of workers decreased by 41%;

- Human-factored incident costs reduced by 53%;

- Labour–management relationships and labour-to-labour communication improved.

As a result, it was found that adoption of C^{3}RS is beneficial in improving not only safety but also safety culture.

However, these types of evaluation are very complicated and time-consuming, although they may be very beneficial and essential in the early age of adoption. Therefore, these detailed third-party evaluation systems are difficult to enforce if conducted in the long term. Therefore, it is recommended that a permanent evaluation system with some easy methods, apart from comprehensive evaluation programmes in adoption stages, should be adopted to proceed with continued improvement.

6.3.7 Findings from the Case Study of C^{3}RS

The case study for C^{3}RS was conducted to identify the overview and functionalities of C^{3}RS and to capture the key points in the operation process.

C^{3}RS began in 2007 in the US, and currently only applies to eight railway companies. While the scope of application is expanding gradually, only a small part of the US railway industry applies it.

C^{3}RS provides official legal protection, so reporters are protected from discipline, decertification and enforcement by FRA under certain conditions, and it ensures the confidentiality of reporters in various ways. Problem-solving in C^{3}RS is led by independent PRTs, which were established by each company and include specialists from various sectors.

Since C^{3}RS has been introduced in accordance with the systematic planning of analysis of previous cases, it has a comprehensive evaluation programme. The results of the evaluation programme show that safety and safety culture has been improved qualitatively and quantitatively:

- Labour–management relationships, labour–labour communication and relationships improved;

- Discipline cases decreased by over 90%;

- Derailments cause by run-through switches decreased by 50%;

- Human-factored derailments decreased by 31%;

- Decertification of workers decreased by 41%;

- Human-factored incident costs reduced by 53%;

- Car movement between incidents improved by about 31%.

As a result, the application of C^3RS has positively influenced safety culture and safety performance. Key lessons learned through the case study are:

- The application of C^3RS is beneficial for improving safety and safety culture;

- The protection system for reporters helps employees to report actively;

- PRTs are important entities in solving the problems;

- The evaluation system is beneficial to verify the effectiveness of C^3RS.

6.4   Lessons for Model Development

The case studies were conducted in order to verify the safety level of Korea's railway industry and to check the structure and effectiveness of CIRSs.

The safety level was considered by reviewing safety performance indicators. Recently, safety performance in Korea has reached a similar level to that of major EU countries. On the other hand, safety culture has been found to remain at a relatively low level of awareness and utilisation, and more improvement is needed in some areas of safety culture.

The case studies of CIRSs were conducted through examining actual practice in the UK and US. These were conducted to identify issues for creating a CIRS model. CIRAS is well operated as a complementary reporting channel, and the benefits of C^3RS have been proved through a comprehensive evaluation programme.

Through the case studies, the author identified some lessons and issues for developing a CIRS model:

- Safety performance in Korea's railway industry has steadily improved and has reached a similar level of safety to that of major EU countries, but safety culture should be improved more;

- Application of CIRSs is beneficial for improving safety and safety culture;

- Confidentiality is the most important value and has helped people to report actively;

- As a complementary reporting channel, CIRAS has solved many issues that had not been solved by existing reporting channels;

- The scope of reporting coverage should be broadened to collect information on various topics of safety concern;

- Evaluation systems are beneficial to verify the applicability of CIRSs.

7 Questionnaire Surveys

The questionnaire surveys were conducted to measure the safety culture in Korea's railway industry, with a view to introducing a CIRS to Korea's railway industry. Although Korean TOCs have measured safety culture since 2011, railway construction sites, which might significantly influence railway safety, have not yet measured safety culture. Therefore, these questionnaire surveys focused on railway construction sites.

The questionnaire surveys were conducted in two phases.

The first survey was conducted to assess the reporting culture of the railway construction sites prior to the full-scale survey on safety culture, and was intended to determine whether additional reporting channels are needed to improve safety culture.

The second survey explored the safety culture of the railway construction sites and was intended to provide exact information on the need for an additional reporting channel based on the first survey.

As the safety culture of railway construction sites has not yet been measured, the questionnaire surveys are the first practical surveys of safety culture in Korean railway construction sites.

7.1 Preliminary Questionnaire Survey

7.1.1 Purpose

The preliminary questionnaire survey was conducted to discover Korean railway engineers' and supervisors' perception of reporting cultures. For this purpose, the questionnaire consisted of items related to the reporting of safety concerns.

Through this questionnaire survey, the author wanted to roughly understand the reporting culture of railway construction sites and to confirm the need for further detailed surveys.

Moreover, the author wanted to review the possibility of under-reporting to identify whether additional reporting channels are needed.

7.1.2 Preliminary Questionnaire Survey Methods

7.1.2.1 Survey Items

The preliminary questionnaire survey included items on position, reporting scheme for safety concerns, reporting culture for safety concerns and under-reporting. All questions were multiple choice, apart from one open-ended question about under-reporting.

The questions were established through a literature review on reporting culture (HSE, 2005). The draft questionnaire was reviewed by an expert in incident reporting systems.

Position

The first question in the preliminary questionnaire survey asked each respondent to identify their position. The author did not include any items related to personal information, to ensure the confidentiality of respondents, but included their position in order to conduct analysis according to position. There were four categories of position:

- Site managers;
- Supervisors;
- Site engineers;
- Manual workers.

Reporting Scheme for Safety Concerns

This item consists of two questions related to reporting scheme and operation of the scheme. Through this item, the author wanted to identify how reporting schemes were being operated. All questions had Yes/No answers.

Reporting Culture of Safety Concerns

This item was the main item of the survey and aimed to identify the reporting culture of respondents. The part comprised seven questions and was developed to measure four sub-items as shown below. All questions were multiple choice type, using a five-point Likert scale whereby 1 represented 'strongly disagree' and 5 represented 'strongly agree'.

- Leadership: two questions;
- Two-way communication: two questions;
- Learning culture: one question;
- Attitude towards blame: two questions.

Under-reporting

This item comprised two questions and was developed to identify the facilitation measure for reporting and the reasons for under-reporting. One question was multiple choice and the other was open-ended.

7.1.2.2   Survey Target

As it was a preliminary survey, the author selected 15 sample sites near operating railways among about 350 railway construction sites in Korea. Table 9 shows the target sites and staff. At each target site, five people were selected for survey.

Table 9. Target of preliminary questionnaire survey (The author)

Target	Total	Civil	Track	Building	Signal	Communi-cation	Electricity
Site	15	8	3	1	1	1	1
Staff	75	40	15	5	5	5	5

7.1.2.3   Survey Administration

The questionnaire survey was conducted between 21st and 22nd April 2016. The questionnaires were distributed to 75 engineers, supervisors and managers who worked on the selected 15 different railway construction sites in Korea near operating railways.

The author selected the sites to measure the reporting culture of the people who work in dangerous environments. They were chosen at random among the roughly 350 railway construction sites which held contracts with KR.

The author explained the overview of the questionnaire survey and asked for participation by phone calls. Respondents were chosen randomly at the 15 sites. After 2 days, the author closed the survey after confirming there was no intention for additional participation.

All questionnaires were created, distributed and collected through the Google Docs Questionnaire form. The questionnaire is included in Chapter 12 (Appendix).

7.1.2.4   Survey Analysis

As the questionnaire survey was simple, Microsoft Excel was employed to analyse the completed questionnaires. The results data was exported from Google Docs Questionnaire and imported to Microsoft Excel. The results were analysed two ways, i.e., analysis by item and analysis by position.

7.1.3 Results

7.1.3.1 Respondents

Of the 75 questionnaires, 62 questionnaires were completed, an 82.8% response rate. Table 10 shows the work positions of the respondents. Among them, site engineers (36 people) were most likely to participate; manual workers (one person) represented the smallest proportion.

Table 10. Positions of respondents (The author)

Position	Site Manager	Supervisor	Site Engineer	Manual Worker
Respondents	16	9	36	1
%	25.8%	14.5%	58.1%	1.6%

7.1.3.2 Overall Results

Analysis of the overall responses for reporting culture demonstrated that the mean value was 4.440 and the data ranged widely from 2.857 up to 5.000 as shown in Figure 17.

The standard deviation was 0.943 and the median value was 4.429. The mean value for safety culture was 88.8%. This value was higher than the values of Lee et al (2016) or Son et al. (2015). However, as the range of values of the results was broad, reporting culture level should be determined according to the specific details.
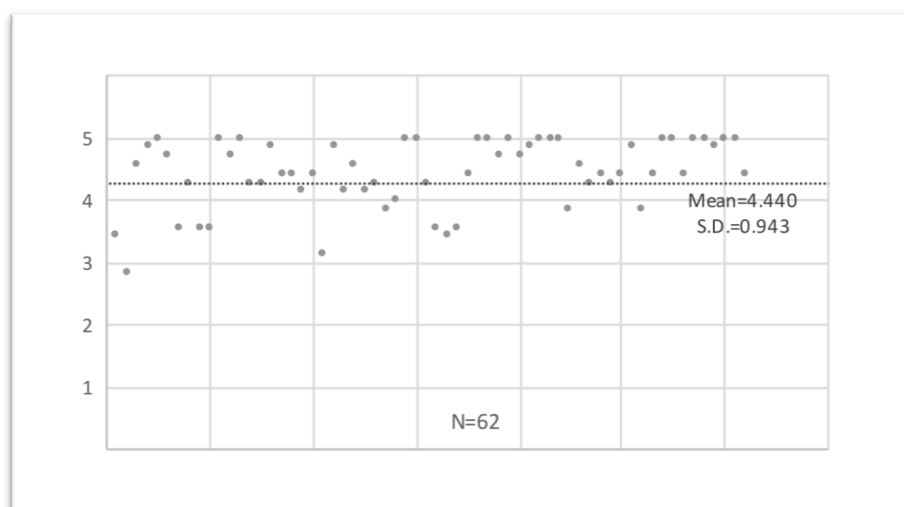
Figure 17. Results of the preliminary survey (The author)

7.1.3.3   Analysis by Items Surveyed

Reporting Scheme for Safety Concerns

The majority of respondents replied that they have a reporting scheme for safety concerns, as shown in Figure 18.

Sixty people out of 62 respondents said they were operating reporting schemes of safety concerns. Among them, 48 people (77.4%) replied that confidentiality was secured.

However, the responses do not reflect the actual situation: reporting schemes of safety concerns, e.g., CIRSs, are not operating well. Many people may be confused between accident reporting systems and incident reporting systems.
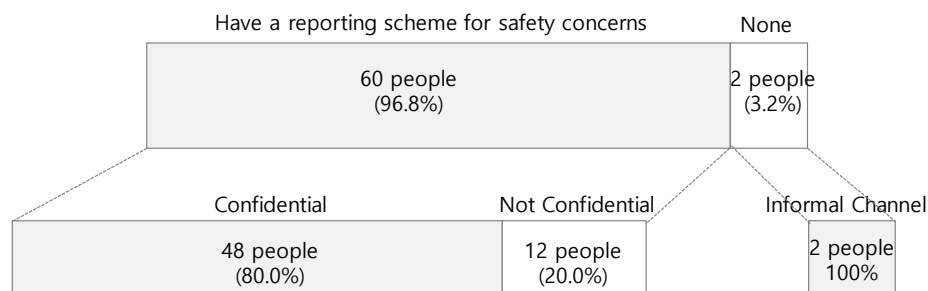
Figure 18. Reporting schemes for safety concerns (The author; n = 62)

Reporting Culture for Safety Concerns

The questionnaire about reporting culture consisted of seven questions, and the survey results are shown in Figure 19. Many of respondents answered positively for all questions except Q9, which was related to blame culture.
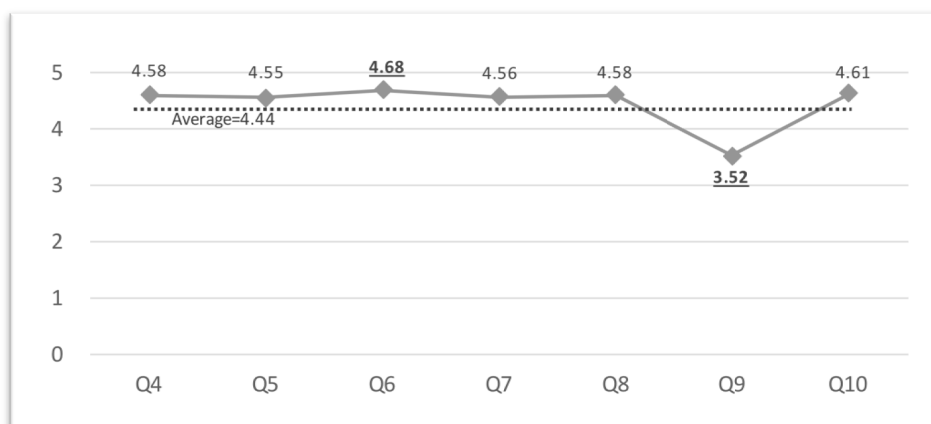
Figure 19. Result of measurement by item (The author; n = 62)

Table 11 shows the results of the measurement by item.

Table 11. Measurement results for reporting culture (The author; n = 62)

Indicator	Question	Response				
		Negative				Positive
		1	2	3	4	5
Learning culture	(Q4) How often do the issues get resolved?			10%	22%	68%
Leadership	(Q5) Are you satisfied with the effectiveness of management in dealing with safety concern?			3%	39%	58%
	(Q6) Do management accept responsibility to deal with the safety concern?			2%	29%	69%
Two-way communication	(Q7) Are staff provided with feedback about the outcome or progress of the reported concerns?		3%	7%	21%	69%
	(Q8) Are the issues tracked from the time that they are raised through to closure?	2%		3%	29%	66%
Attitudes towards blame	(Q9) Are you worried about being punished, if you were report to safety concerns?	19%	11%	10%	18%	42%
	(Q10) Are you willing to report a safety concern, if confidentiality can be secured?	2%	3%	2%	19%	74%

As a result, all items show similar values except Q9, which shows a significant deviation in the results compared to the rest of the items.

According to Q9, about 30% of respondents were very worried (19%) or worried (11%) about being punished when they report safety concerns.

This means that workers have a serious obstacle to reporting safety concerns. Usually, these obstacles are associated with under-reporting, so it can be inferred that the risk of under-reporting is enormous in Korean railway construction sites.

- Issue: Under-reporting exists in railway construction sites in Korea.

Fortunately, however, there was a high willingness for workers to report frankly, as shown from the answer to Q10. The greatest number of people strongly agreed with the question. If a proper reporting channel is prepared, it is certain that people will use it actively.

- Issue: To solve under-reporting, a brand new reporting channel is necessary.

Under-reporting

There were two questions related to under-reporting: one was multiple choice and the other was open-ended.

Firstly, Q11 was a question about how to encourage reporting safety concerns.

In this regard, Figure 20 shows solutions to encourage reporting of safety concerns. A clear and simple reporting procedure was selected most frequently by the respondents, followed by continuous education and confidentiality for the reporter.
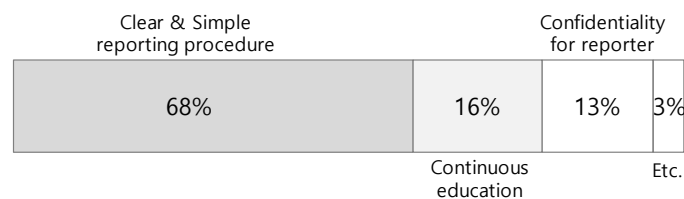
Figure 20. Solutions for under-reporting (The author)

Therefore, clearly defined lists of reportable incidents should be presented.

Indeed, continuous education and confidentiality for reporters were deeply related to a previous study on successful reporting systems (Vincent, et al., 1999).

- Issue: Clearly defined lists of reportable safety issues are necessary;
- Issue: Continuous education should be conducted to staff.

Secondly, Q12 was an open-ended question about the causation of under-reporting. Twenty-five people out of 62 respondents submitted their opinions.

Although this data was qualitative, the author classified it according to type and arranged it in a graph as shown in Figure 21.
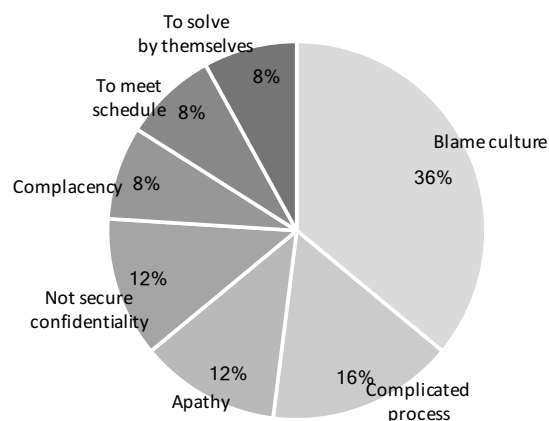
Figure 21. Reasons for under-reporting (The author)

Most people pointed out that blame culture (36%) was the cause of under-reporting.

In addition, a complicated reporting process (16%), unsecured confidentiality (12%) and apathy (12%) also were chosen as main reasons for under-reporting.

- Issue: Blame culture is the most urgent problem that needs to be solved.

The opinions submitted provided a lot of precious information, related to personal inconvenience, institutional absurdities, occupational priorities, etc. besides blame culture.

For example:

"Even if I find a risk and request action, the improvement of it must be done by myself."

"It is urgent to have a concise reporting procedure because the complexity of reporting process and documents cause under-reporting."

"There is a fear of subsequent activities after reporting."

"Due to the tight construction period, general issues are to be resolved by themselves."

"I am afraid that by reporting internal problems, external assessments are discouraging."

"I think it's redundant because it's possible that internal problems can be solved by ourselves."

The results of the preliminary survey showed that there is under-reporting in the Korean railway industry, as seen in other industries. To overcome this, measurements are urgently necessary to improve the blame culture cited as the cause of the under-reporting.

7.1.3.4   Analysis by Position

There were no particular differences among the results for reporting culture for safety concerns analysed by position, as shown in Table 12.

Table 12. Results of measurement by position (The author)

Position	Total	Site manager	Supervisor	Site engineer	Manual worker
Respondents	62 (100%)	16 (25.8%)	9 (14.5%)	36 (58.1%)	1 (1.6%)
Mean value	4.440	4.420	4.444	4.433	5.000

Though the results for manual workers were comparatively higher than other positions, they did not have much effect because there was only one respondent.

Figure 22 shows the results measured by position for each reporting culture item.

The analysis showed that no difference was found for all category items by position, except Q9. The results for Q9 showed a distinct difference according to position. In general, the safety culture of managers is more positive than that of manual workers. However, the opposite results were obtained from Q9.
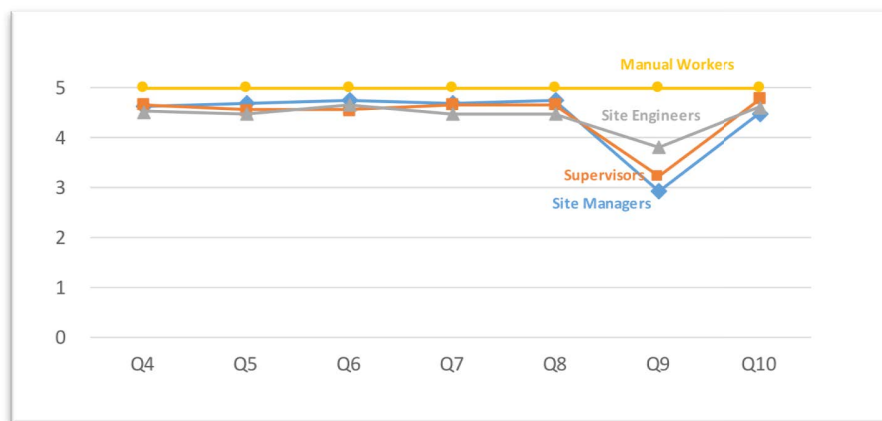
Figure 22. Results of reporting culture by position (The author)

Q9 was intended to measure the fear of being punished when reporting safety concerns. However, in Korea, managers often face punishment related to accidents.

Although it is often just a warning, sometimes it is very sensitive because severe penalties or loss of employment can be applied for severe accidents.

Therefore, the results can be judged to have reflected the reason.

- Issue: Safety awareness of managers is more critical in relation to reporting accidents and safety concerns.

7.1.4 Findings from the Preliminary Questionnaire Survey

The preliminary questionnaire survey was conducted to measure Korean railway engineers' and supervisors' perception of reporting culture.

The survey comprised three items: reporting scheme, reporting of safety concerns and under-reporting.

From the 15 railway construction sites, 62 people participated in the survey.

The results of the preliminary survey showed that:

- Overall results of the survey were very positive, with a mean value 4.440 out of 5.000;

- The possibility of under-reporting was detected;

- Blame culture was cited as the reason for under-reporting, and needs to be solved urgently.

As a result, the author identified that the Korean railway industry needs to adopt new complementary reporting channels apart from the existing reporting systems to overcome under-reporting and blame culture.

Also, the author captured some practical lessons and issues for developing a KCIRS model:

- Clearly defined lists of reportable safety issues are necessary;

- Continuous education of staff should be conducted;

- Safety awareness of managers is more critical in relation to reporting of accidents and safety concerns.

7.2   Main Survey

7.2.1 Purpose

The main questionnaire survey was conducted to identify the safety culture of the railway construction workforce in Korea. Recently, new railway construction, electrification and maintenance works which are conducted near operating railways have increased in Korea.

These types of work are very dangerous because there is not sufficient space to work, and installing safety facilities is very difficult and needs a lot of manpower and equipment. However, if accidents happen in these areas, it seriously affects operation of the railway. To secure the safety of railways, systematic SMSs, sufficient safety facilities and a positive safety culture of employees are crucial.

However, the preliminary questionnaire survey showed that some people were concerned about under-reporting. In Chapter 6.1, the author showed that a safety culture assessment tool was developed only a few years ago, and has only been applied to a limited number of people in the operating companies. Therefore, the author intended to measure safety culture in Korea's railway construction sites, which has not been measured to date. Thus, the author wanted to identify the fundamental perception of safety culture of workers in Korean railway construction sites.

Prior to this survey, the author had identified concerns about the inconvenience of existing reporting systems and under-reporting of safety events. Therefore, the author included open questions about these topics in further research.

Lastly, this survey was intended to review the necessity for an additional reporting channel to complement existing reporting channels.

7.2.2 Main Questionnaire Survey Methods

7.2.2.1   Survey Items

This questionnaire survey included questions on demographics, railway safety culture and under-reporting. The questionnaire was based on the ORR's HMRI Safety Culture Inspection Toolkit (HSE, 2005) and other related literature on safety culture.

The author chose the ORR's toolkit because it is based on scenarios, so the respondents had the advantage of the survey having a familiar approach and using experiences similar to their own.

The questionnaire consisted of 49 questions and most questions were multiple choice apart from one open-ended question about under-reporting.

The author changed the toolkit's interview format to a questionnaire format to survey safety culture through more respondents; all questionnaires were designed to be anonymous to ensure confidentiality.

Demographics

The first section of the questionnaire survey asked respondents to supply eight demographic items. The author intended to use the demographic information in analysing the results. The demographic questions were:

- Gender: male or female;
- Civil status: married or not married;
- Age: 20–29, 20–39, 40–49, 50–59, above 60;
- Education: middle school, high school, university, graduate school;
- Total experience: less than 1 year, 1–5, 6–10, 11–15, 16–20, more than 20 years;
- Railway experience: less than 1 year, 1–5, 6–10, 11–15, 16–20, more than 20 years;
- Position: site manager, supervisor, engineer of contractor, engineer of subcontractor, manual worker;
- Discipline: civil, building, track, electricity, communication, signalling.

Railway Safety Culture

The section on railway safety culture was designed to measure five main indicators with 40 questions: leadership, two-way communication, employee involvement, learning culture and attitude towards blame (HSE, 2005).

Table 13 shows the indicators, questions and assessment criteria.

The 40 questions were based on six scenarios provided by HSE (2005), i.e., safety management, safety concern, change management, transfer of information about shift duties, time-critical and degraded situations and incident management.

To do this, the author made a draft of questions from the list of questions in the ORR's toolkit, then sent the draft questionnaire to three experts in Korea's railway industry for evaluation.

A five-point Likert scale was employed in this research whereby 1 represented 'strongly disagree' and 5 represented 'strongly agree'.

The questionnaire survey was aimed at Korean workers; however, as all materials were written and reviewed in English, the author translated the questionnaire into Korean.

Table 13. Railway safety culture questions (adapted from HSE (2005))

Indicator	Assessment criteria	Questions
Leadership	Management visibility Performance vs. safety management priority Safety-prioritised behaviour	8
Two-way communication	Internal safety concern reporting system Approachable management Active response to feedback Safety information communication system Feedback systems	9
Employee involvement	Employee involvement in safety discussions Employee participation in the change processes	5
Learning culture	Safety culture/climate monitoring Safety concern investigation and mitigation procedure Safety concern log	10
Attitude towards blame	Culture of trust Employee awareness of accountabilities Fault allocation process Disciplinary process Safety accountability	8

A Specific Question for Under-Reporting

The questionnaire survey included an open-ended question related to under-reporting of safety concerns. The author added the question to find out the reasons why people hesitate to report safety concerns.

Respondents were allowed to freely write an answer the question.

7.2.2.2   Survey Targets

The author selected 44 railway construction sites. The target sites, adjacent to operating railways, were chosen randomly from 379 construction sites that hold contracts with KR.

For each site selected, the author selected seven or 10 people for the survey according to the site magnitude. Finally, 371 people were selected as target staff.

Table 14 shows the target sites and staff.

Table 14. Targets of the main questionnaire survey (The author)

Target	Total	Civil	Track	Building	Signal	Communi-cation	Electricity	Improve-ment
Sites	44	19	3	2	2	3	5	10
Staff	371	190	21	20	14	21	35	70

7.2.2.3   Survey Administration

The questionnaire survey was conducted between 3rd and 5th August 2016.

The 44 target sites were chosen randomly among the 379 construction sites that hold contracts with KR. All selected sites were located adjacent to operating railways.

Respondents were chosen randomly at the selected sites.

Prior to conducting the questionnaire survey, the author explained the overview of the questionnaire survey and asked for participation for each site by phone calls.

The questionnaires were distributed through the internet to 371 engineers, supervisors and managers who worked on the 44 different railway construction sites.

As all sites were located in Korea, all questionnaires were created, distributed and collected through a Google Docs Questionnaire form. The questionnaire is included in Chapter 12 (Appendix).

After 2 days, the author closed the survey after confirming the intention for additional participations.

7.2.2.4   Survey Analysis

The author adopted IBM SPSS Statistics (v. 24) and Microsoft Excel to calculate the results of the questionnaire survey. The results data was exported from Google Docs Questionnaire into IBM SPSS Statistics and Microsoft Excel.

Analysis of the results was conducted in three ways. Firstly, the author analysed the results of the survey according to the safety culture indicators. The author extracted the issues and lessons through analysing the results on the basis of each assessment criterion of indicators.

Secondly, the author conducted the analysis according to the characteristics of respondents. Using the demographic information included in the survey, the author conducted the analysis according to position, experience and discipline.

Lastly, an open-ended question about under-reporting of safety concerns was analysed separately.

7.2.3 Results

7.2.3.1   Respondents

The questionnaire survey was conducted between 3rd and 5th August 2016.

Out of 371 people targeted, 224 people participated in the questionnaire survey, resulting in a valid response rate of 60.4%.

Table 15 shows the demographic information of the respondents.

The majority of respondents were male (98.7%), and many respondents were married (79.0%).

The largest group was their 40s (35.7%) followed by those in their 50s (26.8%); 16 people above 60 years old participated (7.1%).

The level of educational attainment among the respondents was quite high. Many of the respondents had graduated from university (71.0%).

Many of the respondents (34.8%) had more than 20 years' experience in the construction industry. However, the amount of railway experience respondents had was less than their construction experience. The majority of respondents had railway construction experience of only 1 to 5 years (38.8%). This shows that as the railway industry has recently become active, the number of new workers involved in the railway industry has increased.

The position of respondents was evenly distributed, but the proportions of contractors' engineers and manual workers were slightly higher (respectively 26.3%).

Many of the respondents were working in the civil discipline (64.7%), and the remainder were distributed in the rest of the disciplines.

Table 15. Demographics of the respondents (The author)

Gender	Male			Female		
	221 (98.7%)			3 (1.3%)		
Civil status	**Married**			**Not married**		
	177 (79.0%)			47 (21%)		
Education	**Middle school**		**High school**	**University**		**Graduate school**
	8 (3.6%)		46 (20.5%)	159 (71.0%)		11 (4.9%)
Age (years)	**20–29**	**30–39**	**40–49**	**50–59**		**above 60**
	18 (8.0%)	46 (20.5%)	84 (35.7%)	60 (26.8%)		16 (7.1%)
Position	**Site manager**	**Supervisor**	**Engineer of contractor**	**Engineer of subcontractor**		**Manual worker**
	53 (23.7%)	29 (12.9%)	59 (26.3%)	24 (10.7%)		59 (26.3%)
Total experience	**Less than 1 year**	**1–5 years**	**6–10 years**	**11–15 years**	**16–20 years**	**More than 20 years**
	9 (4.0%)	27 (12.1%)	32 (14.3%)	39 (17.4%)	39 (17.4%)	78 (34.8%)
Railway experience	**Less than 1 year**	**1–5 years**	**6–10 years**	**11–15 years**	**16–20 years**	**More than 20 years**
	39 (17.4%)	87 (38.8%)	44 (19.6%)	20 (8.9%)	15 (6.7%)	19 (8.5%)
Discipline	**Civil**	**Building**	**Track**	**Electricity**	**Communication**	**Signalling**
	145 (64.7%)	11 (4.9%)	11 (4.9%)	23 (10.3%)	20 (8.9%)	14 (6.3%)

7.2.3.2   Overall Results

The results of the questionnaire survey were analysed with IBM SPSS Statistics (v. 24) and Microsoft Excel. As a result of reliability analysis using IBM SPSS, the Cronbach's alpha of 'attitude towards blame' was calculated at 0.552, which was below the reliability criteria of 0.600. Thus, the author excluded Q42 to ensure reliability. The results of re-analysis showed that all indicators had values above 0.600 for Cronbach's alpha, which meant that the questionnaire surveyed reliably. Therefore, this analysis of results is based on the 39 questions.

Overall, the survey results showed that many respondents responded positively to the survey. As shown in Table 16, the mean value of the 39 questions reached 4.413 out of 5.000, a high value. This means that people in Korea's railway construction sites have a very positive safety culture. If the score is converted to a percentage, it is very high at 88.2%. The value is much higher than that for Korea's railway safety culture measured by KTSA (81.7% in 2015).

Table 16. Overall results of the questionnaire survey (The author)

Indicator	Questions	Mean	S.D.	Cronbach's α
Leadership	8	4.354*	0.960	0.755
Two-way communication	9	4.526	0.738	0.835
Employee involvement	5	4.493	0.675	0.896
Learning culture	10	4.483	0.770	0.756
Attitude towards blame	7	4.179*	0.987	0.666
Total	**39**	**4.413**	**0.846**	

n = 224; * below the overall mean value

However, there were many differences among the result values for the five safety culture indicators.

Most respondents had positively rated 'two-way communication' (mean = 4.526, S.D. = 0.738), 'employee involvement' (mean = 4.493, S.D. = 0.675) and 'learning culture' (mean = 4.483, S.D. = 0.770).

Meanwhile, the indicators of 'attitude towards blame' (mean = 4.179, S.D. = 0.987) and 'leadership' (mean = 4.354, S.D. = 0.960) had a comparatively low rating.

Of the two indicators, the former is a crucial factor for making an effective reporting system.

The value for 'attitude towards blame' was not much lower; however it is necessary to respond to it because it was too low compared to other indicators. In particular, because blame culture affects reporting culture considerably, it is necessary to take active measures.

Figure 23 shows the distribution of the entire survey data for 224 people. As shown in Figure 23, it has been found that the distribution of respondents ranges widely, from 3.205 to 5.000. Many of the respondents' answers were located below the mean value for safety culture. Thus, detailed analysis is required for each indicator.
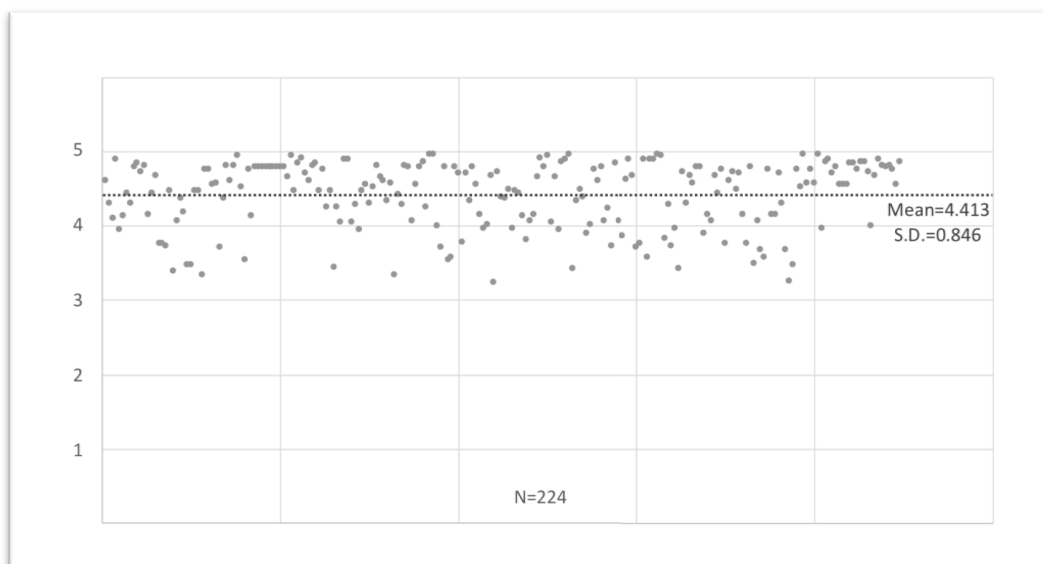
Figure 23. Distribution of the respondents' answers (The author)

7.2.3.3   Analysis by Indicators of Safety Culture

Leadership

'Leadership' is the indicator for measurement of management attitude towards safety. It measures whether management have the belief that safety is always the best value and takes precedence over performance (HSE, 2005).

Table 17 shows the results for leadership.

Table 17. Results for leadership (The author)

Assessment criteria	Questions	Mean	Standard deviation
Management visibility	5	4.601**	0.604
Performance vs. safety management priority	2	3.685*	1.396
Safety priorities behaviour	1	4.455	0.675
Leadership	**8**	**4.354**	**0.960**

n = 224; * lowest value; ** highest value

The mean value for leadership was 4.354, lower than the overall mean value of 4.413. Among the three assessment criteria for leadership, 'performance vs. safety management priority' had the lowest mean value of 3.685, the lowest value among all assessment criteria.

This shows that managers do not have the belief that they consider safety as a paramount. Normally, they have tended to prioritise schedule or cost rather than safety in railway construction sites.

HSE (2005) recommended that management should repeatedly make sure employees consider safety as the first priority in order to improve the indicator of leadership.

The indicator directly influences the formation of a positive safety culture in employees; therefore, it is very important and needs to be improved as soon as possible.

- Issue: Management must make sure to put top priority on safety.

Two-Way Communication

'Two-way communication' is the indicator of whether organisations have channels through which all employees can be involved in safety-related matters, and whether the flow of information is successful in both directions.

Table 18 shows the results for two-way communication.

Table 18. Results for two-way communication (The author)

Assessment criteria	Questions	Mean	Standard deviation
Active response to feedback	1	4.388*	0.731
Approachable management	2	4.632	0.599
Feedback systems	1	4.395	0.975
Internal safety concern reporting system	2	4.681**	0.582
Safety information communication system	2	4.464	0.688
Two-way communication	**8**	**4.526**	**0.738**

n = 224; * lowest value; ** highest value

As a result, the mean value for two-way communication was 4.526, higher than the overall mean value of 4.413. The indicator had the highest value among the five safety culture indicators.

However, there was something noticeable about the detailed assessment criteria. The two assessment criteria related to feedback had lower values than the overall mean value. If feedback activities are not sufficient, employees are disappointed and become less active in reporting safety concerns. The criteria affect the reporting rates of accidents and safety concerns.

To improve these factors, it is necessary to establish specific feedback channels and check them periodically.

- Issue: Feedback channels must be strengthened.

Employee Involvement

This assessment criterion measures whether all employees in the organisation can participate in the process of making important decisions, and whether actual participation and feedback are successful.

Table 19 shows the results for employee involvement.

Table 19. Results for employee involvement (The author)

Assessment criteria	Questions	Mean	Standard deviation
Employee involvement in safety discussions	1	4.357*	0.768
Employee participation in change processes	4	4.527**	0.646
Employment involvement	**5**	**4.493**	**0.675**

n = 224; * lowest value; ** highest value

The mean value was 4.493, higher than the overall mean value of 4.413, and the standard deviation was 0.675.

Between the two assessment criteria, the value for 'employee involvement in safety discussions' was below average. This indicates that although safety activities should be conducted by all constituents, they are just led by some managers.

As shown in the results of interviews, in Korea, normal workers do not want to participate in safety activities, and they tend to be very negative. Many workers are not involved in safety activities, other than requiring safety gear for themselves.

To improve this, more opportunities should be created for employees to engage in safety activities.

- Issue: Safety discussions must be facilitated to engage more people.

Learning Culture

This indicator is related to activities from which lessons are learned about safety concerns and which prevent future accidents through the lessons, e.g., finding problems, establishing measures and monitoring the process. The indicator measures whether the learning activities are conducted well in the whole hierarchical structure of organisations.

The results for learning culture are shown in Table 20.

Table 20. Results for the learning culture (The author)

Assessment criteria	Questions	Mean	Standard deviation
Incident investigation system	6	4.479	0.811
Safety concern investigation and mitigation procedure	2	4.529**	0.648
Safety concern log	1	4.496	0.689
Safety culture/climate monitoring	1	4.406*	0.815
Learning culture	**10**	**4.483**	**0.770**

n = 224; * lowest value; ** highest value

The mean value for learning culture was 4.483, somewhat higher than the overall mean value of 4.413. Both assessment criteria had good values, but that for 'safety culture/climate monitoring' was slightly lower than the overall mean value.

Actually, in Korea, periodic measurements of safety culture were not conducted, and not a lot of people were aware of safety culture.

Although the values for learning culture were slightly higher than the overall mean value, further improvement is necessary.

Periodic measurement of safety culture is one of the critical processes for identifying the vulnerability of safety systems and to achieve continuous improvement of safety.

Therefore, measurements of safety culture should be conducted on a regular basis.

- Issue: Measurements of safety culture are not conducted regularly.

Attitude Towards Blame

It is important to recognise that the ultimate responsibility for accidents is held by the organisation. This indicator measures how well employees understand that investigations of accidents or incidents are for learning lessons not for punishment.

The results for attitude towards blame are shown in Table 21.

Table 21. Results for attitude towards blame (The author)

Assessment criteria	Questions	Mean	Standard deviation
Culture of trust	1	4.531**	0.676
Disciplinary process	2	4.150	1.086
Employee awareness of accountabilities	1	4.509	0.621
Fault allocation process	2	3.710*	1.085
Safety accountability	1	4.491	0.715
Attitude towards blame	**7**	**4.179**	**0.987**

n = 224; * lowest value; ** highest value

The mean value for attitude towards blame was 4.179, quite a lot lower than the overall mean value. Among the five assessment criteria, 'disciplinary process' and 'fault allocation process' had very low values which were much lower than the overall mean value.

In particular, the value for 'fault allocation process' was 3.710, the second lowest value among the 20 assessment criteria.

Normally, people are extremely worried about being punished for causing accidents on sites. The root causes of accidents should be sought at the organisational level. If it is sought at the individual level, safety culture could be seriously affected.

Therefore, it is important to construct an appropriate and just culture in organisations.

- Issue: Blaming individuals hinders communication and causes a delay in reporting of safety events.

7.2.3.4   *Analysis by Characteristics of Respondents*

This questionnaire survey contained eight demographic questions. The information obtained was analysed by position and experience.

Analysis by Position

This analysis was conducted to identify the various safety subculture in hierarchical organisations. There were five types of position, and the results are shown in Table 22.

Table 22. Analysis of safety culture by position (The author)

Position	Questions	Mean	Standard deviation
Manual workers	59	4.323*	0.877
Subcontractors' site engineers	24	4.402	0.794
Contractors' site engineers	59	4.448	0.832
Supervisors	29	4.420	0.831
Site managers	53	4.477**	0.850
Total	**224**	**4.413**	**0.846**

n = 224; * lowest value; ** highest value

The mean value for manual workers was 4.323, quite a low value. The rest of the job positions showed similar values for safety culture.

Clearly, there were gaps between managers and manual workers in terms of safety culture.

Cooper (2000) and Harvey et al. (2002) mentioned subculture caused by functional groups, hierarchical levels, organisational roles, etc.

Although the differences between positions were not significant, it is clear that manual workers had a more negative safety culture than managers.

In order to overcome the gaps between different positions for safety culture, and to construct a positive safety culture, strengthening relationship between staff and management, improving level of trust within the hierarchy and promoting greater employee ownership in safety issues are necessary (Clarke, 1998).

Above all, there is a need to improve communication between positions.

- Issue: There are gaps in safety culture between managers and manual workers.

Analysis by Experience

The analysis by experience was divided into two types, i.e., total experience and railway experience. As the railway industry is specific area, the author wanted to identify the difference between them.

The survey showed that many respondents had more than 20 years of total experience (34.8%), but railway experience was shorter than total experience. Many people had 1 to 5 years' railway experience. Table 23 shows the results for safety culture by experience.

Table 23. Analysis of safety culture by experience (the author)

Experience	Overall construction			Railway construction		
	People	**Mean**	**S.D.**	**People**	**Mean**	**S.D.**
Less than 1 year	9	4.316*	0.852	39	4.339*	0.843
1–5 years	27	4.436	0.770	87	4.405	0.845
6–10 years	32	4.393	0.873	44	4.407	0.854
11–15 years	39	4.414	0.863	20	4.476	0.745
16–20 years	39	4.330	0.875	15	4.631**	0.741
20 years or more	78	4.466**	0.832	19	4.381	0.973
Total	**224**	**4.413**	**0.846**	**224**	**4.413**	**0.846**

n = 224; * lowest value; ** highest value

In both cases, as experience increases, it has a positive effect on safety culture. This is more clearly identified when analysed by graph, as shown in Figure 24 and Figure 25.
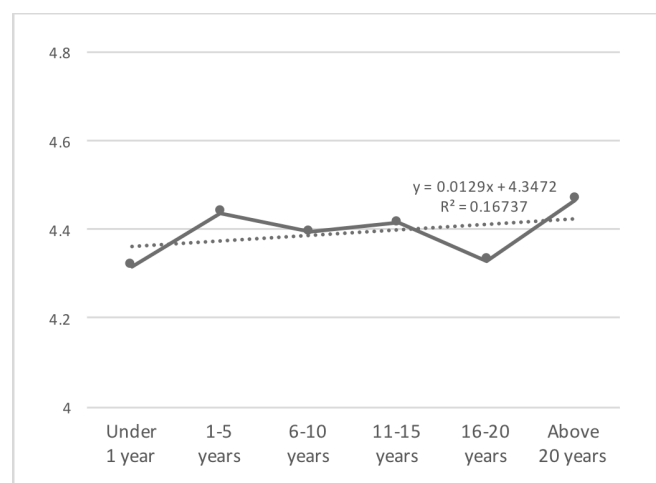
Figure 24. Analysis of safety culture by total experience (The author)
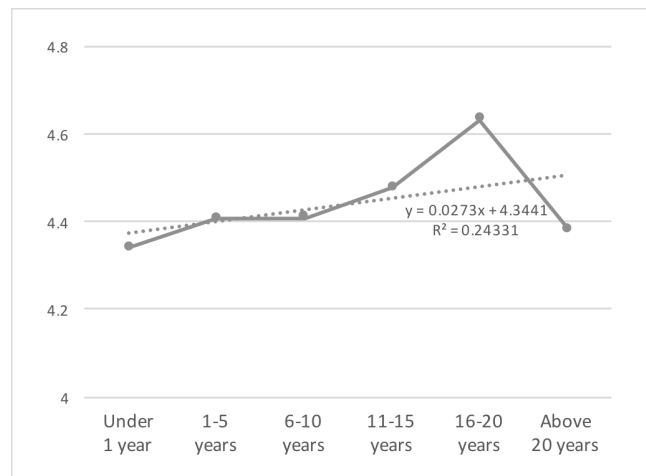
Figure 25. Analysis of safety culture by railway experience (The author)

In both cases, employees with less than a year's experience were the most negative about safety culture. It is natural to take a critical stance against a new environment. However, as workers who are not familiar with their surroundings often experience accidents, it is important to manage them with special attention.

The most positive attitudes to safety culture were seen for those with more than 20 years of total experience and 16 to 20 years of railway experience.

The analysis shows that, although values fluctuated and a causal relationship was not obvious, it is clear that the less experienced the worker, the less positive his or her attitude to safety culture.

- Issue: A safety culture education programme is necessary for less experienced people.

7.2.3.5   Open-Ended Question

At the end of the questionnaire survey, an open-ended question (Q49) asked respondents why under-reporting happens.

This question is related to Q37 (incidents are sometimes not reported in line with the prescribed processes). The response value for of Q37 (4.348) was also not good, lower than the overall mean value (4.416). Although this type of question requires qualitative replies, the author analysed the results on a quantitative basis.

All 85 opinions were submitted, and the answers were categorised by type of answer except for 22 opinions unrelated to the question, as shown Figure 26.
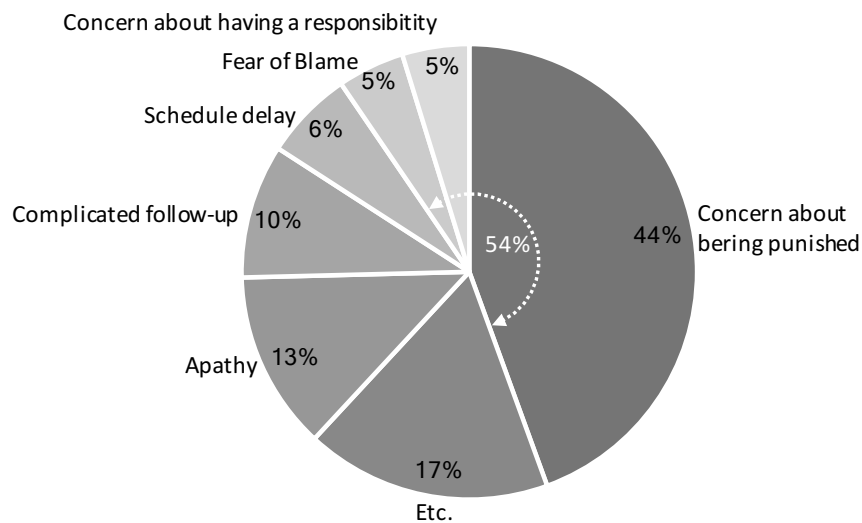
Figure 26. Reasons for under-reporting (The author)

Many opinions were about the fear of being punished. More than half of respondents said that under-reporting happened because they were afraid of being punished (54%), e.g.:

> *"After reporting safety concerns, I think I or my company will be penalised for dealing with it."*

> *"I am afraid that my site will be harmed related to my reporting, so I do not report it if I think I can handle it"*

> *"Under-reporting happens to avoid the burden of punishment and the preparation of various materials that is necessary after reporting."*

> *"Because it affects the company's future contracts."*

> *"I feel I am going to be penalised for being a whistle-blower."*

After concern about being punished, apathy (13%) and complicated follow-up (10%) were cited most frequently.

Under-reporting is a common occurrence in many industries and countries. It is very difficult to solve, and it is even difficult to grasp the magnitude of under-reporting.

However, if it is neglected, there is a serious risk to safety and safety culture, and thus it is necessary to take proactive measures.

Therefore, it is necessary to introduce a CIRS that differentiates existing reporting channels, to determine the most efficient tool to prevent under-reporting.

- Issue: Fear of being punished negatively affects workers' reporting of safety events.

7.2.4 Findings from the Main Questionnaire Survey

The main questionnaire survey was conducted to measure the safety culture in Korea's railway industry.

The survey consisted of 49 questions categorised into three parts, demographics, safety culture and under-reporting.

From the 44 railway construction sites near operating railways, 224 people participated in the survey. The results of the survey are shown below:

- Overall results were very positive, with a mean value of 4.413 out of 5.000;
- 'Leadership' and 'attitude towards blame' were identified as deficiencies;
- There was a gap in safety culture between managers and manual workers;
- Fear of being punished negatively affected reporting of safety events.

The analysis shows that, although Korea's railway construction sites had good results for the safety culture survey, more improvement is necessary because there was a clear concern about under-reporting. Also, the author identified some practical lessons and issues:

- Management must ensure safety is a top priority;
- Feedback channels should be strengthened;
- Safety discussions must be facilitated to engage more people;
- Safety culture must be measured regularly;
- Blaming individuals hinders communication and causes a delay in reporting of safety events;
- A safety culture education program is necessary for less experienced people.

7.3 Issues for Model Development

The questionnaire surveys were conducted to identify the real perception of safety culture on Korean railway construction sites. The survey was conducted in two phases.

For the preliminary survey, the results showed that Korean railway construction workers have a very positive safety culture, with a mean value of 4.440 out of 5.000. However, the author identified the possibility of under-reporting caused by blame culture.

For the main survey, the results again showed that Korean railway construction workers have a very positive safety culture, with 4.413 out of 5.000. But the author detected a gap in safety

culture between managers and manual workers. Also, many workers suffered from fear of being punished, which had a negatively effect on reporting of safety events.

Through the questionnaire surveys, the author identified some practical lessons and issues for developing a CIRS model:

- Clearly defined lists of reportable safety issues are necessary;
- Feedback channels must be strengthened;
- A safety culture education programme is necessary;
- Safety culture must be measured regularly;
- Safety discussions must be facilitated to engage more people.

8   Interviews

Prior to establishing the CIRS model, interviews were conducted in order to create a more efficient CIRS model by supplementing the research findings from literature reviews, case studies and questionnaire surveys. The interviews were conducted in two categories: people working on railway construction sites in Korea and people working at CIRAS in the UK.

8.1   People in Korea's Railway Industry

8.1.1 Purpose

The purpose of this sort of interview was to evaluate the safety culture and to identify safety issues in Korea's railway industry. Although the author conducted a quantitative evaluation of safety culture from on-site supervisors to manual workers through other questionnaire surveys, the practical purpose of this sort of interview was to conduct an exhaustive assessment to identify underlying issues not identified in the questionnaire surveys. This interview was not intended to measure the level of safety culture of Korea's railway industry, but intended to find out the real issues related to safety culture on each site.

8.1.2 Design of Interviews

8.1.2.1   Methods

The Korean railway industry, to date, has not produced a tool that can be used for interviews to measure the safety culture; this interview was based on the HSE Safety Culture Toolkit. The toolkit, a safety culture measurement tool using interviews, was developed to measure the safety culture in the British railway industry by ORR (HSE, 2005). There are many ways to measure safety culture, and many of them use the method of interviewing. However, the author conducted these interviews with the ORR's tools to facilitate comparison with the results of the questionnaire survey and ensure consistency with the results of the questionnaire surveys.

The interviews created for this research were based on the ORR assessment tool and consist of five indicators that make up safety culture, i.e., leadership, two-way communication, employee involvement, learning culture and attitude towards blame (HSE, 2005).

The author created a standardised set of questions for interviews to maintain consistency throughout all interviews.

The interviews were conducted by telephone with staff working on Korean railway construction sites. All interviews were conducted in Korean. The results of the interview were

written up and confirmed by the interviewee. The results approved by the interviewee were translated into English and then utilised in this thesis.

In this process, all records related to interviewees were kept anonymously, ensuring that the identity of all interviewees was kept confidential.

8.1.2.2   Selection of Interviewees

The railway construction sites were selected following the step to represent typical railway construction sites in Korea.

The author selected a conventional railway project and an early-phase project to identify recent trends in safety culture.

After selecting one project to identify realistic safety culture, finally three of the seven sites included in the project were chosen randomly. The sites selected are shown in Table 24.

Table 24. Sites selected for interviews (The author)

Site A	Site B
- Area: civil works - Contract price: £52 million - Progress: 0.48% - Length of railway: 11.90 km - Structures: 5 bridges, 4 tunnels and 2 stations	- Area: civil works - Contract price: £115 million - Progress: 19.9% - Length of railway: 8.12 km - Structures: 2 tunnels and 1 bridge
Site C	**Project 1**
- Area: civil works - Contract price: £78 million - Progress: 0.6% - Length of railway: 12.79 km - Structures: 2 tunnels, 1 station and 5 bridges	Sites A, B and C are included in Project 1.

Interviews were conducted for each of the three selected sites. For each site, three people, i.e., site manager, supervisor and safety manager, were interviewed, and the project manager of the owners was also interviewed.

Finally, to understand the safety culture throughout the project, 10 people were selected, including the project manager of the overall project.

Interviews were conducted during the period of 5th to 7th July 2017 and interview results were finalised by being reviewed by interviewees between 17th and 21st July 2017.

8.1.2.3 Development of the Question Set

The development of the interview question set for this research was based on the questions presented in ORR's safety culture toolkit (HSE, 2005). The questions are designed to measure five safety culture indicators, i.e., leadership, two-way communication, employee involvement, learning culture and attitude towards blame. These indicators are assessed through 22 different assessment criteria. The author prepared a question list that represents the corresponding criteria, as shown in Table 25.

These selected questions were used as a standard question set for consistent interviews and were applied equally to all interviewees.

Table 25. Question set for interviews (adapted from HSE (2005))

Indicator	Assessment criteria	Questions
Leadership	Management visibility	Is the safety management system established? Do the managers have an interest in this? Are the managers performing a good safety inspection?
	Safety-prioritised behaviour	Do you think safety is paramount even if you have a serious situation such as being behind schedule or poor quality? Is it possible for employees to report without regard to cost of safety?
	Performance vs. safety management priority	Do managers have clear views that safety is paramount? Are there sufficient costs associated with safety?
Two-way communication	Internal safety concern reporting system	Is there a framework for reporting safety concerns? Does it work well? Any confusion during operation?
	Approachable management	Do you have a chance to meet the manager regarding safety concern reporting? Do the managers ask the staff if there are any safety concerns?
	Active response to feedback	Is there a good communication system with regard to changes and employees receiving feedback quickly?
	Safety information communication system	Is safety-related information communicated well at the start of the shift or whenever there is a handover of duties? Do you think these processes are effective?

Indicator	Assessment criteria	Questions
Two-way communication	Comprehension of safety information	Are employees actively accessing or requesting safety information? Do employees or employers have all the safety information needed to work?
	Feedback systems	Is there a strategy to share information from accident investigations?
Employee involvement	Employee involvement in safety discussions	Is there a way for employees to participate in safety management? (staff excluding Safety Manager)
	Employee participation in the change processes	Does your company have procedures for managing changes? Do you have a system to communicate with others when changes occur?
	Employee training about the change	Is your company aware of the need for training when changes occur? And is your company doing training accordingly?
	Employee motivation	Are employees reporting voluntarily in the process of change? Are you positive about change?
Learning culture	Safety culture/climate monitoring	Does your company measure safety culture periodically?
	Safety concern investigation and mitigation procedure	Are reported items fully investigated?
	Safety concerns log	Is safety concern spread to employees? Is a similar concern processed well if similar concerns occur?
	Incident investigation system	Is there a thorough investigation and implementation of the measures for root causes of accidents?
Attitude towards blame	Culture of trust	Are safety concerns constantly reported and addressed? Does the manager handle safety concerns when safety concerns are identified?
	Employee awareness of accountabilities	Are all employees aware of safety responsibilities? Is this checked periodically?
	Safety accountability	Do managers take charge of safety first and take responsibility according to their results? Are all staff and manual workers fully aware of their responsibilities and obligations in emergency situations?
	Fault allocation process	Why do you investigate for accidents? To prevent future accidents or punishment of those involved? Is there any punishment or blame on the person involved prior to identifying the root cause?
	Disciplinary process	Is the process clearly divided according to the degree of error? Does the degree of disposal change every time?

Each of these questions was applied in the interviews to address the six activities and issues. Interviewees were presented with scenarios that are common in the field to help them understand.

The categories of scenarios which were used in the interviews are (HSE, 2005):

- Safety management;

- Safety concerns;

- Change management;

- Transfer of information about shift duties;

- Time-critical and degraded situations;

- Incident management.

These scenarios are aligned with ORR's scenarios in the safety culture toolkit. However, the author presented specific examples to the interviewees, citing situations that are specific to railway construction sites in Korea. The Scenarios is included in Chapter 12 (Appendix).

8.1.2.4   Data Analysis

All of the results of the interviews were written according to the scenario. However, personal information was not recorded at all to secure confidentiality of the interviewees. Therefore, data was collected and analysed, excluding personal information, i.e., age, education, experience, etc. The results of the scenario-based interviews were organised in line with safety indicators for analysis purposes; an assessment of safety culture was conducted and analysed according to the definition of the 22 assessment criteria. The analysis results were grouped by safety culture indicator.

In addition, analysis of the safety culture by job role was conducted, and the results of the questionnaire surveys and the interviews compared. Further analysis of interview results is presented in Chapter 8.1.3.

8.1.3 Results

The interview results were analysed according to the indicators of safety culture and position of interviewee. The safety culture of Korean railway construction sites was generally found to be positive, but some deficiencies were found.

The intention was to analyse the interview results based on the problems mentioned.

8.1.3.1   Analysis by Indicator

Safety Leadership

All interviewees said that managers were implementing various initiatives to promote safety level, and managers were clearly aware of their role and responsibility for safety. It was certain that managers had a positive safety culture overall.

- All site managers clearly knew that they were the responsible person for safety management on the sites and had a sense of responsibility;

- All site managers conducted safety tours within sites twice every day and ordered remedy of deficiencies;

- It can be positively evaluated that most field staff stated that safety is a top priority. However, the project manager felt that cost had a higher priority than safety on the sites. This is because project manager takes a more critical position on safety than site managers;

- A positive note was found in that managers are often encouraged to implement costly safety measures, e.g., additional safety facilities;

- The project manager for the whole project was more critical on safety issues, thinking that site managers place significant emphasis on project cost rather than safety.

Two-Way Communication

Slightly vulnerable areas were found relating to the indicator of two-way communication. In particular, many interviewees had difficulty in reporting safety concerns and communicating safety information with managers or other people.

- Most safety information was delivered in the course of safety training, i.e., one-way communication, and some people felt inadequate to build a framework for two-way communication;

- Most managers were asking for active reporting of safety-related information by frontline workers, but there were not many reports from frontline workers;

- Some procedures for ensuring that the necessary safety information has been communicated were unsystematic;

- In some cases, e.g., shift duties, communication of safety information is not structured well and it was sometimes impossible to confirm whether it had been delivered or not because it was only verbally communicated;

- There were some procedures for reporting safety concerns, but there were few safety concerns reported.

There was a higher chance of preventing future accidents through investigation of safety concerns. In order not to miss such good opportunities, efficient reporting systems are necessary to conduct proactive excavation, reporting and investigation of safety concerns.

- Issue: Insufficient systems to report safety concerns.

Sometimes, information exchange procedures for safety were unclear even when accurate information was needed, and the verification procedure sometimes failed.

- Issue: Unsystematic procedures for delivering and verification of safety information.

Employee Involvement

Effective involvement of employees is crucial, since safety-related information should be communicated appropriately to managers who need to make appropriate decisions at the time of need.

- Most employees had a lot of interest in safety, and managers encourage active participation by employees;
- There was a lack of sufficient workers' voluntary participation on various sites;
- Workers took corrective actions against points but they were not actively involved in other matters except those directly related to the safety of the individual, e.g., safety gear. Site managers expressed concern about this;
- Even though safety information was systematically managed by contractors and subcontractors, it was not clear that the system delivers safety information to field workers.

Even though employee involvement is crucial in safety systems, there was lack of voluntary participation of frontline staff on many sites.

- Issue: Lack of voluntary participation by workers.

Existence of a Learning Organisation

Each site conducted various safety education programmes in accordance with relevant legislation and rules, and a lot of safety relevant information was delivered to staff through the programme well. When a safety event was reported, the investigation identified the root

cause and the results were widely shared to prevent future accidents. However, a problem was found in that some safety concerns were not reported.

- At many sites, the concept of safety culture was not yet established and measurement of safety culture was not conducted at most sites;

- Safety-related information was communicated through meetings and documents etc.; however, most safety information was communicated to workers through a safety education programme;

- Although most sites had a system for learning lessons through investigation of safety concerns, the safety concerns were not often reported so the opportunity for learning was limited;

- Although the system for investigating accidents was well-equipped, it is necessary to better understand and utilise experience and knowledge acquired through investigations.

It was identified that measurement of safety culture had not been conducted. As measurement of safety culture helps to obtain a more comprehensive understanding for safety culture, periodic measurements of safety culture are advisable. However, even the managers had seen very low levels of awareness about the need for measurement of safety culture.

- Issue: Lack of awareness and measuring of safety culture.

Attitude Towards Blame

As a blame culture prevents workers from reporting safety events, and thus hinders learning from past safety events and has a negative impact on safety culture, the management of blame culture is very important. Some workers were very afraid of the punishment involved in safety events. Because of this, it was understood that safety concerns were not reported properly.

- Managers and workers were clearly cognisant of their responsibility for safety;

- The investigation of and problem-solving system for safety concerns was sometimes unclear, and reporting of safety concerns was not properly implemented. In many cases, these safety concerns were considered to be part of the daily routine and the fear of being punished related to safety concerns prevented people from reporting them;

- Most workers had a positive perception that the purpose of accident investigation is not to punish but to identify the root cause;

- Most of the criteria for personal punishment by accident were clearly established but the measure was so strong that many workers tended to be very fearful. These fears could lead to under-reporting of accidents, thus quick resolution is needed.

Most staff were well aware of the procedures and reporting targets. However, there was ample probability that the fear of severe punishment involved with an accident would lead to under-reporting of accidents.

- Issue: Fear of severe punishments for individuals involved in accidents.

8.1.3.2   *Analysis by Job Role*

The interviews were conducted for four positions, i.e., supervisor, site manager, safety manager and project manager. They were all aware of the importance of safety and possessed adequate knowledge of the SMS and operation. Regarding measurement of safety culture and reporting of safety concerns, every interviewee felt that improvements were needed. Analysis of results is shown below.

Supervisors

Generally, the supervisors had positive attitudes to and extensive knowledge of the SMS.

The results are similar to the results of the questionnaire surveys, in that supervisors have the most positive position on safety. However, the author found the following insufficient aspects:

- The supervisors were not familiar with the concept of safety culture and measurement of safety culture;
- Many supervisors worried that safety concerns were not reported properly.

Site Managers

Overall, the site managers had a relatively positive safety culture and had extensive safety knowledge, but they were relatively critical in comparison to other site positions. They were believed to be performing well in the organisation and in operation of overall SMS. However, as a legal liability for safety, they need improvement as follows:

- Some sites lack awareness of the concept and measurement of safety culture;
- Believed that safety work was being carried out only by some staff, so demanded that all staff should work responsibly on safety works;
- Believed that active reporting was necessary for safety concerns, but did not think it was well operated.

Safety Managers

As practical people managing safety affairs, they had a positive safety culture overall. However, they provided the following points that required systematic supplementation:

- More safety facilities for workers are needed. If necessary, safety facilities should be installed even if at a higher level than the legal standard, based on on-site judgment;

- Improvements are required in practical areas, including simplified safety-related documents;

- As with other positions, there was a relatively low perception of safety culture.

Project Manager

The project manager had a more critical stance on the safety culture of the sites. The person wanted to extend site safety information to the project manager and hoped that workers at the sites would change more actively with regard to safety works. Although safety systems had improved more than ever before, the project manager thought that there was plenty more room for advancement.

- The project manager was not familiar with the concept and measurement of safety culture;

- The project manager believed that more than 30% of safety concerns had not been reported, and that important safety concerns must be reported to project managers;

- The manager felt that the safety consciousness of individuals in the sites was still insufficient and further improvement was needed;

- The manager believed that communication of safety information at the sites was somewhat perfunctory, and in particular was asking for more active sharing of safety information at the sites;

- The manager believed there was a problem with the safety consciousness of subcontractors.

8.1.4 Findings from Interviews in Korea

The purpose of this sort of interview was to evaluate the safety culture and to identify safety issues in Korea's railway industry.

As a result of the interviews, it was found that there is a fairly positive safety culture on Korean railway construction sites. People in every position were clearly aware of the importance of safety, and the safety system was generally well constructed. Some sites had also

implemented highly efficient safety management initiatives. However, a lack of awareness of the concept and measurement of safety culture was found at all sites. Furthermore, improvement in the lack of reporting safety concerns was recognised as an urgent task.

The indicators of 'attitude towards blame' and 'existence of learning organisation' were relatively underrated, and 'leadership' was rated higher than other indicators.

The site managers had a very positive safety culture; on the other hand, the project manager evaluated on-site safety from a more critical position.

Through the interviews, the author identified some lessons and issues for developing a CIRS model:

- Insufficient system to report safety concerns;
- Unsystematic procedures for delivering safety information;
- Lack of voluntary participation by workers;
- Lack of awareness and measurement of safety culture;
- Fear of severe punishment for individuals involved in accidents.

8.2 People Within CIRAS in the UK

8.2.1 Purpose

The purpose of the interviews was to understand the concept of CIRSs, and the operational status and process of CIRAS, the most successful CIRS in the railway industry. Since it was developed in 1996, CIRAS has played an important role in improving the safety culture of British railways for the past 20 years. As these interviews were conducted early in the research, they focused on identifying the overall status of CIRAS and understanding the crucial factors of the system. Because CIRAS is the oldest and most extensively adopted CIRS in the railway industry, a lot of experience and knowledge has been accumulated. Thus, it was appropriate for the purpose of this research.

8.2.2 Design of Interview

8.2.2.1 Method

As the primary purpose of this interview was to identify the overall status of the system, the interviews were arranged by the author to meet with the principal staff involved in the operation of the system and to hear an explanation of CIRAS.

The interviews were conducted in London at the CIRAS office on 2nd February 2016. The interviews lasted about 20 to 40 minutes per person.

8.2.2.2 Selection of Interviewees

CIRAS is operated with as few as 15 members of staff, as shown in Figure 27.
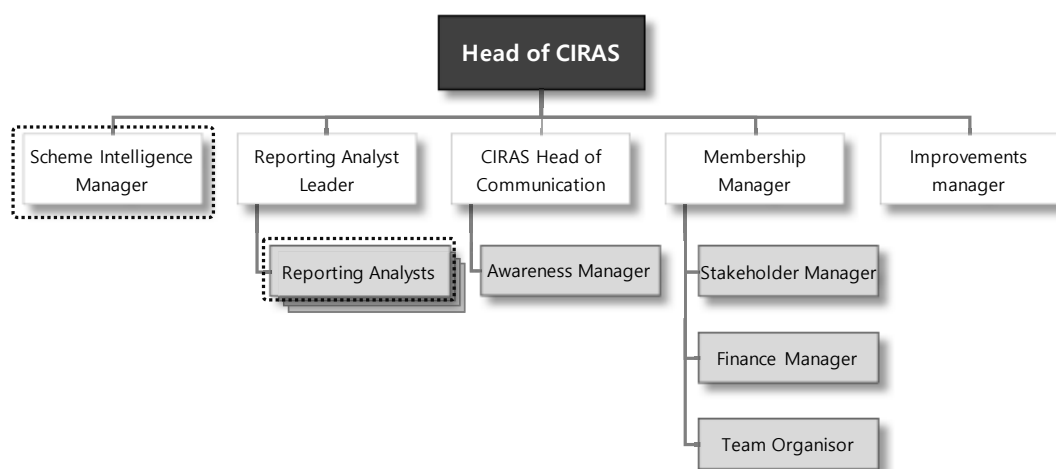
Figure 27. Organisational structure of CIRAS (adapted from CIRAS)

The interviews were conducted with the intelligence manager, communication manager and a report analyst who had knowledge of the concept and operation of CIRSs.

8.2.2.3 Questions Used in the Interviews

As the purpose of the interviews was to understand the status of CIRAS, the questions comprised general information relating to this.

The list of questions was sent in advance and some replies were given in advance. On the day of the interview, the interviewees explained the status and functionality of CIRAS based on the pre-provided question list. After the explanation, some additional questions followed.

The main content of the questions was:

- General information on CIRAS;

- Annual performance and results;

- Annual budget and funding methods;

- Work process for processing reports;

- Strategy to secure confidentiality;

- Current challengers to CIRAS.

8.2.3 Results

The staff at CIRAS had great pride in their success, and they considered secure confidentiality for reporters as the primary factor for success. Based on this success, more than 1,000 companies participate in the CIRAS scheme, exceeding the scope of railway territory. Nevertheless, the number of operating staff in CIRAS remains relatively small compared to the number of participating companies.

All interviewees highlighted securing confidentiality, and the work process of CIRAS was focused on the guarantee of confidentiality.

The main results of the interviews were as follows:

- Confidentiality is CIRAS's most important asset, and is crucial for system to function;

- Independence is very important to ensure confidentiality; even though CIRAS is within RSSB, it is independently operated;

- To guarantee confidentiality of reporters, their information is known only by two people in CIRAS;

- External assumptions or questions related to reporters should be sternly blocked;

- All data related to individuals is completely removed within 6 months, eliminating the risk of hacking;

- When distributing the report of safety concerns to related companies, if the content of the report is too general, companies have difficulty in solving the issue, and thus CIRAS strives to provide 'balanced information' within the limits of securing confidentiality;

- CIRAS is operated independently using fees from the participating companies which are arranged according to the size of the company;

- CIRAS consists of staff with experience in a variety of areas, including media, communications, physiology, etc.;

- When first becoming aware of CIRAS, people are curious about why an additional system is needed. However, 75% of the issues addressed in CIRAS had not been resolved by internal reporting systems. CIRAS is a good system to complement existing reporting channels;

- 95% of CIRAS reporting is submitted by frontline staff;

- When receiving an internal report on received issues, a separate confirmation check is conducted.

8.2.4 Findings from Interviews in the UK

The purpose of the interviews was to understand the concept of CIRSs, and the operational status and process of CIRAS.

As a result of the interviews, it was identified that confidentiality is of paramount value for CIRAS, and every work process is designed and conducted to secure confidentiality.

From the interviews, the author identified some lessons and issues for developing a CIRS model:

- Confidentiality is CIRAS's most important asset;

- The independence of CIRAS is very important to ensure confidentiality;

- Various measures are adopted in work processes to ensure confidentiality;

- CIRAS is a complementary reporting channel that collaborates with existing reporting channels.

8.3   Issues for Model Development

Interviews were conducted to evaluate the safety culture of the Korean railway industry, and to identify the status and success factors of CIRAS.

From the interviews, the author found out the real issues related to safety culture on railway construction sites, and captured precious operational properties of CIRAS.

Key issues and lessons learned during the interviews to be used in developing the CIRS model are:

Safety Culture of the Korean Railway Industry

- The Korean railway industry has a systematic SMS, but lacks the systems and perception for handling safety concerns;

- Frontline staff lack willingness to voluntarily participate in reporting of safety concerns;

- Cognition and utilisation of safety culture is insufficient;

- Many people are exceptionally anxious of the punishment caused by accidents.

Operation of CIRAS

- Ensuring confidence of confidentiality is paramount in CIRAS;

- Minimising contact with the reported issues of safety concerns is necessary;

- Personal data must be checked completely so it is not included in reports, and for completed issues it must be erased as soon as possible;

- As most reports on safety concerns are submitted by frontline staff, defining the scope of reporters is important;

- CIRAS is suitable for operating in a complementary manner rather than a competitive manner with other reporting channels.

9 CIRS Model for Korea's Railway

The Korean railway industry already has systematic SMSs, and various reporting systems are also in operation. However, the results of the research through questionnaire surveys, case studies and interviews show that additional reporting systems are necessary to supplement the weaknesses in the current reporting systems and to improve safety culture.

Accordingly, the author developed a CIRS model for the Korean railway industry, considering the existing CIRS cases and issues found during the research. Thus, the author called the CIRS model the KCIRS model. The KCIRS model presented in this research covers the entire Korean railway industry, but has been specifically elaborated to create a more detailed model for the railway construction and maintenance sector.

9.1 Methodology for Designing a CIRS Model

To make an effective CIRS model, the author developed the framework shown in Figure 28. The purpose of establishing the framework was to systematically summarise the issues and lessons learned through the research, and to ensure that they were properly reflected in the new model.
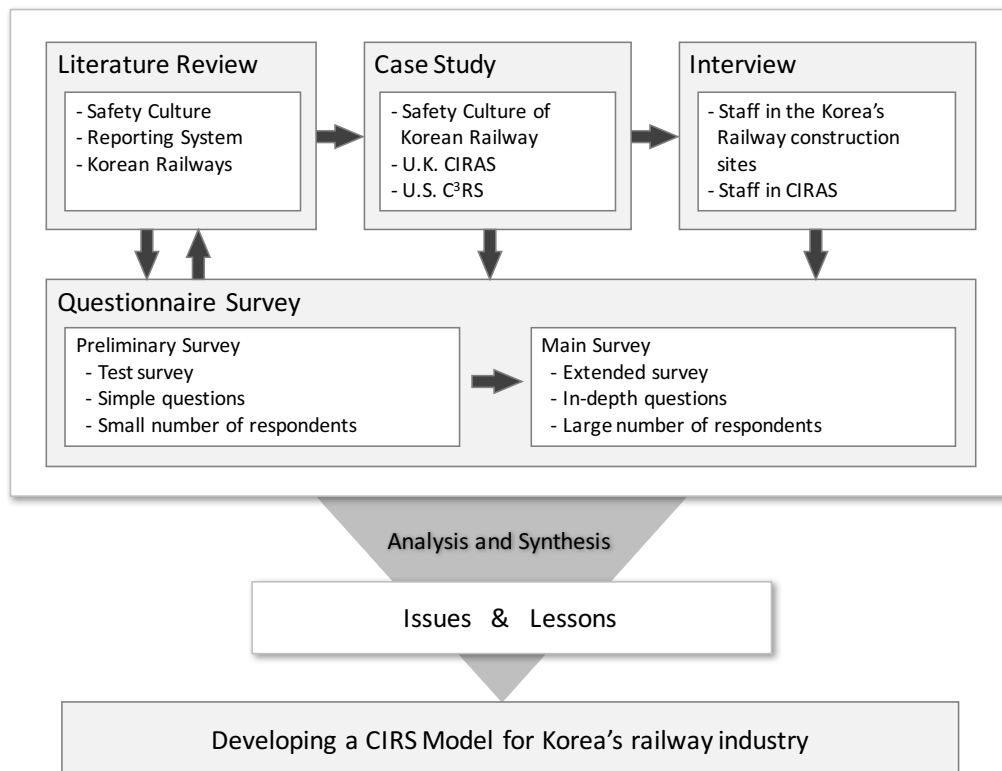

Figure 28. Framework for developing a CIRS model (The author)

Through this framework, the author intended to connect the findings of this research and a new CIRS model organically.

The framework for developing a CIRS model consists of the following:

- Literature Review

  The literature reviews were conducted on three main themes, safety culture, reporting system and Korean railway industry, to obtain the basic information needed to establish a CIRS model. The literature reviews were conducted continuously throughout the research, and the findings were reflected in the establishment of a CIRS model;

- Case Study

  The case study method was used to obtain basic data needed to establish a CIRS model through practical cases. CIRSs have been used in various fields, such as aviation, healthcare and nuclear power plants, and have already been adopted in the railway industry, e.g., in the UK, US and Canada. The author selected two examples of best practice for CIRSs from railway industries operating successful CIRSs. Thus, CIRAS in the UK and C^3RS in the US were chosen. Currently, the institutions are operating the CIRSs very successfully.

  As the operational scales or systems were very different, the introduction process and application targets were also very different. These reflected the reality of each railway industry which made it a good comparison.

  In addition, the author selected Korea's railway safety culture as a case study. Through this, the author identified the actual safety culture and reporting culture of Korea's railway industry, which helped establish a CIRS model for Korea's railway industry;

- Questionnaire Surveys

  Questionnaire surveys were conducted on Korea's railway industry in two stages. The surveys used quantitative methods and the accuracy of the survey results was reinforced by collecting answers from a wide variety of people.

  Based on the surveys, the author verified that a new reporting channel is required in addition to the existing reporting channels in Korea, and identified the strengths and weaknesses of safety culture which were applied to the KCIRS model;

- Interviews

  Two types of interview were conducted. The first was conducted with staff on Korean railway construction sites. This was to examine the safety culture of the Korean railway

industry in a qualitative manner. The second was conducted with CIRAS staff in the UK. This was to identify the success factors of CIRAS;

- Analysis and Synthesis

The author analysed all the research results and synthesised the lessons and issues. These results are directly reflected in the KCIRS model.

9.2 Content

The author organised a CIRS model for Korea's railway industry, called the KCIRS model, which includes the structure, functions and processes for operation of the model. It also includes operational strategies to help successful operation of the model, e.g., an education and evaluation strategy. Furthermore, the measures for ensuring confidence of confidentiality were included.

9.2.1 Structure of the KCIRS Model

As most of Korea's railway industry is owned and operated by central or local governments, and most organisations have a monopoly position, the structure of the industry is relatively simple, as shown in chapter 6.1.1. Thus, the author developed the KCIRS model as a modular structure in a functional manner. This is a different approach to one where an institution manages the whole railway industry, as in the UK, or where each railway company operates its own system, as in the US.

Figure 29 shows the CIRS model for Korea's railway industry which was developed on the basis of the framework shown in Figure 28.
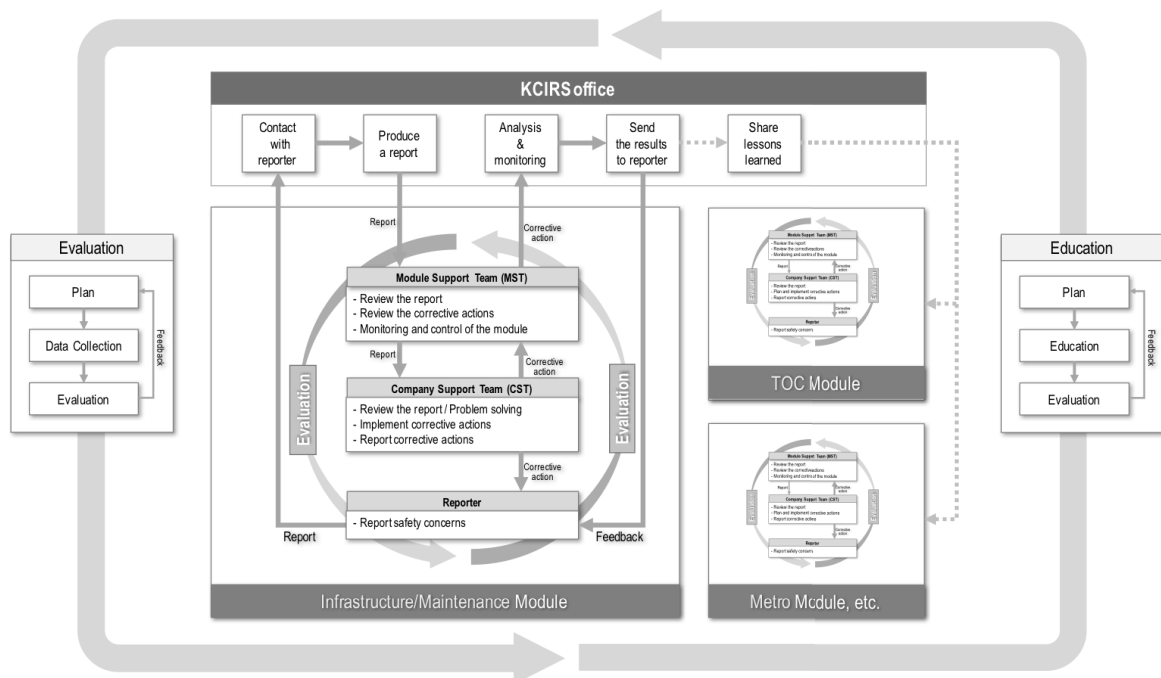

Figure 29. The KCIRS model for Korea's railway industry (The author)

The infrastructure module mostly deals with KR. TOCs form the TOC module, and metro companies belong to the metro module, etc. Similarly, each company forms a module with

companies with similar characteristics. This modular structure has the advantages of being able to attempt gradual adoption of the model and being used as a standard model in other industries.

There are four distinct elements that make up the model, i.e., KCIRS Office (KCO), Module Support Team (MST), Company Support Team (CST) and reporter. To configure the KCIRS model, each element was defined as having unique roles and responsibilities which are presented in detail in the next section.

9.2.2 Roles and Responsibilities

All roles and responsibilities within KCIRS must be defined in the 'System Operating Procedures', and the procedures should be carefully prepared in accordance with operational conditions. The procedures must be created in advance, before the start of operation of the KCIRS, and must be announced publicly. In this regard, the author defined the standard roles and responsibilities related to the KCIRS model as outlined below:

KCIRS Office (KCO)

KCO may be created by the government or the industry.

- KCO is the core organisation that operates KCIRS, and operating KCIRS is the primary role of KCO. The basic function of operation is managing safety concerns, i.e., collecting reports of safety concerns, and passing the reports to the appropriate MST. The KCO manages accumulated data;

- There are two additional roles besides the operation of KCIRS, i.e., the roles of evaluation and education;

  - KCO should measure the impact on KCIRS of safety and safety culture, and should develop a continuous development process by identifying strengths and weaknesses through the evaluation process;

  - KCO is required to be responsible for education, which is related to sustainability of KCIRS. KCO must disseminate the safety-related knowledge accumulated by operation of KCIRS, and should establish the proper concept of KCIRS and ensure that the system continues to operate in the future;

- In general, an independent organisation is required to perform the KCO role. However, the roles of KCO can be changed in case of coordination with MST according to the circumstances. In such cases, the characteristics of KCO should be decided according to the roles;

- Confidentiality ought to be everywhere. All work processes must be designed and implemented on the basis of securing confidentiality.

KCO works with other organisational units to achieve its objectives, i.e., MSTs and CSTs.

Module Support Teams (MSTs)

MSTs are organisational units that should be established in each module to monitor and to control the actual operation of each module of KCIRS. They are responsible for carrying out the following functions:

- When reports of safety concerns are submitted through KCO, MSTs perform a role in reviewing them and assisting the relevant company to make a proper decision;
- MSTs are responsible for the evaluation and education of the entities within the module. However, MSTs should divide the roles to avoid overlap with the education and evaluation roles of KCO.

Although MSTs may be formed as independent organisations within the module, it is permitted for leading companies to take the role.

Company Support Teams (CSTs)

CSTs are organisational units for practical implementation of KCIRS, organised by each company. In comparison with C^{3}RS, CSTs are responsible for both the roles of PRTs and Support Teams. They are tasked with the following activities:

- CSTs execute the role of practical problem-solving, i.e., reviews reports, plan and select corrective actions, implement the actions;
- CSTs need to select experts in each discipline.

Reporters

As stated in chapter 1.1, reporters are the people who report safety issues. They are responsible for doing the following:

- The reporter plays a role in discovering and reporting safety concerns;
- Basically, all employees must be able to act as reporters.

9.2.3 Scope for Reporting

The scope of reporting is important in the operation of CIRSs. Too wide a scope for reporting can produce difficulties in the operation of CIRSs, and too limited a scope can reduce the number of reports, thereby making CIRSs obsolete.

If the scope of reporting is not clear, the reporter may be confused, resulting in inconsistent reporting. Vincent et al. (1999) recommend having a clearly defined list of reportable incidents for successful incident reporting.

However, a new approach to safety has recently become popular. The approach is not only interested in accidents and incidents, i.e., focusing on Safety-I, but also in everyday actions and outcomes, i.e., focusing on Safety-II. Indeed, we can find risks as well as opportunities in everyday actions and outcomes (Hollnagel, 2014).

In this respect, the author suggests that the scope of reporting must be defined as broadly as possible to obtain sufficient cases for the operation of KCIRS. As KCIRS is a complementary reporting channel, not the sole reporting channel in the railway industry already, KCIRS needs to access a wider range of topics that general reporting channels do not address.

The tentative scope of reporting for KCIRS is as follows:

- Unsafe work practices;
- Unsafe conditions;
- Inadequate safety gear;
- Inadequate safety facilities;
- Fatigue;
- Public safety;
- Any other risks to safety.

It is recommended that the practical scope of reporting is specified on a modular basis.

The scope of reporting should be suitable for the characteristics of the module, which should be defined through careful consideration before adoption of the module.

Designation and management of the scope should be conducted under the supervision of KCO to maintain consistency of data and to utilise the data strategically in the future.

9.2.4 Processes of Reporting

The reporting process is the most important function of the KCIRS model which is to report, analyse and resolve safety concerns. To propel efficiency of reporting, definition of the reporting targets and processes is important. Securing confidentiality of reporters is also an important factor to judge whether the function of reporting is successful or not. Therefore, clear definitions and exact examples are required according for reporting processes.

The roles of accepting, reviewing and distributing reports normally belong to the core organisational units that operate CIRSs. Although it is possible to share the role of core organisational units with MSTs, it can adversely affect securing confidentiality. Therefore, it is advisable to grant a reporting function to a single organisational unit.

Thus, the author also gave the role of managing reports to KCO.

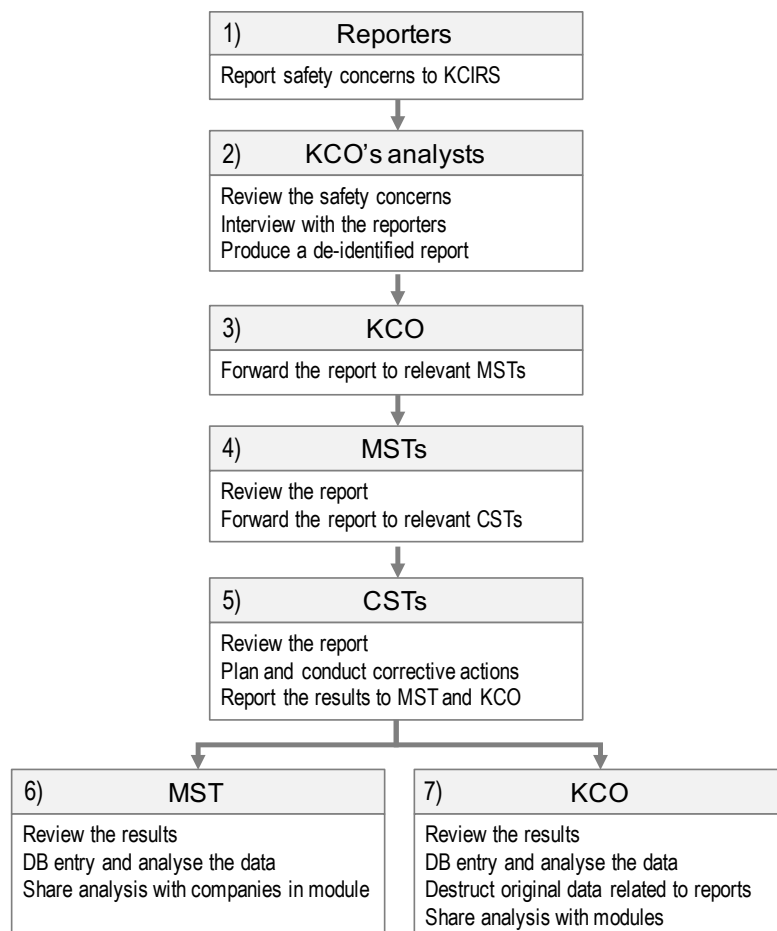Figure 30 shows the processes of reporting in the KCIRS model.

Figure 30. Reporting processes of KCIRS (The author)

As shown in Figure 30, the operational processes of KCIRS are:

1) People voluntarily report safety concerns to KCIRS, and KCO verifies whether the reported safety concerns are to be handled or not. All cases are accepted, except for exclusion targets, e.g., accidents, anonymous reports, personal faults etc.;

2) KCO's analysts review the reported safety concerns, and contact the reporters for interviews if more detailed information is necessary. The analysis results for the safety concerns are stored in a database, and a sanitised report of the safety concern is created which has the personal information of the reporter completely excluded;

3) KCO sends the sanitised report to MSTs. At this point, KCO must determine which MST to send the safety concern report to, according to the relationship with the reported safety concerns;

4) MSTs review the reports deployed by KCO and input the information on their database. MSTs distribute the reports to relevant CSTs. MSTs must select a number of companies to ensure confidentiality, so that no-one can identify the personal information of the reporter;

5) CSTs review the reports and establish corrective actions if necessary, and conduct corrective actions after the internal decision process. They report the results to the MST and KCO by compiling the results of the reports.

6) MSTs review the outcome reports from the CST and then record them in the database. MSTs analyse the database and share the results with companies within the module;

7) KCO reviews the outcome report of the CST and then records it in the database. MSTs completely remove the personal information associated with the reports from their database. Results and analysis of safety concerns must be shared with relative MSTs, and each MST shares the information with companies within the module.

In the operation of KCIRS, KCO and MSTs have important roles. The roles of KCO and MSTs must be appropriately distributed so that the roles and responsibilities of the reporting process do not focus on a specific organisation.

If the roles of accepting and managing reports of safety concerns are given to KCO to ensure confidentiality, the roles of analysis and distribution of results must be allocated to MSTs to prevent the concentration of roles and responsibilities.

9.2.5 Securing Confidentiality

Ensuring confidentiality of reporters is very important in the operation of CIRSs. Even a single breach of confidentiality can cause a collapse in confidence of CIRSs (Davies, et al., 2000).

Barach and Small (2000) demonstrated that the most obvious way to ensure confidentiality of reporter and data is providing anonymity, but there are definitive disadvantages of anonymity:

- Analysts cannot contact the reporter when additional information is needed;
- Anonymous reports are unreliable and not transparent;
- Ensuring anonymity is often difficult.

The method of allowing anonymous reporting may be the most fundamental way to ensure confidentiality, but for these reasons confidentiality is needed more than anonymity in reporting processes (Benn, et al., 2009; Hudson, 2003). Indeed, there have been few instances of ensuring anonymity in incident reporting systems introduced (Barach & Small, 2000).

Allowing anonymous reporting can cause a reduction in the sense of responsibility, which can have a serious impact on reliability. Therefore, ensuring confidentiality should be deemed more important than guaranteeing anonymity.

The author used the following principle to ensure confidentiality in KCIRS:

- Minimise access to personal information;
- Prevent creation of sensitive personal information in principle;
- Delete even mandatory personal information after finishing processes;
- Manage the balanced personal information based on efficiency and confidentiality.

In this regard, the author presents two approaches to ensure confidentiality for reporters: ensuring confidentiality during the reporting process and ensuring confidentiality related to data archiving after reporting process.

Methods for ensuring confidentiality in the reporting process include:

- Securing confidentiality for reporting methods, e.g., web, mail, etc.;
- Restrict and minimise handling of reported materials;
- Pre-verification of confidentiality of the materials before dissemination;

Methods for ensuring confidentiality related to data archiving after the reporting process include:

- Disposal of received original data sources after solving the reported safety concerns;

- Disconnecting the database from the internet;

- Applying encryption systems to the database;

- Only storing anonymous data in the permanent database.

As data management techniques are rapidly developing areas, sufficient review processes are required before application of robust security technologies.

Data management techniques need to be applied to the most powerful security technologies; ongoing improvement is necessary during operation periods as well as during initial processes.

9.2.6 Systematic Evaluation Programme

The function of evaluation is intended to validate the effectiveness of CIRSs. Once the effectiveness of CIRSs is validated, the rationale for expanding their application is easily acquired. In addition, there is an advantage that errors can be corrected in the early stage through evaluation processes if CIRSs are adopted more widely.

CIRAS, the UK's CIRS in the railway industry, was simultaneously applied in Britain in 2000 and does not have a specific evaluation function (Langer, 2014). It is obvious that CIRAS has contributed greatly to improve railway safety in Britain, but it is regrettable that the contribution cannot be objectively measured.

On the other hand, C^{3}RS, the US's CIRS for the railway industry, has been applied gradually, and a systematic evaluation programme has been implemented at the same time by an independent external agency (Volpe National Transportation Systems Center) (Ranney, et al., 2015). This is a good example of a process of ensuring the validity of a CIRS before extending application. Identifying the current situation exactly is important in setting proper goals. Thus, an evaluation process is necessary for the efficient adoption of CIRSs.

Evaluation can be divided into two types: self-evaluation and external evaluation. External evaluation is desirable for fairness, while self-evaluation is desirable to maximise the effectiveness of learning through continuous self-evaluation.

In accordance with the objectives of education, i.e., continuous improvement, the author selected an internal evaluation system to maximise a continuous learning culture, and granted the role to KCO.

However, it is also a good approach for KCO to conduct an evaluation together with an independent research institution. This can complement objectivity and expertise, which is the drawback of internal self-evaluations. In order to conduct objective and effective evaluation,

establishing an evaluation plan is important. Through evaluation planning, the evaluation structure of CIRS should be constructed as follows:

- Evaluation purpose;
- Evaluation scope;
- Evaluation stakeholders;
- Evaluation methodology, e.g., interview, questionnaire survey, data analysis, etc.;
- Evaluation cycles, e.g., adoption phase (baseline, intermediate and final evaluation) and operation phase (annual evaluation).

The use of reliable data improves the quality of evaluation. Selection of the data types to use is important. Therefore, the effectiveness of data should be thoroughly evaluated at the stage of evaluation planning. Thus, it is possible to conduct comprehensive evaluation on CIRSs through adoption of safety data as follows:

- Safety culture;
- Accidents and incidents;
- Fatalities;
- Corrective actions;
- Derailments and damage to facilities;
- Other safety indicators.

9.2.7 Education and Improvement Activities

The function of education is related to sustainability of CIRSs. Ongoing education of staff is essential for the continuous operation of CIRSs, because many safety concerns cannot be reported if the concept and processes of CIRSs are not properly explained to staff in advance. In that case, many frontline staff are often not convinced of the confidentiality of systems. The importance of the function of education increases particularly in areas where personnel are frequently replaced. Therefore, it is appropriate to perpetuate the function of education. To achieve this, it is more efficient to unify the roles of education because it is necessary to secure more than a certain scale of organisation.

Therefore, the author also gave the role of education to KCO.

However, often KCO may not be able to afford to educate the whole railway industry because operational units are usually very small. Compared to the scale of operational units, there may be many organisations. In order to overcome that, the role of education may be shared

with other operational units, e.g., important education can be implemented by KCO, and ongoing education can be considered as a role shared with MSTs.

9.2.8 Adoption Methods of KCIRS

CIRSs are clearly beneficial to improve safety and safety culture. There are two ways of adopting the scheme:

- Instant adoption by the whole railway industry;

- Incremental adoption by several railways.

In the UK, CIRAS (the UK's CIRS in railways) began in 1996, and was extended to include all mainline railways in Britain by the influence of the Ladbroke Grove collision (1999). In the US, C^3RS (the US's CIRS in railways) began in 2007 and it is being operated in eight railway companies at the moment. C^3RS is gradually expanding its scope of application.

Instant adoption by the whole railway industry is ideal, but CIRSs are based on the idea of voluntary involvement. It may need much more time for negotiations among all railway companies if there are no fatal tuning points, such as the Ladbroke Grove disaster.

Thus, it is obvious to choose the second option. To introduce a CIRS on Korea's railway industry, the author intends to present the following method:

- Select a module to adopt a CIRS in Korea's railway industry as a pilot project;

- Establish an evaluation plan and criteria for the module;

- Adopt a CIRS in a module;

- Evaluate the results of the module for adoption of the CIRS;

- Complement the errors and faults that are found through an evaluation period;

- Extend the scope of CIRSs to the whole railway industry.

This adoption process of CIRSs is very similar to the process in the US.

9.3   Future Work

This research was intended to improve safety culture through changes in the reporting culture of Korea's railway industry. The author identified that Korea's railways have a relatively positive safety culture but a lack perception of the concept of safety culture. However, at the same time, there were also things to improve.

In particular, the author identified that a new reporting channel is necessary to complement the existing reporting channels because of concerns about under-reporting, and dissatisfaction with existing reporting channels. Based on these findings, the author developed a CIRS model suitable for Korea's railway industry.

However, more specific implementation measures are necessary to adopt the KCIRS model. In particular, further research on the next three items will enhance the effectiveness of KCIRS.

9.3.1 Developing a Detailed Evaluation Programme

The author regards an evaluation programme as the most important part of the KCIRS model. The author has mentioned in chapter 9.2 the evaluation system of KCIRS. However, chapter 9.2 presented only a framework for evaluation of KCIRS. Therefore, it is necessary to conduct further research on a more practical methodology for the evaluation process.

In particular, it is necessary to conduct research on data types, indicators and criteria for evaluation. Measurement tools have been developed extensively, but have not been specialised for CIRSs.

If further specific methodology is developed through further research, it will be more beneficial for improving safety culture by adoption of CIRSs.

9.3.2 Specialisations for Other Modules

The KCIRS model is constructed on a modular basis, depending on the situations and conditions in Korea's railway industry.

Accordingly, the KCIRS model presented in chapter 9.2, is based on the module of railway construction and maintenance. The construction and maintenance sector is important in the railway industry, but other modules, e.g., operations, metro, etc., also occupy important territory in the railways. Therefore, in addition to the construction and maintenance module presented in this research, further research is needed for each module.

Further clarification of the KCIRS model, through additional research into consideration of the characteristics of each module, should be conducted before the adoption of the KCIRS model.

In particular, metros which are operated by local governments, or private railways, have different characteristics to mainline railways, and therefore should be researched accordingly.

9.3.3 Standardisation for Increasing Applicability

The KCIRS model has been designed to apply to Korea's railway industry which has not yet adopted a CIRS. Besides Korea, many countries around the world have not introduced CIRSs in their railway industry. Improvement of reporting culture through CIRSs is a rational means of creating a positive safety culture and thus requires efforts to propagate it.

This requires research into standardisation of the KCIRS model.

Although this involved research into existing reporting channels, the KCIRS model was compiled based on Korea's railway industry.

Since the purpose and operation method of reporting channels is different depending on the situations and conditions of each country, consideration of these is required.

Standardisation of CIRS models is necessary to facilitate improvement in safety culture through CIRS adoption in countries where one has not yet been applied.

10 Conclusion

This research was conducted to improve the safety culture in Korea's railway industry. For this purpose, the author selected employees of railway construction sites adjacent to railway operations in Korea, and conducted case studies, questionnaire surveys and interviews.

Through this research, the author identified their positive safety culture, but at the same time found some areas of safety to improve. In particular, the author identified the necessity for a new reporting channel because many people were worried about under-reporting and felt uncomfortable with existing reporting channels.

Based on these findings, the author developed a new CIRS model, called the KCIRS model, that complies with Korea's railway conditions.

To this end, operational methods were researched, i.e., the structure of the model, reporting process and scope, roles and responsibilities, measures for securing confidentiality, strategies for evaluation and education, etc.

10.1 Findings

Case Studies

- Korea's railway safety performance has steadily improved to date but safety culture should be improved more;
- Application of CIRSs is beneficial for improving safety culture;
- Confidentiality is the most important value of CIRSs;
- Evaluation systems of CIRSs have various advantages.

Questionnaire Surveys

- Korea's railway safety culture requires improvements in some areas;
- Under-reporting of safety concerns was inferred;
- To overcome under-reporting and to improve safety culture, adoption of CIRSs is necessary.

Interviews

- Korea's railway industry has a systematic SMS;
- It lacks the system and perception for handling safety concerns;

- Active participation of staff and utilisation of safety culture are necessary;

- Confidentiality is paramount for CIRAS;

- Considering the scope of the reporter is important;

- CIRAS is a reporting channel complementary to existing reporting channels.

10.2 Recommendations

KCIRS Model

The author developed a framework for a CIRS model, and on the basis of the framework developed the KCIRS model as shown in Figure 31. The author recommends that this model is applied in the Korea's railway industry to improve railway safety culture.
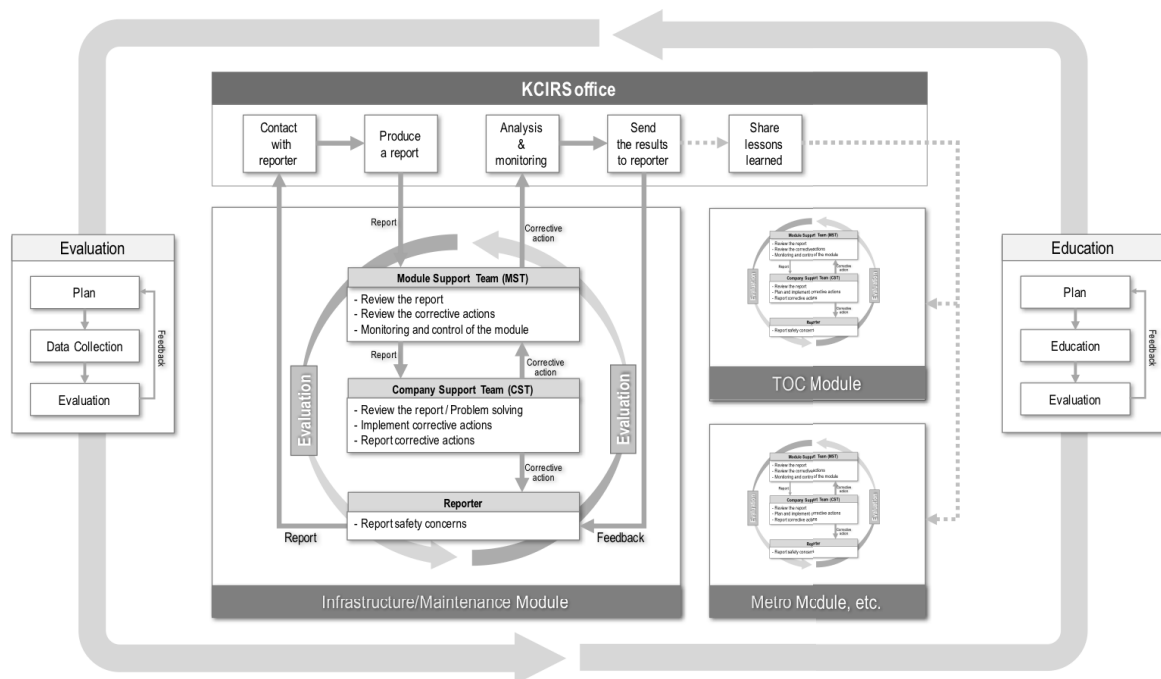
Figure 31.KCIRS model for Korea's railway industry (The author)

The KCIRS model comprises functions, processes and operational strategies for its successful operation, i.e., roles and responsibilities, scope for reporting, processes of reporting, securing confidentiality, systematic evaluation programme, education and improvement activities, adoption methods of KCIRS, etc.

The author ascertains that adoption of CIRSs will facilitate improved safety and safety culture in Korea's railway industry.

10.3 Future Work

Through this research, the author identified that a new reporting channel is necessary to complement existing reporting channels. Based on these findings, the KCIRS model was developed for Korea's railway industry.

However, more specific implementation measures are necessary to enhance the effectiveness of the KCIRS model:

- Developing a detailed evaluation programme

  More practical methodologies for the evaluation process, which will be beneficial to improve safety culture by adoption of CIRSs, are necessary;

- Specialisations for modules

  KCIRS is a modular model and is based on the module of construction and maintenance, thus further clarification for other modules is necessary before actual adoption of KCIRS;

- Standardisation to increase applicability

  The KCIRS model has been designed to apply to Korea, but many other countries around the world have not yet introduced CIRSs. Therefore, the standardisation of CIRSs is necessary to facilitate their adoption.

This further research will be beneficial to improve safety culture by adoption of CIRSs.

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12 Appendix

12.1 Questions of the Preliminary Questionnaire Survey (adapted from HSE(2005))

Questionnaire

Thank you for replying to this questionnaire survey.

This questionnaire will only be used for academic purposes, and your answers will be secured confidentially.

You are working on a construction site that is close to a mainline railway. Your work can influence safety on the railway, and your own safety may be affected by the operation of the railway. Therefore, eliminating safety concerns in advance is beneficial for safe working conditions and railway operation.

In the questionnaire survey, a safety concern is defined as an event or condition that is unlikely to occur at the moment, but which in the near future may develop into an accident.

Please bear in mind that accidents are not included in the survey.

Thank you.

1. What is your position?

  1) Site manager   2) Supervisor   3) Site engineer   4) Manual worker

2. Does your organisation have a system for people to report safety concerns?

1) Yes   2) No

If you answered 'Yes', go to Question 3-1. If you answered 'No', go to Question 3-2.

    3-1. If you have a safety concern reporting system, does it secure confidentiality for the people reporting safety issues?

      1) Yes   2) No

    3-2. Have you ever made an informal report about a safety concern?

      1) Yes   2) No

Please reply to the following questions assuming that you have used a safety concern reporting system or made an informal report about safety concerns.

4. How often do the issues get resolved?

  1) Always   2) Quite often   3) Occasionally   4) Very occasionally   5) Never

5. Are you satisfied with the effectiveness of management in dealing with safety concerns?

  1) Fully   2) Mostly   3) Sometimes   4) Not   5) Never

6. Does management accept that it is its responsibility to deal with the safety concern once it has been reported?

  1) Fully   2) Usually   3) Sometimes   4) Not   5) Never

7. Are staff provided with feedback about the outcome or progress of the reported concern?

  1) Fully   2) Mostly   3) Sometimes   4) Not   5) Never

8. Are the issues tracked from the time that they are raised through to closure?

  1) Fully   2) Mostly   3) Sometimes   4) Not   5) Never

9. Are you worried about being punished if you were report a safety concern?

  1) Fully   2) Mostly   3) Sometimes   4) Not   5) Never

10. Are you willing to report a safety concern if confidentiality can be secured?

  1) Fully   2) Mostly   3) Sometimes   4) Not   5) Never

11. What do you think are the solutions for under-reporting?

  1) Clear and simple reporting procedure

  2) Confidentiality for reporters

  3) Continuous education for reporting systems

  4) Reinforcement for under-reporting

  5) Other_____

12. What do you think is the root cause of people hesitating to report safety concerns?

   (open-ended question)

Thank you.

12.2 Questions of the Main Questionnaire Survey (adapted from HSE (2005))

Questionnaire

Thank you for replying to this survey.

This questionnaire survey was developed to research construction sites near mainline railways.

This questionnaire will only be used for academic purposes, and all the information will be treated entirely confidentially.

Thank you very much for your help.

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1. What is your gender?

   1) Male   2) Female

2. What is your civil status?

   1) Married   2) Not married

3. How old are you?

   1) 20-29   2) 30-39   3) 40-49   4) 50-59   5) Above 60

4. How much experience do you have in construction overall?

   1) below 1year 2) 1-5 years 3) 6-10 years 4) 11-15 years 5) 16-20 years 6) Above 20 years

5. How much experience do you have in railway construction?

   1) below 1year 2) 1-5 years 3) 6-10 years 4) 11-15 years 5) 16-20 years 6) Above 20 years

6. What is your education level?

   1) Middle school   2) High school   3) University   4) Graduate School

7. What is your position?

   1) Site manager 2) Site engineer 3) Subcontract engineer 4) Manual worker 5) Supervisor

8. What is your working discipline?

   1) Civil   2) Building 3) Track   3) Electricity   4) Signalling   5) Communication

For the following questions, please select an answer which reflects the extent to which you agree with the statement.

Safety management (7 questions)

9. Formal systems are in place for managing safety in my workplace:

   1) Strongly disagree 2) Partly disagree 3) No opinion 4) Partly agree 5) Strongly agree

10. Safety responsibilities are defined for all personnel:

   1) Strongly disagree 2) Partly disagree 3) No opinion 4) Partly agree 5) Strongly agree

11. I am aware of my responsibilities for my own safety:

   1) Strongly disagree 2) Partly disagree 3) No opinion 4) Partly agree 5) Strongly agree

12. I am aware of my responsibilities for others' safety:

   1) Strongly disagree 2) Partly disagree 3) No opinion 4) Partly agree 5) Strongly agree

13. The effectiveness of the safety management systems and policies is monitored:

   1) Strongly disagree 2) Partly disagree 3) No opinion 4) Partly agree 5) Strongly agree

14. Management involves staff at all levels in safety-related decision-making:

   1) Strongly disagree 2) Partly disagree 3) No opinion 4) Partly agree 5) Strongly agree

15. Management monitors and reviews employees' thoughts, opinions and feelings concerning the effectiveness of safety management within the organisation:

   1) Strongly disagree   2) Partly disagree   3) No opinion 4) Partly agree   5) Strongly agree

Safety concern (8 questions)

16. An effective system is in place for staff to report safety concerns:

   1) Strongly disagree   2) Partly disagree   3) No opinion 4) Partly agree   5) Strongly agree

17. I know the person or body to whom I must report safety concerns:

   1) Strongly disagree   2) Partly disagree   3) No opinion 4) Partly agree   5) Strongly agree

18. Staffs find it easy to approach management about safety concerns:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

19. Management is dealing effectively with safety concerns:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

20. Management accepts that it is its responsibility to deal with safety concerns once they have been reported:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

21. All issues from safety concerns are resolved in a timely fashion:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

22. Staff are provided with feedback about the outcome or progress of a reported concern:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

23. Issues are tracked from the time that they are raised through to closure of the case:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

Change management (5 questions)

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24. My company implements technical changes using a structured method:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

25. My company implements organisational changes using a structured method:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

26. My company implements operational changes using a structured method:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

27. As part of the change process, logs are maintained of the key risks, and action plans for the management of these risks are recorded:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

28. Staff at all levels are involved in the change management process:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

Transfer of information about safety related information (3 questions)

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29. Safety-related information is effectively communicated to staff at the start of a new project, shift handover, or where a handover of duties is required:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

30. All risks and mitigation measures are communicated to the staff concerned:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

31. The communication system is reviewed and monitored for its success:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

Time-critical and degraded situations (4 questions)

32. Safety is effectively managed during a time-critical and degraded situation:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

33. Staff understand their roles and responsibilities in a time-critical and degraded situation:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

34. In some circumstances, a member of staff is placed under pressure to meet performance objectives:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

35. Management checks that safety is being prioritized by staff:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

Incident management (14 questions)

36. I know the incident reporting procedures in my company:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

37. Incidents are sometimes not reported in line with the prescribed processes:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

38. All incidents are investigated:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

39. I know who is responsible for investigating an incident:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

40. The causes of incidents are always determined correctly and reasonably:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

41. Actions are always taken to prevent the incident from occurring again:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

42. Disciplinary measures are an effective method to reduce incidents:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

43. Disciplinary measures must not be applied:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

44. Disciplinary measures must be applied in case of serious incidents:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

45. Recommendations from the investigation are communicated throughout the company:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

46. I have not reported incidents because of fear of being punished or blamed by colleagues:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

47. I will actively report incidents if confidentiality for reporters can be secured:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

48. I will actively report incidents if there is no danger of being punished:

   1) Strongly disagree   2) Partly disagree   3) No opinion   4) Partly agree   5) Strongly agree

49. What do you think is the root cause of people hesitating to report incidents?

   (open-ended question)

Thank you.

12.3 Scenarios for the interviews in Korea (adapted from HSE (2005))

Indicator		Question
Scenario 1: How managers manage safety		
Leadership	Management visibility	Is the safety management system established? Do the managers have an interest in this? Are the managers performing a good safety inspection?
Learning Culture	Safety culture/climate monitoring	Does your company measure safety culture periodically?
Employee Involvement	Employee involvement in safety discussion	Is there a way for employees to participate in safety management? (staff excluding Safety Manager)
General question		What do you think of the safety management system of your site? What are its pros and cons?
Scenario 2: Someone has a safety concern		
Two-way Communication	Internal safety concern reporting system	Is there a framework for reporting safety concerns? Does it work well? Any confusion during operation?
	Approachable management	Do you have a chance to meet the manager regarding safety concern reporting? Do the managers ask the staff if there are any safety concerns?
Attitude towards Blame	Culture of trust	Are safety concerns constantly reported and addressed? Does the manager handle safety concerns when safety concerns are identified?
Learning Culture	Safety concern investigation and mitigation procedure	Are reported items fully investigated?
	Safety concerns log	Is safety concern spread to employees? Is a similar concern processed well if similar concerns occur?
General question		Do you think that safety concerns reported and resolved well in your site?
Scenario 3: A site undergo a significant change		
Employee Involvement	Employee participation in the change process	Does your company have procedures for managing changes? Do you have a system to communicate with others when changes occur?
	Employee training about the change	Is your company aware of the need for training when changes occur? And is your company doing training accordingly?
	Employee motivation	Are employees reporting voluntarily in the process of change? Are you positive about change?
Two-way Communication	Active response to feedback	Is there a good communication system with regard to changes and employees receiving feedback quickly?
General question		Do you think that timely information related to changes are available to employees at the appropriate time?

Indicator		Question
Scenario 4: Transfer of information about shift duties		
Two-way Communication	Safety information communication system	Is safety-related information communicated well at the start of the shift or whenever there is a handover of duties? Do you think these processes are effective?
Attitude towards Blame	Employee awareness of accountabilities	Are all employees aware of safety responsibilities? Is this checked periodically?
Two-way Communication	Comprehension of safety information	Are employees actively accessing or requesting safety information? Do employees or employers have all the safety information needed to work?
General question		Do you think the safety related information is communicated well at the time of shift or handover in your site?
Scenario 5: Time-critical and degraded situation		
Leadership	Safety prioritised behaviour	Do you think safety is paramount even if you have a serious situation such as being behind schedule or poor quality? Is it possible for employees to report without regard to cost of safety?
	Performance vs. safety management priority	Do managers have clear views that safety is paramount? Are there sufficient costs associated with safety?
Attitude towards Blame	Safety accountability	Do managers take charge of safety first and take responsibility according to their results? Are all staff and manual workers fully aware of their responsibilities and obligations in emergency situations?
General question		Do you think that safety system is being constructed and implemented in your site so that safety can be maintained even in emergency?
Scenario 6: Events following an incident		
Learning Culture	Incident investigation system	Is there a thorough investigation and implementation of the measures for root causes of accidents?
Attitude towards Blame	Fault allocation process	Why do you investigate for accidents? To prevent future accidents or punishment of those involved? Is there any punishment or blame on the person involved prior to identifying the root cause?
	Disciplinary process	Is the process clearly divided according to the degree of error? Does the degree of disposal change every time?
Two-way Communication	Feedback systems	Is there a strategy to share information from accident investigations?
General question		Do you think the accident investigation, corrective measures, and implementation of measures are properly implemented?