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**Rail Human Factor Training: Adaptation of Crew Resource
Training in KCRC to Enhance Modern Railway Safety**

A thesis presented in partial fulfilment of the requirements
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Abstract

Abstract of thesis entitled:

Rail Human Factor Training: Adaptation of Crew Resource Training in KCRC to Enhance Modern Railway Safety

Authored by Tak Sum Tsang

Recent world headline disasters such as the September 11 attacks, 2005 London transport bombings and 2003 Daegu Subway arson attacks sent a strong warning to all nations that mass-transit systems are highly susceptible to arson or terrorist attacks with catastrophic consequences. Whilst it may be impossible to ever eliminate all forms of threats, one thing remains clear- the effectiveness of crew response to emergency situations can make a key difference between a minor incident and a full blown disaster.

Staff effectiveness relies upon corporate awareness, training and investment into safety. Even a state-of-the-art system requires suitably matched and experienced staff for smooth, efficient and incident-free operation.

Unfortunately, incident reports reveal consistently that about 70% of aviation and railway incidents have roots in human factors, highlighting the need to invest in

effective, safety-oriented training to expose staff to operational and emergency situations in order to minimise or mitigate human error consequences.

In aviation, crew resource management (CRM) was developed to address this need. CRM's effectiveness in improving teamwork, communication and staff response to emergency results in its popularity in the medical, nuclear, and military sectors. Although some work had begun to modify CRM for the railway industry, none yet existed in China or Hong Kong. Having observed the effectiveness of CRM and line oriented training (LOT) in aviation, this work documents the introduction of CRM and LOT in Hong Kong in the West Rail (WR) division of the Kowloon-Canton Railway Corporation (KCRC).

One-hundred-and-twenty drivers, station and traffic controllers from WR took part in a three days CRM training program. The program used lectures, video aided training facilities (VAT) and integrated training facilities (ITF) to expose staff to CRM and safety related concepts. ITFs were used in LOT programs to simulate emergency and abnormal operation scenarios to test and train ability of teams to handle such situations. Feedback was provided by computer, video and voice records, and trainer comments.

The effectiveness of the training program was tested in an emergency drill in conjunction with Hong Kong police, fire and hospital services by comparison of a control group and the CRM trained group to evaluate the program effectiveness. It was observed that the CRM group displayed better incident handling capabilities, stronger teamwork and communication throughout the exercise. When analysing incidents, CRM trained members were able to recall and consider more factors of human performance.

As the instituted CRM program is still in its infancy, more time is required to prove its effectiveness. It is believed that even in this short introduction period it has raised staff awareness of safety and human factors, and improved overall teamwork and performance in WR. Now that WR serves as a knowledge portal to the rest of KCRC divisions, it is envisioned that CRM will be extended to other KCRC rails. In later years it may also broaden to intercity rails to Mainland China to improve staff performance. An effective CRM program will be the key to minimise impact and consequences if one day disaster does strike.

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Table of Contents

ABSTRACT.....	I
ACKNOWLEDGEMENTS	I
TABLE OF CONTENTS.....	II
LIST OF FIGURES	VI
LIST OF TABLES	VII
CHAPTER 1. INTRODUCTION.....	1
1.1 Background on CRM	2
1.2 Outline and Scope	3
CHAPTER 2. INTRODUCING CREW RESOURCE MANAGEMENT.....	4
2.1 Aviation Experience on Line Oriented Training (LOT) and Crew Resource Management (CRM)	4
2.2 The Birth of Crew Resource Management (CRM).....	4
2.3 CRM Design and Structure.....	8
2.4 CRM Objectives	9
2.5 CRM Training Phases	10
2.6 Guiding Principles for CRM Training	13
2.7 Line Oriented Flight Training (LOFT)	14
2.8 Importance of CRM and LOT programs	16
2.9 Justifications for Crew Resource Management in KCRC	18
CHAPTER 3. LITERATURE REVIEW ON HUMAN FACTOR	20
3.1 Introduction.....	20
3.2 Human Factor Distinctions	21
3.3 The Swiss Cheese Model.....	23
3.4 Examples of Human Factor Errors	25
3.5 Two Ways of Looking at Human Error.....	27
3.6 The Bad Apple Theory.....	28
3.7 The New View on Human Error	31
3.8 Managerial Error.....	32
3.9 The Importance of teamwork in the Railway Industry	35
3.10 Factors that influence training Success.....	36
CHAPTER 4. THE NEED FOR SAFETY ORIENTED TRAINING IN RAILWAY INDUSTRY	39
4.1 Problems encountered in the Railway Industry	41

4.2 Experience Erosion over Time.....	42
4.3 Situation Awareness	45
4.4 Teamwork Effectiveness.....	46
4.5 Identifying areas of training needs	47
CHAPTER 5. ADAPTING CRM AND LOT TRAINING FOR RAILWAY	48
5.1 Similarities between Railway and Aviation industries	48
5.2 Adapting CRM and LOT for Railway	49
5.3 Interpretation of CRM and LOT in Railway Industry	50
5.4 CRM and LOT Skills to be developed.....	50
5.5 Corporate Training Goals	52
5.6 Training Methods.....	52
CHAPTER 6. THE CURRENT KCRC SAFETY MODEL	54
6.1 Introduction to KCRC.....	54
6.2 Incident responses.....	56
6.3 Safety Management	57
6.4 KCRC Safety Management System.....	58
6.5 Limits of Safety Management	58
6.6 KCRC West Rail	59
6.7 Comparisons between East and West Rail.....	60
6.8 Shortcomings of current training needs	63
CHAPTER 7. TRAINING FACILITIES IN KCRC	64
7.1 Integrated Training Facilities (ITF)	64
7.2 ITF Overview.....	66
7.3 Application Approach of ITF.....	68
7.4 Decision Support System (DSS).....	70
7.5 DSS Design Concept	70
CHAPTER 8. CURRENT TRAIN CREW TASK ANALYSIS.....	73
8.1 Train Driver Tasks and Criteria of Competence	74
8.2 Job Descriptions of Senior Traffic Controllers and Train Controllers.....	78
8.3 Skill Pattern of Train Drivers/Traffic Controllers.....	81
CHAPTER 9. ORGANISATIONAL ISSUES	84
9.1 Difficulties faced by TOC in reformation.....	84
9.2 Organisational budget constraints.....	85
9.3 The importance of Organisation Culture	87
9.4 Rail Enquiries and proportioning blame.....	89

CHAPTER 10. THE PRINCIPLES OF HUMAN FACTOR DESIGN	92
10.1 Ergonomics Design.....	92
10.2 Human Factor Design	92
10.3 Human Machine Interface (HMI) Design.....	93
10.4 Task effectiveness	95
10.5 Train Control & Signalling System Design	96
10.6 The Trade-Off between Automatic and Manual Driving	99
10.7 The Perspective of Train Driver.....	101
10.8 Rule-Based Instructional Design	104
CHAPTER 11. RESEARCH DESIGN	107
11.1 Course Design for Human Factor Training	107
11.2 Defining Objectives	109
11.3 Teamwork Skill Dimensions.....	111
11.4 CRM Training Areas	114
CHAPTER 12. TRAIN SERVICES OPERATING PRINCIPLE	117
12.1 Emergency operations.....	117
12.2 Major Functions of Station Operations.....	118
12.3 Incident / Emergency Handling	118
12.4 West Rail SOP's Hierarchy	118
12.5 KCRC Rule Book Coverage	119
12.6 WR Contingency Manual Coverage	120
12.7 WR Special Operating Procedures Coverage	122
CHAPTER 13. CRM TRAINING PROGRAM: METHOD	123
13.1 Course Participants	123
13.2 Training Materials.....	124
13.3 Procedure	124
13.4 Measurement of Effectiveness.....	126
13.5 Statistical Analysis.....	127
13.6 CRM Training for Train Crew	127
13.7 Emergency Drills	131
CHAPTER 14. CREW PERFORMANCE ASSESSMENT.....	135
14.1 Immediate post CRM training result- computer records from ITF responses	135
14.2 Performance result- West Rail annual performance results and observations from drills	137
14.3 Performance Result of West Rail.....	138
14.4 Staff Commendations.....	140

14.5 Staff Complaints	141
14.6 Performance Result in 2005 and 2006.....	143
14.7 Change in Safety Attitude	146
CHAPTER 15. DISCUSSION OF CRM EFFECTIVENESS IN KCRC	158
15.1 Post Training Performance	159
15.2 Workplace Performance.....	163
15.3 Research Observations.....	166
15.4 Post CRM action plan	168
CHAPTER 16. CONCLUSIONS	171
CHAPTER 17. RECOMMENDATIONS	174
REFERENCES	178
APPENDIX A. KCRC PROTOCOLS TO HANDLING ABNORMAL OPERATIONS	187
A1. Definitions of Normal and other conditions	187
APPENDIX B. CURRENT DRIVER AND CREW TRAINING IN KCRC	190
B1. Training facilities	190
B2. Train Driver.....	190
B3. Traffic Controller	191
B4. Station Staff.....	192
APPENDIX C. TRAIN COURSE FOR CRM INSTRUCTOR.....	193
C1. Training Objectives	193
APPENDIX D. STATISTICAL DATA AND CALCULATIONS.....	205
D1. Raw Data and t-test analysis for CRM effect on the number of over 8 minute delays experienced in WR.	205
D2. Raw Data and t-test analysis for CRM effect on the number of customer complaints in WR.	206
APPENDIX E. PRE/POST CRM ATTITUDE CHANGE DATA ANALYSIS	207
APPENDIX F. CHECKLIST FOR OBSERVER.....	251
APPENDIX G1. KCRC ANNUAL REPORT 2006.....	257
APPENDIX G2. KCRC ANNUAL REPORT 2006.....	258
APPENDIX G3. KCRC ANNUAL REPORT 2006.....	259
APPENDIX H. ADDITIONAL FIGURES AND MOVIES IN CDROM.....	260

List of Figures

FIGURE 1. TYPICAL TARGET DOMAINS FOR TRAINING IN CRM (ADAPTED FROM ICAO, HUMAN FACTOR DIGEST 1989).....	12
FIGURE 2. THE IMPACT ON SAFETY DUE TO EXPERIENCE EROSION (RSSB, 2003B).....	43
FIGURE 3. THE ROUTE MAP OF KCRC SHOWING STATIONS AND ROUTES OF EAST RAIL (BLUE) AND WEST RAIL (MAGENTA) SERVICES IN HONG KONG. COVERAGE OF MTRCL IS SHOWN AS THIN GREY LINES.	55
FIGURE 4. OVERVIEW OF ITF ACTIVITIES FOR TRAINING (KCRC, 2006B).	67
FIGURE 5. THE SIX TASK ANALYSIS AREAS FOCUSED BY KCRC CRM TRAINING TO IMPROVE EXISTENT SAFETY PROTOCOLS.....	73
FIGURE 6. SCHEMATIC DIAGRAM OF CAB DISPLAY UNIT (KCRC & ALCATEL SELTRAC, 2003)	93
FIGURE 7. SCHEMATIC OPERATIONS CONTROL CENTRE (OCC) OVERVIEW SHOWING THE IMPORTANCE OF DESIGN AND LAYOUT OF IMPORTANT INFORMATION.	95
FIGURE 8. COMPLEXITY OF SIGNALLING LAYOUT AT LADBROKE GROVE JUNCTION.	97
FIGURE 9. TYPICAL STATION PLATFORM WITH PLATFORM SCREEN DOOR (PSD) (ADAPTED FROM KCRC ANNUAL REPORT, 2004).....	101
FIGURE 10. RESOURCES CATEGORIES AND ALLOCATION IN WEST RAIL CRM (KCRC, 2006B)	112
FIGURE 11. CONTEXT OF CRM TRAINING IN KCRC. CRM TRAINING WILL INCORPORATE ALL ASPECTS SHOWN TO MAKE FULL USE OF EXISTING FACILITIES FOR SAFETY ORIENTED TRAINING.	115
FIGURE 12. SCHEMATIC DIAGRAM OF CAB DISPLAY UNIT (KCRC & ALCATEL SELTRAC, 2003)	119
FIGURE 13. MONTHLY FIGURES OF INCIDENT INCURRING MORE THAN 8 MINUTES DELAY.	138
FIGURE 14. PIE CHART SHOWING BREAKDOWN OF STAFF COMMENDATIONS (96 IN TOTAL) (KCRC, 2005E, 2006B).	141
FIGURE 15. NUMBER OF STAFF COMPLAINS FROM 2004 AND 2005 PERIOD (KCRC 2005E, 2006B).....	141
FIGURE 16. TRENDS IN STAFF COMPLAINTS IN 2005 (KCRC 2005E, 2006B).	142
FIGURE 17. WEST RAIL SERVICE ACHIEVEMENT FOR 2005 AND 2006 (DATA SOURCE:WEST RAIL ANNUAL PERFORMANCE REVIEW REPORTS 2005 AND 2006)	144
FIGURE 18. WEST RAIL WEEKLY SERVICE IMPACTS (DATA SOURCE: FAILURE AND DELAY STATISTICS 2005 AND 2006)	145
FIGURE 19. TRAINING COURSE EVALUATION FORM.....	153
FIGURE 20. COURSE FEEDBACK ON COURSE DESIGN	155
FIGURE 21. COURSE FEEDBACK ON COURSE LEADER.....	155
FIGURE 22. COURSE FEEDBACK ON TRAINING METHOD.....	156
FIGURE 23. OVERALL COMMENT	156
FIGURE 24. COURSE FEEDBACK ON RECOMMENDATION.....	157
FIGURE 25. – COURSE FEEDBACK ON SUGGESTION FOR OTHER COURSES	157

List of Tables

TABLE 1. CLASSIFICATION OF ERRORS BY KLETZ (ADAPTED FROM KLETZ, 2002).....	23
TABLE 2. COMPARISON OF RAIL INFRASTRUCTURE AND RIDERSHIP STATISTICS BETWEEN ER AND WR. .	61
TABLE 3. BASIC TRAINING AND COMPETENCE ASSESSMENT FOR NEW TRAIN DRIVERS.	76
TABLE 4. JOB DESCRIPTIONS OF STC AND TC UNITS DETAILING DEMARCATION OF RESPONSIBILITIES. (DATA SOURCE: RSSB T542)	80
TABLE 5. COGNITIVE SKILL PATTERN CLASSIFICATION OF TRAIN DRIVERS/TRAFFIC CONTROLLERS.....	82
TABLE 6. BREAKDOWN OF TEAMWORK SKILL DIMENSIONS TO RELATED CRM DOMAINS.	113
TABLE 7. COMPARISON BETWEEN CONVENTIONAL AND CRM/LOT TRAINING.	116
TABLE 8. WR RULE BOOK AND KEY SECTIONS	120
TABLE 9. WR CONTINGENCY MANUAL COVERAGE.....	121
TABLE 10. WR SOP'S COVERAGE SECTION HEADINGS.	122
TABLE 11. CRITERIA FOR SORTING PARTICIPANTS INTO GROUPS.	124
TABLE 12. CRM/LOT TRAINING COURSE CONTENTS	125
TABLE 13. MEAN ITF SCORES BETWEEN TEAMS AFTER CRM TRAINING.....	136
TABLE 14. ATTITUDE SURVEY QUESTIONS FOR CREW RESOURCE MANAGEMENT TRAINING.....	146
TABLE 15. WEST RAIL SERVICE PLEDGE AND ACTUAL PERFORMANCE (DATA SOURCE: WEST RAIL ANNUAL PERFORMANCE REVIEW REPORTS 2005/2006)	150
TABLE 16. POST CRM COURSE EVALUATION SCORE	154

Chapter 1. Introduction

Recent world headline disasters such as the September 11 attacks, 2005 London transport bombings, and 2003 Daegu Subway arson attacks sent a strong warning to all nations that mass-transit systems are highly susceptible to arson or terrorist attacks with catastrophic consequences. Whilst it may be impossible to ever eliminate all forms of threats, one thing remains clear— the effectiveness of crew response to emergency situations can make a key difference between a minor incident and a full blown catastrophe.

Any railway system in operation involves a number of interacting mechanical and engineering components under the control of human input. Human operators are responsible for assimilating information under varying temporal and environmental conditions; following conditional rules or their personal experience to make such inputs.

The safety and efficiency of the railway and the quality of responses to incidents are therefore inseparably linked with the alertness and capabilities of human operators.

Despite its importance, the ergonomic and human factors of rail safety has only received attention in recent years where railway agronomists from RSSB Standard

Board (RSSB, 2000) shed some insight to understand and devise relevant human factor work methods and practices. The sustained attention in recent years meant that the government, media, railway industries and general public had also begun to research and focus on human factors when evaluating railway safety and relevant case studies. In this context, the finding of human error should initiate the investigation for error provoking conditions and not end the investigation.

The influence and awareness of such factors lead the decision by train operating companies (TOC) to specifically enforce human factor training. Such training is focused on incident response, equipping staff to respond correctly to unexpected incidents, improving their crowd control and evacuation skills in case of fire or terrorist attacks (Bird, 1974).

1.1 Background on CRM

The concept of human factor may be relatively new to railway management, but have already been extensively researched and reformed in the aviation industry (Morgan, Olson, Kyte, Roop, & Carlisle, 2006). The collective inputs and suggestions from many such studies resulted in a new approach to pilot training in hopes of reducing pilot error. It is now common to find crew resource management (CRM) and line oriented training

(LOT) programs on pilot mental studies (ICAO, 1998 Human Factor Training Manual) showing improved performance and stress adaptations.

As both railway and aviation industries share many similar characteristics and demands, it can be expected that adopting similar training strategies in the railway industry may help develop better training and safety programs for train drivers and traffic controllers. Such a program could improve the efficiency of crew response to any emergencies and reduce the consequences of human errors in the railway sector

1.2 Outline and Scope

The work in this thesis outlines one such training plan for railway by adapting methods already employed in the aviation industry. The form and structure of the aviation training program, its suitability for the railway industry as well as the integration of such a program onto existing railway training programs will be analysed. The program was trialled at the Kowloon Canton Railway Corporation (KCRC) West Rail in Hong Kong to evaluate its effectiveness.

Chapter 2. Introducing Crew Resource Management

2.1 Aviation Experience on Line Oriented Training (LOT) and Crew Resource Management (CRM)

The aviation industry has acquired the ability to communicate as one body. This reflects the industry's communal focus on safety and the ability for all crew to co-operate as one when making decisions and putting it to action. Being a technology intensive, high risk industry, the aviation sector generally has a heavy commitment to safety after many tragedies and accidents from the last one hundred years.

The aviation commitment to bringing safety and quality into its infrastructure and vehicles requires not just well maintained equipment and sound procedures, but heavy investment into all staff and crew members involved. Today's high safety standards and stringent procedures in aviation are the result of decades of research, training and revision into building the best teams and operational environment for maximum effectiveness and system assurance.

2.2 The Birth of Crew Resource Management (CRM)

The motivation for the aviation industry to introduce crew resource management (CRM) training for pilots stems rather unfortunately from serious accidents in the 1970s where

flight crew errors were the primary cause. In 1977, two Boeing 747 aircraft, operated by KLM and Pan American airlines collided on the Tenerife runway, resulting in 583 fatalities. A NASA workshop examining human errors in crashes identified causal factors relating to low assertiveness, weak leadership, pilot fatigue and impaired decision making and communication abilities (Cooper, White & Lauber, 1980).

Such incidents and investigations showed that a collection of highly qualified individuals does not necessarily constitute an effective team (Weick, 1990). Later studies (FAA, 2002) further endorsed the need to address the aspect of crew behaviour, as an analysis of the causes of civil aviation accidents reported that the crew is the primary contributing factor in over 73% of the accidents studied. This finding alerted the aviation industry of the importance of team oriented training and preparation for unexpected events, making room for CRM and LOT programs to be implemented.

It was decided in 1979 at a NASA sponsored workshop that a new method was required to reduce pilot error by making better use of human resources on board to support the pilot (Helmreich, Merritt & Wilhelm, 1999; FAA, 2000). This formed the foundations of the crew resource management program for many airlines, which focused on developing training programs to improve the interpersonal aspect of flight operations.

Although it is not a compulsory training program, it had spread from the USA to many nations worldwide as well as military aviation organisations.

The first cockpit resource management (CRM) program followed closely the work of Blake and Mouton (1964, cited in Helmreich et al., 1999) into managerial and training styles, which purported to diagnose and develop each individual's own preferred managerial style. This meant that the program was heavily based on psychological tests and general concepts such as leadership (Helmreich et al., 1999, FAA, 2000).

Later psychological studies by Helmreich R.L. Ac. Merritt, and J.A. Wilhelm. (1999) contributed to this in building monitored pilot personality profiles to study the relationship between personality dimensions and the use of different strategies in dealing with flight-related stressors.

As time progressed CRM was re-titled crew resource training to emphasise the interpersonal aspects of training (Helmreich et al. 1999). The program became more modular and more specific to aviation skills, as well as being more focused on team building. Other concepts broadened to briefing strategies, situation awareness and stress management to improve crew decision making capabilities and response to emergency situations (Helmreich , RL, J.R Klinect & J.A. Wilhelm 1999).

Beginning from the 1990's, CRM strategies began to become an integral part of normal training to address both technical and human factor components in the light of increased automation (Helmreich, RL 1999) . At this time, CRM also extended to other groups in the aviation system: to the entire flight crew, air traffic controllers, dispatch, and maintenance personnel in order to train them to work more effectively as a team and to jointly accomplish safe operations. CRM was credited in improving safety aspects as well as improving communication and team efficiency, leading to its adoption outside of aviation industry (Neil Krey, 1996). Military aviation, tank and naval crews also have adopted CRM training procedures, as well as other safety critical industries such as commercial shipping, medical and nuclear power industries (Gero David, 1999).

CRM is widely implemented due to many reports of success in reducing the number of crew errors and increased awareness of safety and situations. US Navy research findings concluded that US Naval helicopter crew trained in CRM performed 20% higher on behavioural evaluation, and perform better on a written knowledge test and a scenario-based test than did another group who had not received CRM training (Salas et al., 1999).

2.3 CRM Design and Structure

2.3.1 Design

Designing a CRM program involves a standard training processes (Goldstein & Ford, 2002, Patrick, 1992), starting with defining the training needs, identifying the component skills, deriving the training content, designing the actual course and the evaluation methods (Seamster & Keampf, 2001; Helmreich, Chidester, Foushee, Gregorish & Wilhelm, 1990). It is also recommended that organisational climate data are reviewed (Boehm-Davis, Holt & Seamster, 2001). Instructors in CRM program usually focus upon operational risk assessment and management, railway operations control, communication skills, decision processes and skills, situation awareness, and special and standard operating procedures.

2.3.2 Training Aspects

There are two main aspects to CRM training- cognitive (concepts to be understood) and behavioural (skills to be learnt). Cognitive training methods, from the ICAO Digest Number 2 (reprinted by CAA UK Safety Regulation Group, 2002) include lectures, film/video instruction, readings and programmed texts, computer-based training (CBT), case studies and incident training, and written exercises. Behavioural methods include

role-play, group exercises, and simulator training. Usually a CRM program consists of a number of such modules to impart information most effective to those being training.

2.4 CRM Objectives

CRM is a widely implemented strategy in the aviation community as a training countermeasure to human error. Traditionally, CRM has been defined as the utilization of all resource available to the crew to manage human error (Hawkins, F. 1993).

The objectives of CRM training are as follows:

- To enhance crew and management awareness of human factors which could cause or exacerbate incidents which affect the safe conduct of railway operations;
- To enhance knowledge of human factors and develop CRM skills and attitudes which applied appropriately could extricate railway operations from incipient accidents and incidents whether perpetrated by technical or human factor failings.
- To use CRM knowledge, skills and attitudes to conduct and manage railway operations, and fully integrated these techniques throughout every facet of the organization culture, so as to prevent the onset of incidents and potential accidents.

- To use these skills to integrate commercially efficient railway operations with safety.
- To improvement the working environment for train crews and all those associated with railway operations.

2.5 CRM Training Phases

First generation CRM training (CAA, CAP737, 2003) used psychology as a foundation, with a heavy psychological testing and general management concepts such as leadership (ICAO 1998 Human Factor Training Manual). Basic training conducted in intensive seminars included concepts such as team building, briefing strategies, situation awareness and stress management. Specific model addressed decision making strategies and breaking the chain of errors that can result in catastrophe.

Awareness is the first essential phase, comprising usually of instructional presentations to introduce the importance of concepts such as team building and interpersonal skills. It helps crew members to begin thinking about the importance of such areas and lay the foundational knowledge. Awareness promotes credibility of the program and help in changing existing attitudes towards teamwork and training, but requires the supplement of other phases to retain information presented.

The next phase is practice and feedback, where trainees are given opportunities to test and try out the concepts they have been introduced such as role plays, games and even questionnaires. A way of providing feedback is necessary to highlight the importance of what was done and what may need improvement. LOT training is an example of this.

The final phase is reinforcement, where repeated exposure to the material is given some time after the original training. As a single exposure is never sufficient, repeated reinforcement of material by drills and further LOT activities help crew to retain information and skills in the long term, ideally applying them in their work responsibilities immediately. This also means that CRM should not be considered a one shot ‘quick fix’ to rectify and improve staff performance. Instead, it should be inbuilt into existing training and refresher courses to reap long-term benefits. Attitudes are another indicator of effect because they reflect the cognitive aspects of the concepts espoused in training. The attitudes that have been measured to assess the impact of CRM were ones identified as playing a role in accidents and incidents. (ICAO, 1998).

2.5.1 Training domains

There are many areas targeted in CRM which crew should be aware of, and these are summarised in figure 1 as a hierarchy figure. CRM emphasise on communication, which in turn links to the six other key skills mentioned above in section 2.3.1.

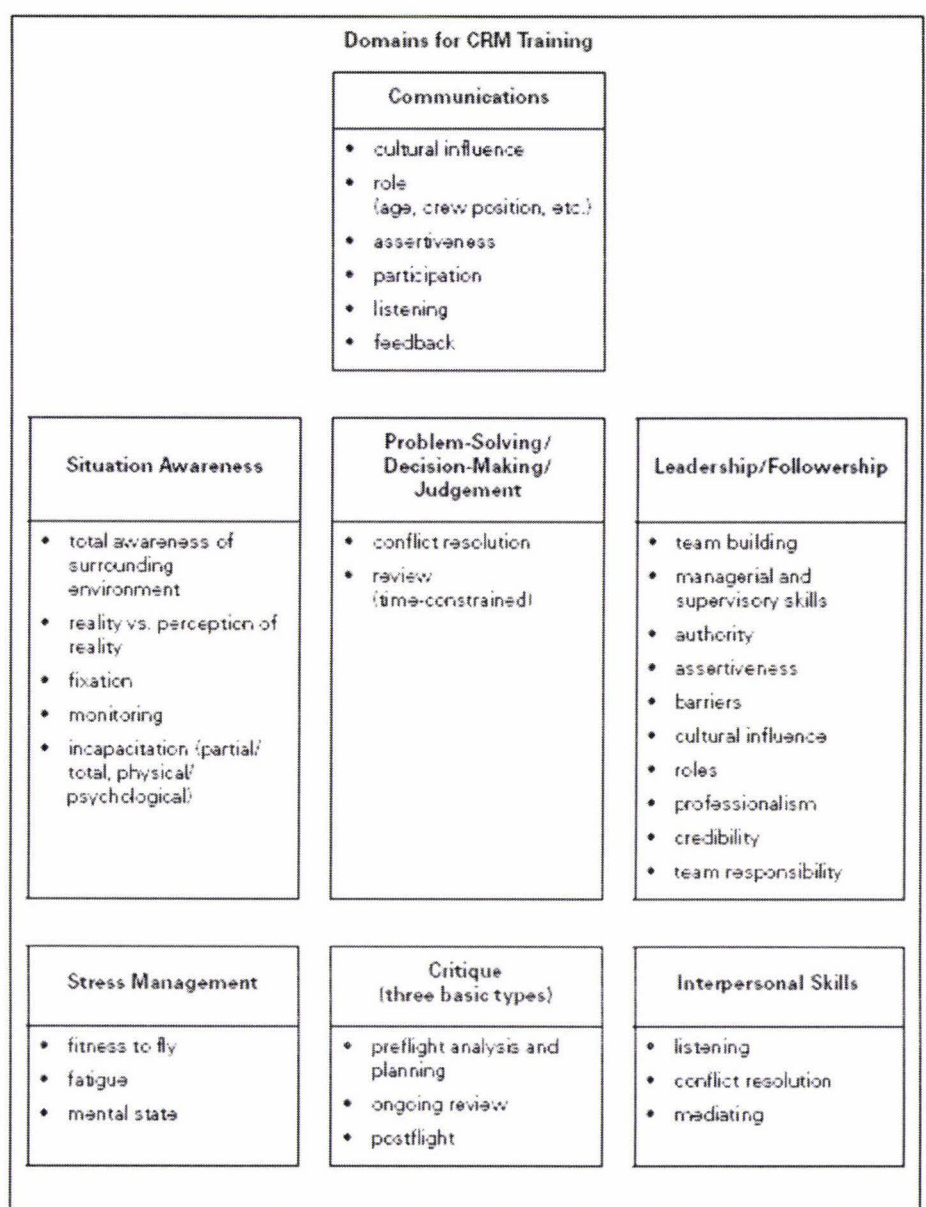


Figure 1. Typical target domains for training in CRM (adapted from ICAO, Human Factor Digest 1989)

These domains are emphasised in most CRM sessions in various industries and constitute key skills to be imparted in training.

2.6 Guiding Principles for CRM Training

The contents and programs of CRM (ICAO, 1998 Human Factor Training Manual) should adhere to the following:

- Training systems are focused on achieving knowledge, skill or attitude;
- Recurrent skills training are delivered in modular form, on a regular basis and over a period of time, so that the skills base is broadened and gradually improved. Thereafter it can be matched to the particular training needs in an individual's performance.
- The use of simulators, ITF for line-oriented training (LOT) can develop basic CRM skills in their crews to a high standard and cost effective method;
- Consistent with other aspect of train crew performance, these standards should be well defined, objective and measurable.
- The knowledge, skills and attitudes required to meet these standards should be equally well specified, so that they can be thoroughly and systematically integrated with other aspects of train crew training and training standards;
- CRM standards of performance have a bearing on railway safety and the efficiency of train operations;
- These knowledge, skills and attitudes have wide applicability and should be incorporated into basic training of all personnel and their respective managers who are involved in the operation and dispatch of aircraft;

- Confidentiality must be maintained during training activities in the classroom simulators and ITF where participants are practicing or experimenting in order to learn skill;
- Where a train crew is considered critically deficient in aspect of CRM, remedial training and appropriate counselling should be made available prior to reassessment.

2.7 Line Oriented Flight Training (LOFT)

Line Oriented Flight Training (LOFT, or more commonly nowadays LOT for non aviation programs) makes use of training simulators with complete crew with flight segment comprising of normal, abnormal and emergency procedures that may be expected in line operations. It emphasize on situations that involve communications, management and leadership. In other words, LOFT involves realistic, 'real-time', full mission training (Safety Regulation Group, 2002).

LOFT is significant as it improves aviation safety through improving training, practice and validation of operation procedures under both normal and emergency conditions. Crew are exposed to the demands and tests that they may encounter one day in line

operation, with realistic difficulties and emergencies to train and evaluate their performance of flight deck management techniques.

LOFT may provide great insight into the airline's operation shortcomings and training effectiveness. If similar mistakes are often made by pilots it may be an indication of weak training or procedural ineffectiveness that should be rectified. By obtaining feedback from crew, it may also highlight instrument location problems, communication difficulties and other imperfections with procedures or infrastructure that could be improved.

To allow for an effective LOFT program, it requires realistic and up to date development of a range of scenarios, methods and instruments that allow for performance evaluation and assessment (e.g. video cameras, interview questions), proper training of the coordinator who's in charge and corporate commitment to make improvements and corrections when feedback is received (ICAO, Human Factor Digest, 1989).

Tools used in KCRC for LOT training include video-aided training (VAT), integrated training facilities (ITF) and decision support system (DSS) as threat management tool (Helmreich, 2000 and RSSB T542).

2.8 Importance of CRM and LOT programs

CRM help the flight crew to value interaction and communication, enabling them to work effectively as a team. It has recently been applied within the rail transportation industry to reduce the number of accidents attributed to human factor (Morgan et al., 2006), and has been the approach used in aviation domains for many years to tackle issues of teamwork among flight crew of the three C's (Wilson, Burke, Priest & Salas, 2005b): concern, cooperation and communication. The benefits of LOT and CRM have been discussed above.

The adaptation of LOT and CRM training in aviation industry resulted in a very positive outcome because of the following factors:

- CRM training improves inter and intra-crew performance to achieve desired results; reducing accidents and errors and increasing safety, flight efficiency, and optimisation resources (Salas, Rhodenizer & Bowers, 2000)
- LOT can provide opportunity for flight crew to handle simulated critical incidents (Salas, Fowlkes, Stout & Milanovich & Prince., 1999). KCRC uses integrated training facilities (ITF) and simulators to present incident scenarios which train crew are unlikely to have experienced due to their varieties.
- Aviation industry needs to balance effectively piloting, communications, crew interaction, leadership and managing all the available resources through CRM,

while safety critical communications become mandatory training in railway industry (RSSB, 2002).

The LOT component should be included in KCRC's program as its railway network has been extended with increasing number of tunnels and underground stations. Due to additional safety risks and factors incurring from such environments, the safety awareness of crew should also be raised and trained to understand and mitigate such risks. Local railway regulators have promulgated in depth advisory information on co-ordination and safety critical communication training but up to now this requirement is not mandated. KCRC now voluntary adapts CRM training to enhance railway safety based on lessons learned from King's Cross and Channel tunnel fire incidents (analysed in section 3.4). There are urgent needs to enforce training on incident handling and emergency evacuation such that crew will be adequately prepared for any situations that may arise.

2.8.1 Criteria to assess the impact of CRM training on pilot performance

Research in improving teamwork in high reliability industries identified four criteria to assess the impact of CRM (Wilson, 2005; Flin, O'Connor & Mearns, 2002):

- Crew behaviour
- Attitudes

- Learning and motivation showing acceptance or rejection of CRM concepts
(Helmreich, Klinec & Wilhelm, 1999)
- Reactions to the training courses

(Statistic analysis of train crew post CRM behaviour change as discussed in chapter 14).

2.9 Justifications for Crew Resource Management in KCRC

Lesson learned from other railway consistently demonstrates failure in human performances as being causal or contributory to railway accidents. Indeed human errors are , in many ways, indicative of failures in the railway system. Therefore, a proactive human factor training concept would be capable of identifying and corrective all human factor deficiencies.

- Lack of structured refresher training for train crew;
- Lack of co-ordination between train crew, station controller and traffic controllers for manpower back-up;
- Lack of interactive training in Standard Operating Procedures (SOP) causing confusion between crew members and creating hazardous situations;
- Optimisation of training costs by using e-learning, computer-based training (CBT), integrated training facilities (ITF) (RSSB, T542);
- To test the effectiveness of using of decision support system (DSS) to support train crews to deal emergencies;

- To develop self-learning portals for train crews;
- To reduce training time, type-rating tests for train drivers, station controllers and traffic controller train crew due to job rotation.

Chapter 3. Literature Review on Human Factor

3.1 Introduction

High cost, technology and maintenance intensive industries like railway, aviation and aerospace often suffer from what's known as a 'graveyard mentality' (Weir, 2000). Serious managerial motivation for improvements and reviews to the existing safety network often comes only in hindsight after serious accidents involving loss of life and public attention. The recent September 11 attacks in 2001, 2005 London train and bus bombings and the 2003 Columbia space shuttle disintegration are such prominent examples. All have initiated much in-depth and serious research in related areas into the prevention and reaction to similar situations in the future.

Whilst it is true that no one could ever predict all possible scenarios and modes of failure of any system, designers and engineers should nevertheless strive their hardest to avoid potential disasters. Despite its importance, making improvements in safety almost always come at extra material, training and infrastructure costs, making it an unappealing choice in any project, particularly at the start. As a result, safety considerations in most projects are acceptable, but not exceptional. Although safety investments and considerations most cost-effective at project draft, less effective safety improvements are usually only made "post mortem" after a costly incident.

It may be unrealistic to expect the graveyard mentality to shift in the near future, but there still may exist a cost effective way to improve upon existing safety standards in the railway industry in a commonly overlooked area- that of staff and crew competency and training, leading to a reduction in human factor errors.

This literature review will focus on three sources relevant to this study: research studies, human factor theories from textbooks and incident reports.

3.2 Human Factor Distinctions

What exactly causes human errors to occur? A century ago, Mach (1905) stated that “knowledge and error flow from the same mental sources; only success can tell the one from the other” (Reason, 1990). It makes sense therefore to categorise and define errors and their causes to pinpoint more precisely such sources.

Reason (1990) describes three levels of performance correspond to decreasing levels of familiarity with the task. As the degree of familiarity decrease, the degree of conscious control over the task will increase. Conversely, if a task is very familiar, little conscious control is exerted over the task, which may make it susceptible to errors.

3.2.1 Skill-based level

Human performance is governed by stored patterns of pre-programmed instructions represented as analogue structures in a time-space domain. Actions are usually largely practiced and little conscious monitoring occurs. Errors at this level are related to the intrinsic variability of force, space or time coordination;

3.2.2 Rule-based level

The rule-based level is applicable to tackling familiar problems in which solutions are governed by stored rules. The rules may have been learnt as a result of interaction, training or observing experienced staff members. The level of conscious control is intermediate. Errors may be caused out of habits, use of an incorrect rule, misdiagnosis, or forcing the situation into previously successful moulds.

3.2.3 Knowledge-based level

Knowledge-based level comes into play in novel situations for which actions must be planned on-line using conscious analytical processes and stored knowledge. Conscious attention is paid to the task. Errors arise due to habitual intrusion rather than adopting new procedures or failure to read the situation comprehensively causing the wrong procedures to be applied.

Better categorisation and understanding of error types helps to design and focus training models on these areas of weakness to reduce their likelihood and draw crew attention.

Later, Kletz (2000) defined four error categories, and the causes of human factor related errors may be classified as mistakes, violations, mismatch or slip/lapse errors, as shown in table 1.

Table 1. Classification of Errors by Kletz (adapted from Kletz, 2002)

Error category	Error Description
Mistakes	Errors that occur because someone who knows what to do did not do so correctly
Violations	errors resulting from someone who know what to do deciding not to do it, usually due to what appears to be a good reason
Mismatch	errors caused by a person’s inability or inexperience to carry out a task
Slip and Lapse	errors due to lapses of attention

3.3 The Swiss Cheese Model

Reason’s Swiss Cheese Model (1990) of human error integrates the human error perspectives into a single unified framework. The model is based on the premise that railway operations can be reviewed as a complex production system (ergonomic perspective) that often breaks down because of ill-fated decisions made by upper level management and supervisors (organisational perspective). However, the impact that these fallible decisions have on safe operations may lie dormant for long periods of

time until they produce unsafe operating conditions such as poorly maintained equipment (ergonomic perspective) as well as unsafe train crew condition such as fatigue (aero-medical perspective) or miscommunications among operators (psychological perspective). All of these factors in turn affect an operator's ability to process information and perform efficiently (cognitive perspective). The result is "human error" followed by an incident or accident. Reason's Swiss Cheese Model provides a comprehensive theory of human error and accident causation.

In general, the errors contributing to a human made disaster recognisably belong to the familiar body of slips, lapses and mistakes to which all of us are prone in the normal course of daily railway operations. Drawing distinctions helps us to realise their differences and to predict and reduce the occurrences of human errors in each of these domains. Whilst violation of railway operation rules such as signal passed at danger (HSE Ladbroke Grove Investigation Report, 1999) tends to decline with age, errors did not. Men at all ages reported more violations than women, but women were significantly more lapse-prone than men (or more honest) (Wiener, 1988). It is not easy to learn the right lessons from past incidents or disasters, but still plenty can be gained.

3.4 Examples of Human Factor Errors

There has been a growing public concern in the light of the terrible consequences of human error: the Tenerife runway collision in 1977, the King's Cross tube station fire in 1987 and the Ladbroke Grove Junction train collisions in 1998. Such incidents listed below and elsewhere in this document reminds us that the tragic human cost should always serve as a solemn reminder that the importance and stringent requirement for safety can never be compromised.

Three major railway inquiry reports in UK were reviewed to ascertain the influence of a lack of experience (competence, training and driver vigilance devices) on safety. The Clapham Junction, Southhall and Ladbroke Grove accidents presented here are typical examples in which staff incompetence was the major contributor to accidents.

3.4.1 Clapham Junction- competency of wiring technician

The accident at Clapham Junction in 1988 involved three trains, two running towards Waterloo and the other train heading towards Haslemere on the opposite line. The immediate cause of the accident at Clapham Junction was incorrect wiring, which created the potential for a false electrical current feed, causing the signal to be green when it should have been red. This caused a train to proceed through the checkpoint,

believing the signal was correct, causing it to collide with a stationary train ahead. The accident killed 35 on board and injured hundreds more.

The root cause of the accident was attributed to human errors. Firstly, the wireman himself had inadequate training and experience on project work, and secondly, management should not have made the error of assigning the incompetent wireman to take over the wiring job from maintenance team. A senior, experienced project manager should have been in charge instead. The report also found the area to be understaffed and workers overworked on repetitive tasks, both of which significantly increase the chance of lapses and errors due to time pressures and lack of concentration.

3.4.2 Southall- Driver Vigilance Device

The accident at Southall in 1997 occurred when a high speed passenger train collided with a freight train. Seven people died as a result of the accident and a further 239 were injured. The accident was caused by signal passed at danger (SPAD) of the high speed train, but the root cause was due to a defective automatic warning system (AWS) which failed to brake the train when a red signal had been passed. Although the system only served as an advisory system, the train driver had grown reliant to the AWS system and failed to double check the signals visually. When the AWS was not in operation, he

could not visually determine the state of the signals and brake in time, causing the accident.

3.4.3 Ladbroke Grove- Train driver at low level of arousal

The accident at Ladbroke Grove in 1999 involved an almost head on collision between two trains due to SPAD, causing 31 deaths and 523 injuries. The new train driver may have had difficulty judging his line due to insufficient route knowledge according to the complexity of the signalling layout at Paddington. Despite past incidents involving SPAD on the same line and common complaints about signal visibility, the driver failed to heighten his concentration. The accident highlighted the importance of clear communication between drivers and control centre crew to fill in each others' blind spots and ensure a safe running environment.

3.5 Two Ways of Looking at Human Error

The human response to each incident is almost always "Why?" Each accident opens up a series of questions in each crash investigation report to find the root cause and who's to blame for the tragedy. What is human error, and can it be eliminated? According to Dekker (2005) there are two ways of looking at human error.

1. Human Factor is not a root cause of a railway accident. Failures are unexpected and do not belong in the system. Failure are introduced to the system only through the inherent unreliability of people
2. Human errors will always have a chance of occurring. It is better to change the situation by early adaptation of system safety management and human factor design to prevent error than expect a person not to make an error.

3.6 The Bad Apple Theory

The first and most commonly held view on human error was titled “the Bad Apple theory” by Dekker (2005). This theory implies that complex systems are well designed and flawless in nature, were it not for the erratic behaviour of some unreliable people (bad apples) in it. The theory attributes that human errors cause accidents: human are the dominant contributor to more than two thirds of them.

According to the bad apple theory, new technology does not remove the potential for human error, but relocates or changes it. Adding or enforcing existing procedures does not guarantee improved compliance. A typical reaction of this theory to failure is procedural over-specification, where mismatches between written guidance and

operational practice always exist, as do discrepancies between operating rules and actual practices.

The bad apple theory applied to high risk domains is most popular because it is logical and relatively straight forward. It is simple to understand and relatively cheap to implement. The theory follows the rationale that people in safety-critical jobs are generally motivated to stay alive and keep their customers alive. Those in charge are assumed to be doing reasonable things by their point of view, focus of attention, knowledge of the situation, objectives and the objectives of the organisation they work for. They would not want anything to happen to customers, as their lives and livelihoods are on the line. In human factors this is called the local rationality principle (Wiener, 1988). Generally the workers will not want to make a mistake, but will do all that they agree are reasonable and appropriate. Therefore, by this argument, the safety considerations of the system should be comprehensive and flawless.

In the event of a failure, the bad apple theory suggests that it is merely an aberration, a temporary hiccup in an otherwise smoothly performing and safe operation. Because of this, nothing more fundamental or more expensive needs to be changed in the systems or procedures other than removing the source of error- people.

In the aftermath of failure, the public and media usually exert enormous pressure on responsible parties to locate and remove the causes of failure. Taking out irresponsible practitioners is always a good start to saving the public image of the incorporation ,(Schneider & Mase 1968). It tells the public that the mishap is not a systemic problem, but just a local glitch in an otherwise smooth operation. When the bad apple is thrown out, all will be fine. The public is satisfied, and the company escapes scrutiny until the next incident.

3.6.1 Is the bad apple theory supported?

Whilst the logic and user friendliness of the bad apple theory is appealing, it has several weaknesses. It is worth remembering that safety is never the only concern, or even the primary concern in industry (Dekker, 2005). Railway and aviation systems do not exist to be safe, they exist to make money and to render a service. Beside safety there are other objectives and pressures such as time, money and customer expectation constraints. Because of this, failures are rarely attributable to individual practitioners, but are the tip of icebergs, mere symptoms of systematic problems to which everyone may be vulnerable to if at the wrong place at the wrong time. The culture of relying on procedures or new technology to make things safe is not beneficial to the company, as humans need to maintain alertness and discretion to deal with complex and dynamic circumstances, which are inadequately covered by pre-specified guidance.

3.7 The New View on Human Error

3.7.1 Human Error is not the Root Cause

In formulating the second and newer view on human error, an investigation was driven by the unifying principle “Human errors are symptoms of deeper trouble” by Dekker (2005). It was found that human error is not the conclusion but the starting point of an investigation. The new view avoids judging people for human error. The point of an investigation is not to find where people went wrong. It is to understand why their assessments and actions seemed to make sense at the time. It makes much more sense to interpret retrospectively the actions of staff or crew members to investigate potential blind spots and loopholes in the system or procedures rather than simply firing or dismissing the incident and its real root cause.

The five guiding principles outlined by INPO nuclear power industry (Strauch, 2006) can be borrowed and applied in railway industry. In such safety critical industries it is not to be complacent and assume errors will never occur, but to expect the inevitable and minimise its risk, extent and consequences when disaster strikes. The principles assume

1. People are fallible- even the best make are susceptible to mistakes
2. Error-likely situations are predictable, manageable and preventable
3. Organisational processes and values influence individual behaviour

4. People achieve high levels of performance based largely on the encouragement and enforcement received from leaders, peers and subordinates
5. Events can be avoided by understanding root causes of mistakes and by the application of lesson learned.

Putting the above into practice by TOCs should be able to boost staff performance as well as reduce the likelihood of error in the company.

3.8 Managerial Error

In enquiries into numerous major rail accidents, including the King's Cross underground fire and the Clapham Junction rail crash, senior management failures were considered to be a primary cause. It is now recognised that the policies and strategies defined by senior management, and the cultures created and engendered by them can predispose accidents to occur or not to occur, and that the final triggering event is often merely the activation of an "accident waiting to happen".

Accident investigators and engineers have difficulty applying the appropriate method to assess human error in most engineering risk analyses, as they do not have appropriate guidance on the subject. The development of a corporate safety culture and of

appropriate processes to reduce risk depends on the ability and willingness of people.

Of all parties, management of TOCs in particular need to learn from past mistakes to prevent future accidents. In fact it can be said that accidents occur simply because we neglect the knowledge that is available (RSSB, 2002). This is almost inevitable if management leaves the task of learning their lessons to subordinates rather than equipping themselves.

From case studies at train crashes at Clapham Junction was due to wrong wired, Southhall and Ladbroke Grove incidents were due to SPAD, media and the general public may be quick to point the finger and blame crashes on train driver errors because train drive always took the blame on train crashes (RSSB, 2004b) to detract attention from other causes, as seen regularly in the media exposure aftermath of any railway disasters. Train driver “error”, however, is often the result of fatigue or roster of unqualified/ inexperienced train crew, both of which are management responsibilities. Cost optimisation in railway always aims to improve efficiency and productivity to lower operating costs. However, the temptation to overwork or under train staff is great to any management under cost constraints. Equally appealing is the decision to reduce the maintenance and appraisal budget in an effort to further cut costs. However such short term savings is often what results in large scale expenses when accidents surface.

This is the precise reason why blame should not rest on crew or driver errors, but find their roots in management (Strauch, 2006).

Once a management decision had been taken, there is a tendency for management to stick it through thick and thin because unpicking a decision is even more difficult and stressful and is in some instances damaging to the person's ego. Reviewers Strauch (2006), Hendrick and Benner (1987) advises that railway management need to be aware of such pressures and be able to respond appropriately in the event of any incident to correctly rectify and re-evaluate existing procedures, crew and modes of operation to eliminate the chance of further related incidents occurring.

The above analysis shows that it is better to revise the situation by early adaptation of system safety management and human factor design to prevent, or allow leeway for error, rather than to expect a person not to make an error.

Previous sections outlined the importance of introducing a safety culture across all levels from management down to drivers and crew. Whilst industry is aware of such a need, what is currently done still have room for improvement by further training focusing on relevant aspects of safety.

3.9 The Importance of teamwork in the Railway Industry

The Railway Safety and Standards Board (RSSB) research program on teamwork in the railway industry (RSSB, 2003a) concluded that teamwork is widely recognised as a key component of the safe operation of the railways, and that all personnel in safety critical roles should be trained in how to carry out safety communications. All initial training for safety critical occupations should therefore cover basic teamwork knowledge and skills to build a foundation for more advanced team working skills. Each crew member needs to be competent and proficient in their area of expertise to contribute effectively to the performance of the entire team. In addition, building teamwork, trust and communication will also be necessary to improve collective performance.

The report also mentioned that “there is clear evidence that inadequate experience or practice affects safety.” Experience is construed as a measure of the amount of exposure and practice of the range of routine tasks in connection to the range of tasks the individual has recently had. Some respondents from the research perceive that there are problems with the level of staff experience for a various reasons, including:

- Recruitment problems due to economic life cycle;
- Relying on existing experience as a mean of developing competence without proper investment in an effective training process;

- A shortage of adequately experienced staff;
- Inadequate assessment or measurement of staff experience;
- Short-sighted succession planning.

Such points highlight the importance of having a sound training program in place that makes full use of current crew's experiences in raising up and training younger team members. Management of TOCs will need to be aware of how to improve all staff experience and exposure levels in their respective posts and also in teamwork to utilise their skills most effectively, whether it be communicating with crew in and outside of their own divisions. It also shows that education of those in managerial positions about the right ways to implement training programs and ensure staff well being is equally important in the contributions of safety in training crew members.

3.10 Factors that influence training Success

Due to these difficulties, competence management and experience management become strategic issues in the railway industry, as they need to not just look at the here and now, but plan for the future and perceive future needs. From an organisational and individual perspective, line oriented training (LOT) or regular refresher training courses becomes mandatory to track, monitor and evaluate the experience levels of train crew.

Competency can then be construed as a measure of whether the individual has recently had sufficient exposure and practice on the job.

According to research findings on training effectiveness (Wiener, Kanki, & Helmreich, 1993), it had often been assumed that the success of training is contingent upon variables such as instructional approach, media, device fidelity, course duration, and diagnostic feedback. Cannon-Bowers, Salas, Tannenbaum & Mathieu (1995) suggested a model of training effectiveness that shows how factors that occur before, during and after training can influence learning. Pre-training factors such as organisational, situational, trainee characteristics and supervisor support tends to build staff confidence, leading to more successful training (Cohen, 1990) and greater chance that the skills learnt will be transferred from training to the workplace (Huczynski & Louis, 1980). In other words, supervisor attention and effort invested into training can have positive effects on performance (Magjuka, Baldwin, & Loher, 1994). Drawing from their own experiences in developing CRM training, Boehm-Davis, Holt, Hansberger & Seamster (1999) concluded that the commitment of senior management is the first step for developing CRM training. Factors that occur during training, such as training method, design, and adherence to learning principles can also affect training outcomes (Smith-Jentsch, Jentsch & Payne, 1995).

Other CRM research findings (Wiener, 1988) state that CRM cannot be isolated from other factors which influence its success. Salas et al. (1999) and Boehm-Davis et al. (1999) gave the examples of how incorporating what is known about training effectiveness into the design of a CRM training program can lead to improved skills in the workplace. If the CRM program receives support from management as sponsors and encouraged the applications throughout the training pipeline, the trainees are engaged and motivated to learn and apply such CRM concept. Such principles should be applied in this research, where KCRC will sponsor and fund relevant teambuilding exercises in the hopes of improving training effectiveness.

Chapter 4. The need for safety oriented training in railway industry

CRM training in railway is equally important as in aviation industry. Just as airline disasters prompted major investigations and revision in the aviation industry, studies of railway disasters and causes also reveal an urgent need for team oriented training. The cases presented here, complementing those already mentioned in chapter 3 showed that railways are equally susceptible to communication breakdown, human errors and poor emergence response by crew and supporting members.

In 1980, the Saudi Arabian Flight 163 cabin crew could not find the correct procedure to handle an onboard fire incident (see chapter 12 for cause and consequences). All 301 people died of smoke inhalation after landing. Likewise, in 1991, two passenger trains collided in the 6.5 km-long tunnel under the River Severn in England injured 185 passengers. The rescuers did not reach the train until two hours later because no-body informed the rescuers due to communication error. In this case, the necessary safety procedures fell like dominoes, as described in chapter 12. The communication efforts were confusing and incorrect thus compounding the situation. Decision-making authority among emergency services complicated rescues attempts. The management of other TOCs learnt a lesson from this accident and reviewed their incident handling and emergency safety procedures.

The Daegu Subway fire in 2003 was caused by arson attack where an arsonist ignited cartons of flammable liquid at the morning rush hour. The fire spread quickly because neither the trains nor the station facilities were made of fire retardant materials. A second train which was dubiously allowed to enter the station was stranded due to cut off of power supply and caught alight quickly. Because the train driver and his superiors did not know how to respond appropriate to the incident, the driver fled the train, taking its key and trapping 79 passengers on board to die. The station also lacked fire extinguishers, emergency lighting and ventilation, killing many victims who survived the fire due to disorientation and asphyxiation.

These incidents illustrated that some critical factors contributed catastrophic consequences; there is far “too much reliance on procedures” and “ineffective communications” in the course of an incident (RSSB, 2001-3).

This is one of the motives for KCRC to develop decision support system (DSS) bases on “what-to-do” checklist to deal with incident handling. The DSS improves the process by guiding the traffic controllers in handling the incident through the respective action plan and mechanism for proper transmission of messages to all the parties concerned corresponding to the kind of incident. It is hoped that a

complementary training program, similar to CRM and LOT be established in addition to this to address all areas of interpersonal skills amongst KCRC staff.

When faced with an emergency situation, the chances of survival can increase a great deal a sound emergency action plan was prepared, and if train crew received adequate training and exposure to such procedures. TOCs should ensure that the train crew is competent and confident enough to handle any disaster, natural or otherwise. If train crews were properly trained, and the trains and the railway infrastructure were made of fire retardant materials, the King's Cross and Daegu station fire disasters could have lessened their severity.

4.1 Problems encountered in the Railway Industry

Railway technology has gone a long way to identify which trains are on the track, and their whereabouts, controlling their progress by keeping safe but efficient train to train separations, and managing communications between trains and operations control centre (Wilson & Norris, 2005). However, the above case studies show that the design, implementation and operation of such systems generate a host of new human factors problems.

Although the implementation of automatic train protection (ATP) was able to significantly reduce the number of fatal accidents due to signal passed at danger (SPAD), driver experience erosion due to control automation was detrimental to safety (Wright, Turner, Antonelli & Bendig, 2003). Over a long period of smooth normal train operations, traffic controllers in operations control centre or train drivers become less efficient in manual control under degraded train operations due to lessened exposure.

4.2 Experience Erosion over Time

Based on results of a brief survey of railway stakeholder in UK in 2003 (Wilson & Norris, 2005), there are reasons to believe the level of driver and crew experience is being eroded in the railway industry (80% of experts agree that this is a potential safety issue), including difficulty in recruiting, contractor's experience, ageing workforce, job specification, loss of experienced staff and multi-skilling. Some respondents perceive that there are problems with the level of staff experience for a variety of reasons, depicted in figure 2, which include recruitment problem, a lack of managing experience, lack of adequate experienced staff; inadequate assessment or measuring of experience and difficulties for succession planning.

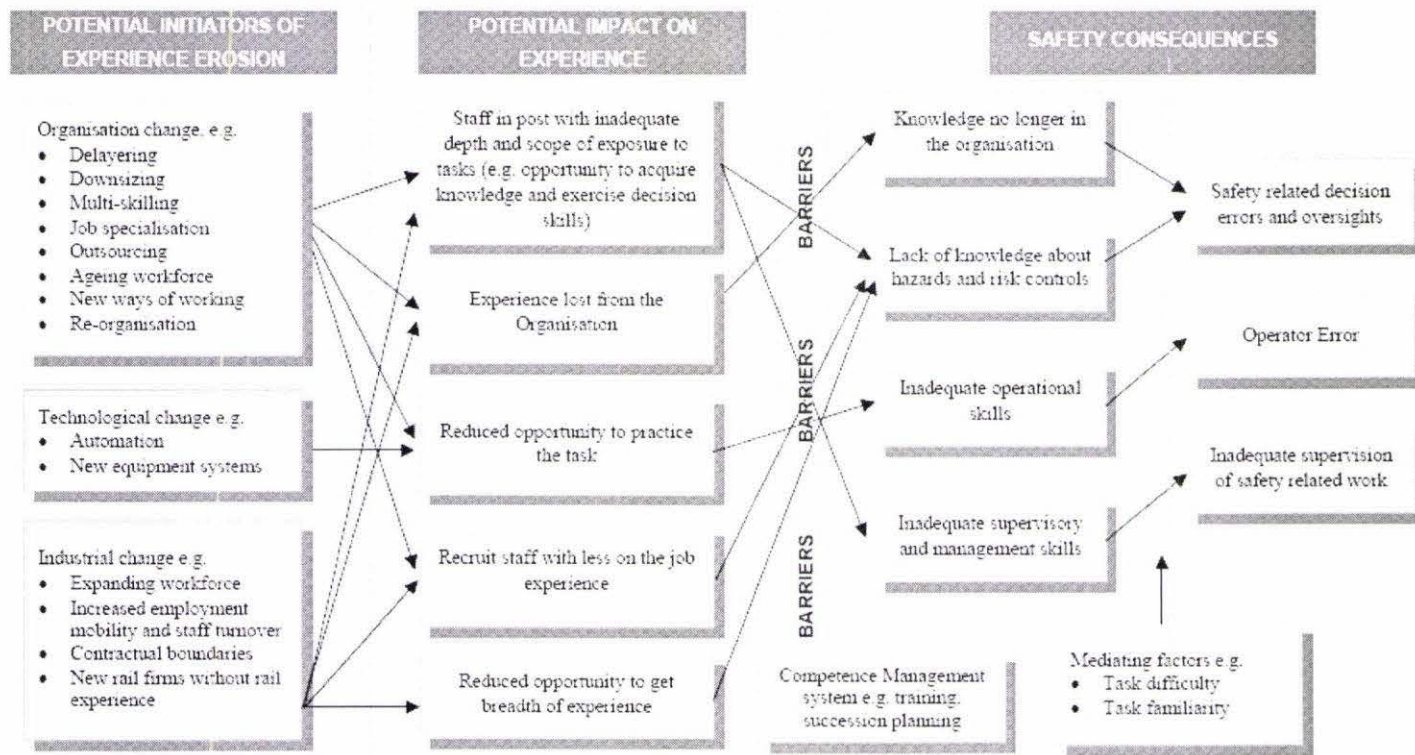


Figure 2. The Impact on Safety due to Experience Erosion (RSSB, 2003b).

Many interlinking factors can be seen to affect or adversely impact safety due to experience erosion.

There is clear evidence that experience erosion does affect safety (RSSB, 2003b). The impact of the loss of staff experience on safety is considered and there is clear evidence that experience should be better managed. Experience is construed as a measure of whether the individual has recently had sufficient exposure to and practice of, the range of tasks to acquire the skills and knowledge.

There are number of key factors (RSSB, 2003b) that appear to bear upon the required level of experience:

- Level of pre-existing competence
- Level of supervision/on line support
- Safety criticality of the tasks
- Task complexity – task specific knowledge needs
- Task frequency typically high level of experience are required to compensate for lower level of qualification and formal training
- Lower levels of experience are accepted where a person is directly supervised or working along side a more experienced competent person;
- High levels of minimum experience are required for more safety critical tasks
- High levels are required where tasks require system specific knowledge

- More frequent review of experience/competence are required in those cases where it cannot be assumed from “time served” that individuals have had the opportunity to maintain their competence through annual refresher training.

The control and allocation of staff members to tasks to which they qualify for is an important arrangement by management to ensure the right people have the right jobs, and that those in safety critical roles have adequate training and experiences.

4.3 Situation Awareness

Incidents like the Clapham Junction accident was due to wrong wired, Southall and Ladbroke Grove accidents were due to train drivers failed to notice signals correctly or for potential dangers showed that there is a need to improve the driver’s awareness of his surroundings in order to detect and respond in time to danger. In CRM terms, signal passed at danger is the malpractice of train driver unable to maintain situation awareness and is a key target area to be addressed.

According to the International Civil Aviation Organisation (ICAO), manual (HF Digest 2 (reprinted by Safety regulation group, 2002), situation awareness refers to “one’s ability to accurately perceive what is going on in the cockpit and beside the aircraft”. It is one of the major skills for development in CRM along with communications,

problem solving, stress management, critique, interpersonal skills and leadership/followership. Crew in safety critical roles should maintain situation awareness (SA) at all times to ensure safety of the vehicle and spot potential dangers in time. SA is necessary in order for people to perform tasks effectively (Endsley, 2000). The Federal Aviation Administration (2002) gives a similar definition, but place more emphasis on the impact of awareness on cue extraction and direct perception (i.e. its contribution to attention) (Kardos, 2004). CRM and LOT training will be able to increase crew situation awareness by studying past incidents and simulator training to high the importance of increasing and maintaining crew alertness.

4.4 Teamwork Effectiveness

Team working is widely recognised as a key component of the safe operation of the railways. Although the train is under the control of one driver with no other navigation crew on board, the driver maintain communication and cooperates with various personnel such as station captains, traffic controllers, central control centre communication staff as well as the automatic train operation device.

Proper crew training as a team helps strengthen teamwork and compatibilities between individual crew members such that they can build rapport and adapt to each others' styles. For this to take place it is important that the team train together during LOT simulations, as well as in work operations. Teambuilding activities unrelated to the

line of work such as games may also help to strengthen bonds.

4.5 Identifying areas of training needs

Identification of such training needs and information require improving competency in safety related decision making (Kardos, 2004). According to the Federal Rail Administration (Morgan et al., 2006), statistics show that 73 percent of rail accidents attribute to human errors. These numbers raise the need in the rail industry to examine all possible methods to increase safety by predicting and preventing human error accidents. Clearly railway needs a program to target and reduce the consequences of human errors. It is expected that CRM and LOT training programs will be the most suitable tools to address this need.

Chapter 5. Adapting CRM and LOT training for Railway

5.1 Similarities between Railway and Aviation industries

Aviation and railway industries have some critical factors in common:

- 70% of accidents were caused by human-factor errors (FAA, 2002, Morgan et al., 2002)
- Most accidents has the capacity to result in huge causalities and fatalities
- Most of the human-factor errors can be mitigated by effective selection and training
- Human behaviours may be affected by managerial or organisational aspects e.g. duty times, shift hours
- Industry is money and profit driven
- Susceptible to graveyard philosophy due to unwillingness to commit capital to invest in safety (Weir et al., 2002)
- Requirements for efficiency optimisation in terms of limiting airspaces or headway between trains.

5.2 Adapting CRM and LOT for Railway

From earlier chapter it is easy to see the benefits that CRM can potentially bring to the railway industry. As yet, CRM exposure in the railway industry is limited, and usually only involve engineers or conductors (Morgan et al., 2006). In Hong Kong and KCRC there had been no prior exposure of CRM to staff and crew members.

It is not easy to directly translate current CRM methods from aviation to railway as the teams and department involved are slightly different, as are operational procedures and emergency pressures. There are many different types of CRM modules and ways to impact information as presented in chapter 2 ranging from lectures to games, and careful selection of content and presentation styles will need to be considered for best impact and relevance. Despite this, most aspects of CRM and LOT training can be applied directly into the railway industry following their methods and focuses, as the training needs and reliance for teamwork of both industries are very similar.

Human reaction to external stimulus/scenario is complex and unpredictable, being subject to the situations and circumstances that they may encounter. No matter in railway or aviation or any other industries, nervousness and fear are the normal instinctive reaction when facing unexpected detrimental changes of conditions/situations.

Whilst this behaviour cannot be fully eliminated, it can be reduced through undertaking effective trainings and simulated scenarios. LOT application directly addresses this need, increasing staff exposure to unexpected circumstances, thereby building their emotional capacity and stress handling techniques such that they may be able to remain calm in the face of danger.

5.3 Interpretation of CRM and LOT in Railway Industry

With reference to the experience gained in aviation industry, CRM and LOT can be applied in railway industry because the working relationship between flight crew and train crew are very similar, they are required to work as a team to enhance railway safety. Railway industry needs to develop the effective balance of customer satisfaction, effective communications, train crew interaction, leadership and managing all the available resource within the railway infrastructure.

5.4 CRM and LOT Skills to be developed

Analogous to aviation industry, skills of train crew to be developed under CRM and LOT training programme should ensure the Train crew that she/he should:

- Ask the right questions and state frankly the opinions for the interests of safety in particular in safety critical communications;
- Make constructive comments to workout differences;
- Be trained in decision making to arrive at safe and sound decisions quickly, and changing one's mind if convinced, in the event of emergency;
- Know as much as possible about the range of different resources available; and use them in the most effective manner

The achievement of CRM depends on company commitment, allocated resources, the structure of the organisation and the quality of staff (Wilson, Norris, Clarke & Mills, 2005a).

Crew Resource Management (CRM) is now widely accepted as the tools for minimising vulnerability to error, and for coping with the unexpected events. In KCRC, CRM training will be further enhanced with line oriented training (LOT), including live drills & exercises to broaden experiences and familiarise crew with regular and emergency scenarios. Train crew needs to know what CRM is and how it can help them work more effectively. They also should understand the value of LOT training on in its practical application.

The end goal from the crew's point of view is the ability to use material and concepts introduced in CRM to avoid avertable accident situations. In cases of unexpected circumstances, they are to identify correctly relevant handling procedures and respond quickly and appropriately to minimise harm and risks.

5.5 Corporate Training Goals

The implementation of the CRM and LOT program aims to strengthen the crew's leadership, situation awareness and the ability in utilising various resources in the decision making process. Furthermore, all safety critical personnel should be given regular opportunities post training to practice teamwork skills through CRM training and regular drills, to simulate incident handling in abnormal or emergency situations. This ensures that their experience and teamwork partnership continues, as well as refreshing information taught in the past and increasing overall familiarity and competence at their roles.

5.6 Training Methods

Train crew performing safety critical functions have been using the training infrastructure (ITF, CBT and VAT) that enable them to build and maintain share awareness with each other and their working situation. KCRC employing personnel

involved in safety critical teams shall follow the policy supported by systems and teamwork practices with internal and external parties such as the government departments.

Chapter 6. The current KCRC Safety Model

6.1 Introduction to KCRC

There are two train operating companies (TOC) in Hong Kong: the Kowloon Canton Railway Corporation (KCRC); and the Mass Transit Railway Corporation Limited (MTRCL). KCRC, established since 1911, is the railway company providing domestic railway services in Kowloon peninsula and new territories as well as intercity trains to Mainland China. MTRCL was established in 1979 and provides metro services between Kowloon peninsula, Hong Kong, Lantau Islands and Chek Lap Kok airport. The daily patronage of the two TOC is 3.7 million- 1.4 million from KCRC and 2.4 million from MTRCL.

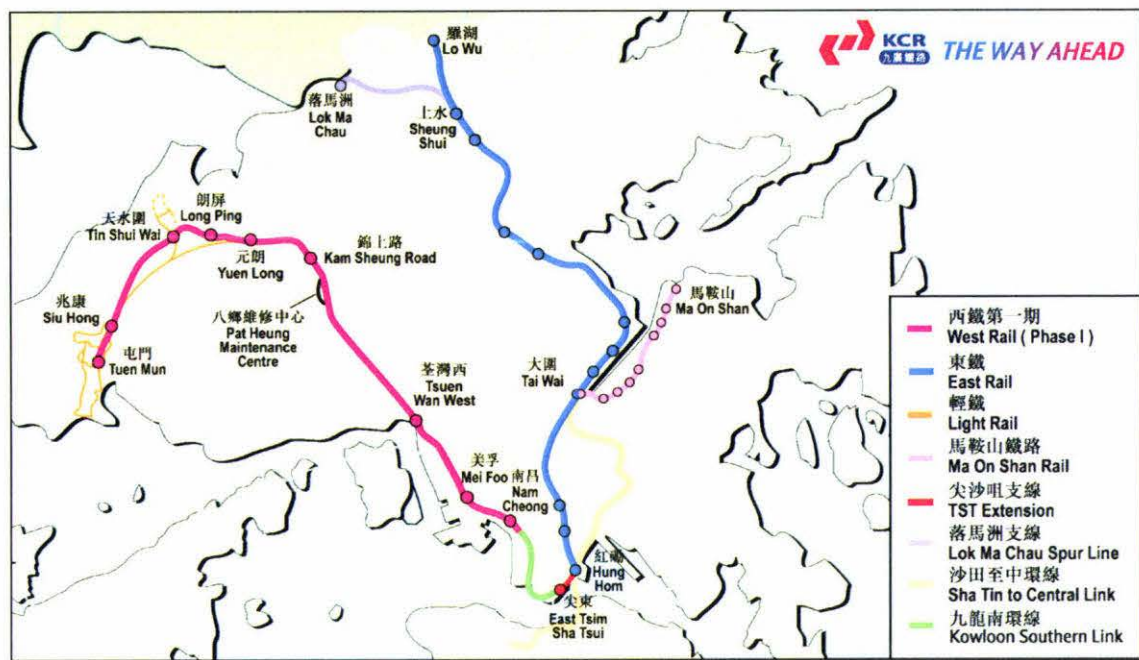


Figure 3. The Route Map of KCRC showing stations and routes of East Rail (blue) and West Rail (magenta) services in Hong Kong. Coverage of MTRCL is shown as thin grey lines.

In the railway sector, an accurate and advanced signalling system is a dominating factor in ensuring railway safety and efficiency. Initially, when railway industry was at its infancy, mechanical signals and manual driving were adopted. The second generation upgraded it to colour light fixed block signalling, and in later years up to automatic train operation (ATO). Nowadays ATO has been extensively developed with the capacity for driverless train controls and operations. For the past thirty years, no fatality incidents for KCRC passengers had been recorded from human error or failure of railway infrastructure.

Subsequent to the modernisation of train control and signalling systems, the optimum headway between successive trains (i.e. waiting time between two consecutive train services) can be as narrow as 90 seconds. This is highly compatible with the world's top metro services.

KCRC provides daily operations of more than 4,400 train trips. The daily patronage of KCRC is 1.4 million; East Rail is 920,000, West Rail 200,000, Ma On Shan Rail 110,000 and Light Rail 400,000 respectively. On average there are over 75,000 passengers per hour taking KCRC train services.

The total working population in KCRC is over 6,200, with over one thousand staff employed as train crew. Train crew consists of train drivers, traffic controllers, and station operators (KCRC, 2005d).

6.2 Incident responses

In KCRC, because of the high volumes and density of train services, minor incidents can rapidly deteriorate into major events if not well managed. The objective if abnormal operations are encountered is to keep trains moving, maintain train air conditioning and maximise throughput. Detraining passengers between stations is only

considered as a last resort. Special precautions will be required for underground or tunnel sections. Using “standing train protection”- the use of trains to deliver the maintenance technicians to access a site, evacuation and emergency maintenance is preferred over other means.

6.3 Safety Management

Train operations are safety critical in many aspects, and the safety of railway traffic is based upon a blend of safety management, rail traffic rules, technical safety equipment and human reliability (KCRC, 2003a). Human factors still play a significant part in many railway accidents. With increasing train speeds and traffic density, a range of technical safety systems have been introduced in various railway systems, but the safety of rail traffic is still highly dependent on reliable human operations. The reliability of the railway staff, particularly the train drivers in doing the right thing is dependent upon a range of circumstances around the various work tasks.

KCRC’s mission is to provide a safe, reliable, profitable and integrated railway network meeting the increasing demand for territorial, cross-boundary and intercity railway services. KCRC is dedicated to finding better ways to:

- Serve customers and meet performance pledges

- Fulfil both Government and corporate objectives
- Maintain financial strength
- Develop sound business partnerships
- Build teamwork and commitment in staff
- Encourage initiative and reward success

6.4 KCRC Safety Management System

Railway safety management system consists of hazard management and control and risk assessment according to EN 50129 standard. Early adoption of a safety management system (SMS) can manage any changes that may affect railway safety (Dekker, 2005). This involves consideration of railway safety throughout the life of the change, but is mostly emphasised before the change is implemented, such as during preliminary hazard analysis. As engineering can never be separated from the other factors that affect safety, particularly human factors, SMS needs to consider all relevant factors in railway operations.

6.5 Limits of Safety Management

KCRC had already adopted system safety management system (SMS) or safety case at the early stage of railway projects. The SMS is used extensively to define sound

systems, practice and procedures, but it is never enough if only applied mechanically.

A successful SMS requires an effective safety culture to flourish. Such a culture enables individuals to fill in the gaps and exercise initiative while retaining high levels of safety performance (KCRC, 2005d).

6.6 KCRC West Rail

This research project focuses on West Rail because it is currently one of the most modern railways in KCRC. The system was commissioned in December 2003 in time for current and future developments in the Northwest New Territories in years to come. It is a railway line measuring 30.5 km in length, running from Tuen Mun in Northwest New Territories to Nam Cheong in West Kowloon (see figure 3). West Rail also has connectivity for interchange for MTR lines at several stations. Currently KCRC is developing the new Kowloon Southern Link to be completed in 2009, which will link West Rail from Nam Cheong with East Rail's East Tsim Tsa Tsui Station.

Technical systems of West Rail consists of an operating control centre (OCC) in the headquarter building and a backup control centre (BCC) in train maintenance depot, where all railway systems and equipment are duplicated. The BCC will form the integrated training facilities (ITF) training platforms for CRM and line-oriented

training (LOT). The implementation of video-aided training (VAT) and decision support system (DSS) are knowledge portals, providing train crew with better routes and rules knowledge for incident handling.

6.7 Comparisons between East and West Rail

6.7.1 Infrastructure and market share comparison

East Rail is Hong Kong's main north south transportation artery, and Hong Kong's only rail link with the Mainland China. In addition to regular East Rail train services, it also operates an intercity passenger service to Guangzhou using its own trains and provides access for other intercity train running to and from major Mainland cities including Beijing, Shanghai and Guangzhou. According to 2006 figures, domestic patronage increased by 15.9% compared to 2005, whilst cross-boundary patronage increased by 1.3% from 2006. This is due to severe competition of cross-boundary services continued from road transportation. Statistics and data noting differences between East Rail and West rail are shown in table 2.

Table 2. Comparison of rail infrastructure and ridership statistics between ER and WR.

Description	East Rail (staff size 1,100)	West Rail (staff size 600)
Route Length (km)	35.1	30.5
Number of stations	14	9
Number of rail cars	444	154
Daily number of trains	544	398
Minimum headway (minutes)	Peak hours 2.5 Off peak hours 5	3.5 6
Average daily ridership	Domestic 656,000 Cross Border 235,500	179,200 N/A
Highest daily ridership	1,184,900	252,800
Intercity Passenger	6	N/A
Services Destinations (number of Mainland cities)		
Average daily passengers	8,520	

West Rail, launched in 2003 is the direct rail link between the North West New Territories and urban Kowloon. The 30.5-kilometre railway includes nine stations runs from Nam Cheong to Tuen Mun. West Rail continued to steadily attract and retain passengers with an increase of 36.3% from previous year.

6.7.2 Information Requirements

Humans have restrictive capabilities, the presentation of information has to be matched to these capabilities to ensure that performance is at an optimum (RSSB, T542)r KCRC adapts crew resource management (CRM) and line oriented training (LOT) by using video-aided training (VAT), and computer-based training (CBT) facilities. Train crew

refresher training could adopt CRM and VAT by using West Rail standby rail systems in Back Up Control Centre (BCC) inter-connecting to simulators. In order to retain post training knowledge, train crew could access the “Knowledge Portal” from KCRC intranet at any time.

6.7.3 Performance Evaluation

The concept of workplace performance appraisal is being used for station controllers and traffic controllers. Train crew inspectors perform ride checks for train drivers. The concept for workplace performance appraisal is replacing traditional school-based performance assessments. By using simulators, significant energy savings were achieved without jeopardising train services. Training budget could be assigned to sponsor team building workshops to improve team spirit.

6.7.4 Key Differences of ER and WR

There are significant differences between East Rail and West Rail railway operations. East Rail provides mixed-modes of domestic/intercity passenger and freight transport, and had provided train services for Hong Kong for almost a century. The civil and structure of East Rail was designed two decades ago. More than 20% of East Rail cross-border passengers are luggage carriers. Due to design constraints, there are no platform screen doors system in East Rail.

West Rail provides train operations for three years using state-of-the-art train control and rail systems with a high degree of automation. West Rail patronage is only 20% of East Rail. Passenger screen door systems were installed to meet safety and efficiency targets.

6.8 Shortcomings of current training needs

All train crews in safety critical roles were trained in adopting safety critical communication skills under the fundamental training courses described above, but this initial training only covers basic teamwork knowledge and skills. Such programs are mainly knowledge-based, passing on knowledge to be memorised and recalled, but does little for practice in a variety of circumstances, let alone improve on skills such as situation awareness, communication, or prepare them adequately for any unexpected circumstances outside of instruction books. This will be the starting point of designing and developing a training program to specifically target such areas to link and complement the knowledge based training already in place.

Chapter 7. Training facilities in KCRC

The backup control centre (BCC) of West Rail has all the instruments and equipment of the main command centre and is usually used for training purposes. Because of this, KCRC already has all the necessary facilities for an effective training program, but lack a well structured and effective way of utilising these facilities for a better training result. The major shortcoming was that these facilities were only treated as compartmentalised pieces of equipment used methodically in training, without the emphasis that all training tasks link up to the overall functional railway system. Consequently, the concepts of teamwork, reliability and interaction amongst crew members had been minimal. CRM will utilise all these facilities fully to best equip and prepare crew off duty to ensure route and emergency knowledge is updated and practiced. The Integrated Training Facilities (ITF) and Decision support system (DSS) will be utilised the major tools of CRM training and are described below.

7.1 Integrated Training Facilities (ITF)

Simulators are undoubtedly useful for providing error data and as basic research tools (Woods, 2004; Morgan, 2006). Cab simulators have been used for many years across the industry, but they tend to have a major limitation: they can only train one person at a time, and there is little interaction with other trainees-even there is more than one

simulator in a facility. Rail-Corp Australia uses virtual rail concept and networked several simulators together. The training session can then be replayed to a classroom of trainees. The latest generation of simulator heralds a move away from the central simulator location to provide remote training wherever it is needed, but this training concept is only effective for large TOC due to cost and equipment requirements. Advance simulators provide a low-cost approach to driver training, and prepare drivers for scenarios that are difficult to replicate on a real, operational railway.

The concept of integration of various training simulators to produce a highly realistic training environment for several West Rail critical systems began in 1998. Railway system simulators including train cab simulator have been available for many years to train up train drivers. They were designed mainly as simple basic operational training tools. Trainees learned by participating in the “pseudo” hands-on exercises in order to become familiar with a particular system or in the case of cab simulator, enhancing their driving skills. The shortfall of cab simulators was lack of integration capability with external equipment.

As the modern railway systems gets more and more sophisticated and complicated under the complex mass transit environment, one single failure in a particular system may generate ripple effects to the normal operation of the railway. The idea of ITF to

integrate the critical railway systems' simulator together to provide training for the operation and maintenance staff together with railway operators would allow them to handle incidents in a practical meaningful way.

7.2 ITF Overview

The Integrated Training Facility (ITF), designed by Prime Task Inc. exclusively for KCRC is a centralised training facility of West Rail that concerns the main control system simulator (for station control), the train control and signalling system simulator (train traffic control) and two cab simulators (train driving) in a networked, integrated team-training environment. A flow diagram showing the use and training methods of the ITF is shown in figure 4. The basic function of ITF, on which all ITF functionality is based on provides integration of these three simulators into one ITF environment. The ITF allows the user to run an exercise involving different combinations of these simulators.

Throughout the task execution, the trainer can use ITF to pause, resume or stop the task from running. In terms of hardware, the ITF employs a network to link up the functional simulators to activate scenarios and to monitor trainee performance. The ITF includes a training instructor workstation to provide overall control and execution of training

scenarios and events, and to control the data communication links with the functional simulators and trainees. During the set-up and execution of team training, the instructor interacts with all other simulators in order to effectively co-ordinate the training. ITF is part of the standby systems in backup control centre readily for fallback train operations. The advantages for using ITF to conduct CRM training because it is accessible via intranet. ITF is the knowledge portal to retain or refresh train crew memories post CRM training. The incident scenarios in ITF are dynamic for changes.

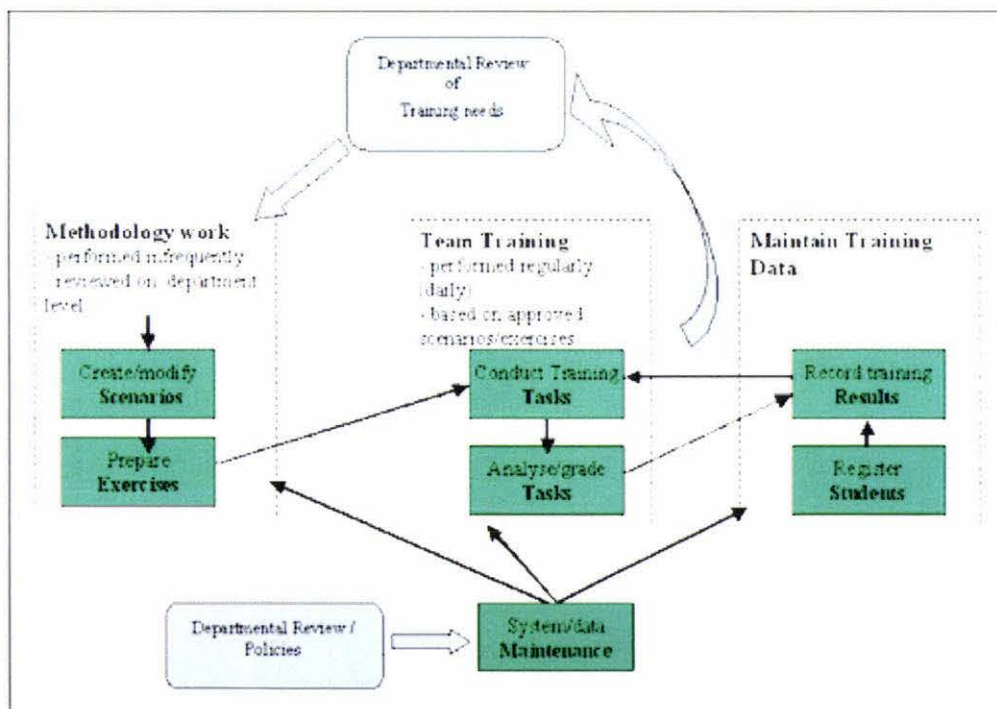


Figure 4. Overview of ITF activities for training (KCRC, 2006b).

Training is an iterative process which involves coordination between the system and trainers to produce relevant exercises and results for assessment.

ITF is designed to have two modes of operation. Under team training mode, the three external simulators will exchange live data with ITF in order to perform an integrated

training task. In standalone ITF mode, ITF only communicates with its own database to provide the trainer the functionality necessary to define, store, and maintain data necessary for subsequent execution of integrated training tasks.

7.3 Application Approach of ITF

ITF is the CRM training platform for train crew, it's activities naturally fall into the following categories:

- Administration, reports and monitoring activities;
- ITF scenario definition and maintenance;
- ITF task set up and execution;
- ITF task replay; and
- ITF task performance evaluation.

The ITF scenario is an ITF abstraction describing the kind of training to be performed.

To define a scenario, the ITF trainer describes the type of situation and the procedure applicable to it. To do this, the ITF trainer shall define the number, roles and positions of the cab simulator trainees involved in the situation, the number and roles of the Main Control System (MCS) simulator operators, and the faults of the cab trains. The MCS is the control and supervisory system for station control, traction power, tunnel

ventilation systems. The equipment that induces the faults and the geographical area within which the situation takes place e.g. tunnel, station, depot, etc. shall also be defined.

Performance evaluation activities are performed by the ITF. The trainer has no direct support or interaction with the functional simulators. The scenario procedures are set against which trainee actions will be evaluated, and the matching of the system events generated by the simulators and the role-playing events generated by the ITF trainers to that procedure, are ITF abstractions invisible to the simulators. To perform an evaluation, the ITF trainer will select a task for evaluation, complete a mapping process of the Tasks Events to the Scenario Steps for each trainee participated in the exercise. The ITF computer will then compute grades and the trainer can provide manual scoring to feed grades to the ITF to finalise the grade for each trainee.

The grading algorithm is performed every time a mapping record is changed or produced. Grading is always run following initial mapping algorithms – the algorithm starts with the first step of the task's scenario and proceeds one step at a time and mapping records will be produced for successful matches. Each step in the scenario has a timing parameter.

The ITF programme is tailored to make up the exercises pinpointing to the abnormal operations/scenarios as described in appendix A.

The concept of using ITF as platform for CRM is relatively new and revolutionary in railway industry. The development of this innovative system has been equally challenging, but should bring about training effectiveness far superior to existing methods.

7.4 Decision Support System (DSS)

Although the same human errors may repeat from time to time, once a new type of error is made, one can regard the incident as a reference to minimise its recurrence, in other words, to learn from mistakes. The provision of DSS facilitates human decision by speeding up the referral of proper guidelines in the event of incident and reducing the error in picking up the correct procedures. This also helps to build up an incident database for reference by the crew.

7.5 DSS Design Concept

There are hundreds of procedures and instruction setup for the basis of WR operations. Its coverage and completeness is tended toward perfection from the system point of

view as it does cover every aspect of mishap or failure. Notwithstanding its comprehensiveness, incidents may still turn out disastrous if the train crew are unable to recall and execute amongst the hundreds of scenarios the most appropriate rules and special operating procedures under stress, especially when it is about to draw public attention under the 8-minute reporting mechanism laid down by the Corporation as a commitment to both the Government and the public.

The development of the Design Support System (DSS) was hence put forward for backup purposes. Its design concept is based on what-to-do approach, aiming to provide information for train crew to deal with incident handling and decision making in particular to ensure a safe environment for West Rail passengers and staff, and to restoring with minimum delay the system to normal traffic conditions.

The built-in incident scenario detection engine checks the occurrence of the incident scenarios. The conditions for detecting a specific scenario are preconfigured in the incident scenario database. If a scenario has occurred in the past, the detection engine will signify the occurrence by setting tags in the computer server. Upon detection of an incident scenario, DSS will present to the train crew a list of advices and action items in window format. The typical recommended action items include:

- How to implement a pre-determined chain of commands automatically via

Main Control System (MCS). MCS the supervisory and control system for

station railway station, overhead line and tunnel ventilation system to return the situation to normal as near as is considered safe;

- Evacuation of stations and/or buildings by automatic public address announcements and setting all fare gates to open

The DSS is a useful tool, not just in real operations but it also provides a very good platform for CRM training in KCRC. Practice of the driver's head knowledge and usage of the decision support system (DSS) would be important both in and out of training and refresher courses so drivers and crew will know the correct procedures and responses in cases of emergency. Even the finest crew cannot be immune from panic attacks, but the DSS is able to impart confidence and calmness, allowing crew to follow a simple step by step checklist to make light work of the many complex procedures required.

Chapter 8. Current Train Crew Task Analysis

The Train Crew Task Analysis provides a way to measure the mental and physical loads at different times of the day and for differing traffic patterns to make judgments about actual workloads at various workload levels. It also provides information to staff regarding the proper use of systems and equipment and offers a better understanding of their features for current and future operations. The analysis results formed part of the CRM basis. A summary of task analysis components are listed in figure 5 to show key areas, discussed in section 8.1.

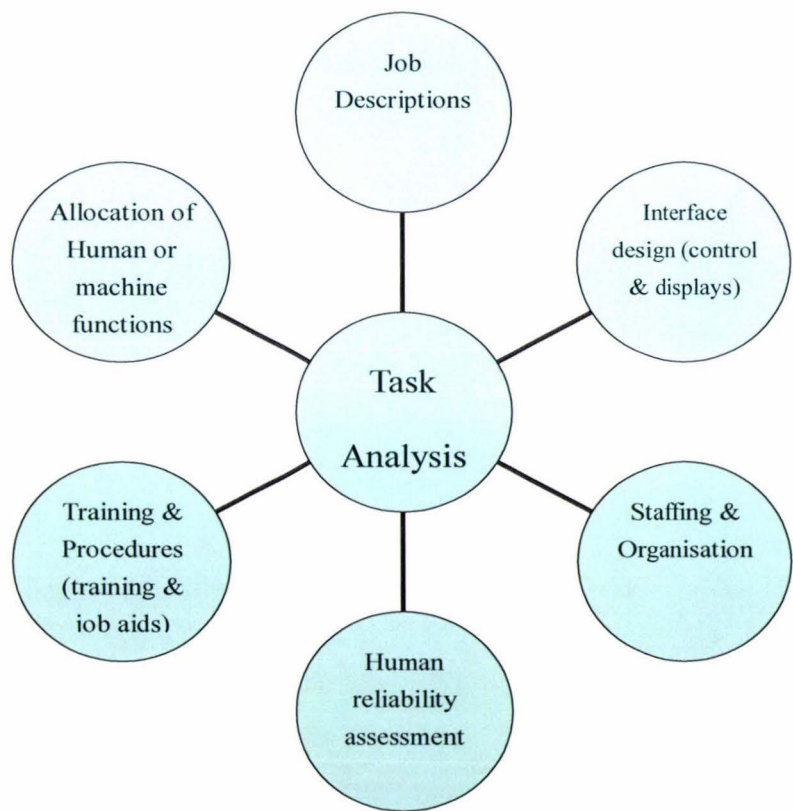


Figure 5. The six task analysis areas focused by KCRC CRM training to improve existent safety protocols.

8.1 Train Driver Tasks and Criteria of Competence

8.1.1 *The Train Driving Task*

Halliday and Porter (1996) produced a task analysis of train driving skills, describing the types of tasks that a driver is required to perform. These include:

- Adherence to trackside signs, boards and indicators- requires vigilance to notice signs, recollection and application of route knowledge, decision making, fast and appropriate reactions to information;
- Monitor trackside and track ahead surroundings for trespassers and obstructions- requires vigilance, decision making and fast reactions
- Monitoring workers working on the track
- Monitor and adjust speed of train under degraded operating modes

The specific skills required for train driving includes:

- The abilities to remember and recall information
- The ability to think ahead and evaluate the effect of several factors that may affect train performance
- Fast reaction time
- Precise control skills
- The ability to maintain vigilance and concentration under routine or unexpected circumstances

Under manual driving at restricted speed, the train operation relies on the driver to lookout for and responds to danger and warning signals. Therefore, the ability to maintain vigilance and concentration, in addition to good vision, could be considered as key driver skills.

8.1.2 Driver Errors

Halliday and Porter (1996) provided a categorisation and description of the errors that drivers could potentially commit and the underlying causes:

- Failing to spot a danger signal in time to initiate the appropriate braking
- Failure to apply route knowledge
- Failing to spot caution signals
- Failing to spot trackside signs, boards and indicators
- Failing to spot changes in track gradient or curvature (under degraded train operations)
- Spotting a danger signal but assuming it will change (based on route knowledge under degraded operations)

In assessment, the recording of errors as well as skills competency of drivers is equally important in providing constructive feedback both to assessors and drivers to evaluate their capabilities and outline their strengths and weaknesses.

Training for Pre-requisite knowledge and understanding

The fundamental training needs and the associated acceptance criteria have been set out in table 3. The driver is required to undergo an extensive introductory and training course to understand and practice relevant aspects of driving and related knowledge. Regular assessments are carried to test competency.

Table 3. Basic Training and Competence Assessment for new train drivers.

This table, illustrates the current training processes and assessments required of a driver from induction to probation.

Training for Pre-requisite knowledge and understanding	Content and acceptance criteria
KCRC Induction Training	Briefings to new recruits from company representatives, giving welcome, overview of role of the driver: what to do, who they will work with, who they report to and explanation of the principle company values which the driver must uphold.
Performance Criteria	Obtain company welcome, policy briefing and core values briefing. Understand in broad terms the role and responsibilities of the train driver, including the impact of shift working on lifestyle. Obtaining company organization structure, chain of care and reporting, discipline and grievance procedures
Performance evidence	Demonstrates and embrace company values and principles
Knowledge evidence	Verbal/written tests to ensure recollection of facts and reasoning
KCRC Safety Briefings	Understanding of rules and regulations relating to activity as defined in Rule Book. Understanding of rules and regulations

Training for Pre-requisite knowledge and understanding	Content and acceptance criteria
	applicable to activity, as defined in the appropriate section of the company's train operating manual.
Performance Evidence	Assessment requirements defined in training courses, including general line safety. Assessed by observation of learnt skills in the classroom or workplace oral and written tests. Assessment results to be used as supporting evidence of competence.
Knowledge Evidence	Verbal and written tests to ensure recollection of facts and reasoning
KCRC Train Driver Documentation Plus Supporting Briefing	Understanding of rules and regulations relating to activity as defined in Rule Book. Understanding of rules and regulations applicable to activity, as defined in the appropriate section of the company's train operating manual.
KCRC Defensive Driving Policy Briefings	Issues relating to company defensive driving policy. Explanation of the range of consequences of SPADs to passengers, track workers, users of level crossings, the company and to the driver. Highlight the principal causes of SPADs, known risk factors, and mitigating actions. This is intended to be treated as an introduction to professional driving, to instil correct values and attitudes to the driving role.
Performance Criteria	Describe the principal SPAD risks, and explain how these may be avoid
Supporting Knowledge	Use the train operating manual for principal traction types. Use special operating notice

Training for Pre-requisite knowledge and understanding	Content and acceptance criteria
	Use the driver Rule Book. Understanding of rules and regulations applicable to activity, as defined in the appropriate section of the company's train operating manual. Recognition of principal SPAD risks, and knowledge of appropriate mitigating actions. Understanding of the principles of professional driving and how these are applied to the driving task
Performance Evidence	Receive train driver documentation plus supporting briefing
Knowledge Evidence	Activities relating to location, acquisition, purposes and use of essential documentation.
Performance criteria	Use the train operating manual for principal traction types. Use special operating notice Use the driver Rule Book.
Supporting knowledge	Oral and written test on understanding of rules and regulations relating to activity, as defined in the Rule Book and train operating manual.

8.2 Job Descriptions of Senior Traffic Controllers and Train Controllers

The function of the Operations Control Centre (OCC) is like the central nervous system of the human body. It co-ordinates different sections of the division to ensure smooth running of trains according to the daily working timetable. Most importantly, the OCC is required to direct emergency operations in case of mishaps or trivial vehicular fault.

In order to have a prompt response in dealing with extraordinary events, all staff in the control centre should maintain strong sense of situation awareness. Although the whole OCC is under the direction of the Traffic Manager, the day-to-day operation is wholly under the direct onus of the duty Senior Traffic Controller (STC), organised in three shifts round the clock working.

STC and train controllers (TC) ought to be working in a harmonious and co-operative style, with the STC being the supreme commanding unit. Normally, the STC will be engaged in formulating directives and the follower execute them. Hence, the STC is a thinker and TC a doer. Occasionally, where there is no marked demarcate in the division of labour, both parties will be actively engaged in carrying out habitual controller actions like radioing, telephoning, typing and commanding. The following table details the different job natures of the two posts:

Table 4. Job descriptions of STC and TC units detailing demarcation of responsibilities. (Data source: RSSB T542)

Job description of Senior Traffic Controller (STC)	Job description of Traffic Controller (TC)
To evaluate passenger service currently being run on all routes and compile urgent information received from other transport organizations to commuters through public address system.	To elicit data from the Train Control and Signalling System that and detect deviations from working timetables in order to inform Senior traffic Controller (STC) of all abnormal delays and other special events.
To draft and disseminate appropriate message to other transport operators and government departments via the broadcasting facsimile system in case of service interruption that exceeds 8 minutes.	To adjust the running of trains to a regular intervals service as set in the working timetables.
To assess the suitability or responses of Traffic Controller and when appropriate, give better alternative instructions. To have close liaison with power controller in respect of matters of electrical supply.	To manage all incidents in a speedy yet safety minded manner and confine any service disruption to as small an area as possible as according to the contingency plan.
To maintain communications with internal senior officials during serious incidents.	To liaise with yardmasters for trains working to and from depots or freight yards.
To ensure proper monitoring of staff performance and keep a high standard of discipline and submissiveness.	
To oversee all administrative matters in Operations Control Centre, for instance, rostering, stationery requisition & etc.	
To assist training of new control staff.	

8.2.1 The yardstick for appraising the abilities of Controllers

The major responsibilities of Controllers as a team are to

- Assure the issue of Prompt, Rational, Efficient, Succinct, and Safe (PRESS) instruction
- Keep affect areas of incidents as small as possible
- Minimise any kind of delays
- Be alert at all times

For a controller to be able to carry out these tasks, she/he must possess the necessary mental ability described below and be able to demonstrate them to the assessors:

- | | |
|-------------------------------|------------------------|
| • Able to work under stress | • Situation Awareness |
| • Emotional stability | • Sound Judgment |
| • Maturity | • Decision Making |
| • Independence | • Power of Action |
| • Self-Confidence | • Cooperation Ability |
| • Awareness of responsibility | • Leadership Potential |

8.3 Skill Pattern of Train Drivers/Traffic Controllers

From the task analysis, table 5 summarises the behavioural skill domains for train drivers and traffic controllers.

Table 5. Cognitive Skill Pattern classification of Train Drivers/Traffic Controllers

(Data source: RSSB, T542)

Skill Domain	Skill	Specific Skill
Information processing	Perception	Visual/spatial judgment
	Attention	Spatial orientation
		Vigilance
		Multitasking
	Psychomotor	Psychomotor co-ordination Reaction speed
Situational awareness	Monitoring	
	Error detection	
Problem solving	Collect information	
	Analyse information	
	Logical reasoning	
	Generate alternatives	
Decision making	Exhaustive inquiry	
	Complex judgement	
	Evaluate resources	
	Priority setting	
	Time management	
Planning	Anticipation	
Co-operation	Listening	
	Communication skills	
	Conflict resolution	
Leadership	Assertiveness	
	Authority	
	Task orientation	
	Teambuilding	Motivation

	Representation	Conflict resolution capability
Stress management	Stress recognition	
	Coping techniques	

There remain of course better methods to evaluate and assess the performance, capabilities and potential of crew members, which will be used in designing the training module in this study.

Chapter 9. Organisational Issues

9.1 Difficulties faced by TOC in reformation

Accident inquiry reports (RSSB, 2002) had repeatedly spelt out the “lack of teamwork and ineffective communications” (p.218), urging TOCs to “amend crew training programs” to include additional assertiveness training to flight or train crew. However, this concept had not been readily taken on board or applied immediately. Particularly in some eastern countries, the managerial hierarchy is so firmly established such that those within senior management have great reluctance to prove their superiors wrong. This has caused many reformation plans to remain dormant or abandoned.

Research into past accidents revealed that improving communication skills between crew members is a priority in the railway industry. The train crash at Ladbroke Grove is such an example. Even though the traffic controllers recognised the SPAD incident and its significance, the two trains still collided due to communication breakdown between the critical parties. The “failure to communicate at all levels” feature most prominently in crash accident investigations, where train radio recorder and train-borne incident recorders revealed that even at the final seconds before disaster strikes, the train crew remain frozen with fear, totally paralysed to utter the right words that might have saved them.

Communication break down was the most common cause in SPAD incidents, but is an area that railway management now feels compelled to address. It is impossible for railway management to deny that the lack of communication had spelled disaster in many accidents over the years. Because of this fact, training courses on how train crew should communicate with one another have become a thriving concern.

9.2 Organisational budget constraints

As mentioned previously, safety is usually a priority in railway services to ensure public safety to maintain company image. TOC have to enforce tighter control on operations and maintenance costs in order to maintain competitive in transport industry.

Excessive working hours may cause hidden human factors such as fatigue, overload, fixation, frustration and time pressure. In KCRC, more training had been provided to train crew for coping with stress and conflict resolution. RSSB Research Report T270 indicates that long working hours were associated with diminished general health of staff members. On job time pressures also contribute to a significant portion of occupational stress. Such factors increase the risk of crew making errors due to

tiredness and fatigue.

It is obvious that such practices involve a degree of compromise into company integrity and guarantee of safety, but the company policy, strategic plans, management style and organisational culture inevitably introduce such management risks. Such measures may be taken to resist economic pressures, train scheduling pressures, competition, overheads, customer services and public image. These risks and unhealthy practices posed by operators and managers are likely to outweigh mechanical ones posed by hardware and software. It is the principle of running the railway at as low as reasonably practicable (ALARP) costs.

Failure to maintain the railway infrastructure adequately saves money in the short term, but ultimately results in catastrophic failure. Improper maintenance causes problems to surface, which, if no corrective measures are taken, the rate of deterioration will accelerate to the point when major intervention is needed. Any short term savings will be dwarfed by the huge cost of restoring the infrastructure to a healthy state. TOCs should learn their lesson learned from UK Railtrack, which became bankrupt after poor train maintenance caused the Hatfield derailment incident.

It is a tragic occurrence in railway and other safety critical industries that additional

safety improvements are only made when their cost is less than the litigation costs of human lives lost. Significant accidents involving large passenger and train crew death tolls provide the strongest pressures for government regulators and the general public to enforce new safety measures.

9.3 The importance of Organisation Culture

Although a “no blame culture” (Reason, 1990) had been heavily promoted in the 1990’s, a “no blame” culture on all unsafe acts often lacks credibility in the eyes of an employee, especially if disciplinary procedures are seen to be used. It may even be seen to oppose natural justice if individuals are perceived to “get away with things”.

In contrast, a “Just Culture” (Reason, 1990) creates an environment that holds people accountable without imposing punitive punishment, and fosters better learning opportunities for continuous improvement. The types of error are classified based on the level of intent and repercussions, pre-determined, communicated and agreed between management and staff in a fair and consistent manner. It requires a sound policy, framework, processes and training to enable staff to recognize the difference between errors occurring from well intended actions and actions that are deliberately meant to harm or disadvantage others.

An organisation's culture reflects its values regarding treatment of errors, blame, and punishment. These values are crucial to establish openness in communication between management and train operating staff. From this follows the level of adherence to regulations, the level of commitment to safety, and the level of trust between train operating staff and management, leading to a healthy corporate environment with transparency and faith.

The importance of organisational culture was realised from accident investigations. Studies have shown that flawed organizational culture was a precursor of disaster, demonstrated by lack of safety concerns, operational pressures, poor leadership, conflict with management, and negative organisational climate (Little, 2004). A high proportion of famous disasters- including Three Miles Island, Bhopal, Challenger, Chernobyl, and the King Cross Underground fires have occurred mainly as a result of latent management failure, overruling important safety precautions and procedures that were, or should have been in place for safety considerations.

Building an overall safety culture comprises the subcultures of an informed culture, a reporting culture and a just culture (Reason, 1990). The keys to a safety culture are intelligent wariness and knowing where the boundary lies between safe and unsafe

operations. It requires effective safety information transmittance via effective reporting systems, the trust of the workforce and a just culture, which can be built and engineered over time. The company culture adopted is crucial in creating a safe environment as this alone is widespread enough to have a constant influence throughout all aspects in any organisation.

9.4 Rail Enquiries and proportioning blame

Railway workers are often afraid to give evidence in fact-finding investigations after railway accidents. They may have become wary of taking part in inquiries after the accident for fear of accusation and punishment. The “shame and blame” culture of various sections of the media, coupled with the desire of the bereaved relatives for justice puts an enormous pressure on investigators to go behind the corporation and blame a few named individuals. As a result, railway workers are at a risk of being made scapegoats or even facing criminal proceedings. The media habitually focuses on the bitterness of the victims in any incident where the cause of the accident has not yet been established or blame attributed. If the accident doesn’t kill the railway worker, the inquiry will be in haste to find a solution to please everyone, even if it means it has to find some scapegoats to assign blame in the process.

While it is true that railway workers do play some role in the cause of many accidents, more often than not their regrettable mistakes are caused by momentary lapses of concentration that can be explained by stress and tiredness or a suddenly worsening medical condition brought about by excessive working hours. In such cases management and supervisors may also be liable for their deteriorating health. On the other hand, a handful of accidents have been caused by wilful neglect of duty or the deliberate failure to follow established procedures designed to ensure safe travel on rail networks. Sometimes these accidents can be ascribed to the actions of a single individual, but on other occasions a number of railway workers have been involved.

In a rare number of instances, the passengers themselves have also initiated a series of events that have led to disaster, apparently oblivious to the dangers inherent in their actions. All this highlights the difficulty of any investigation team to find the right person or groups that may be liable. They are simply looking for a 'bad apple' when none exists. In fact most incidents named in this thesis are caused by a number of non-disastrous, but compounding factors that ultimately climax in critical failure and disaster.

The public and politicians usually only show concern for ticket prices, but may also need to be informed about the tired train crew, cost-cutting in maintenance and overheads, overworked rail workers, ageing infrastructure and marginal spare

capacities so that accidents may be prevented before they occur. The TOC and management of any railway should be aware of the importance of both people and infrastructure as keystones of the company and not compromise on the wellbeing and performance of either.

Chapter 10. The Principles of Human Factor Design

10.1 Ergonomics Design

Human factor design is the application of knowledge about human capabilities and limitations to the design of systems. All essential external aspects of human performance are addressed. For example, ergonomics data can help to define the best way to present information on a display so that it might be interpreted correctly (see figure 6), or where to position the display on a console so that it may be easily seen and to specify the lighting conditions under which the display can easily be read.

10.2 Human Factor Design

The human factor design of West Rail applied a “task analysis” approach in which the components of mental and physical work were measured at different times of the day and for different traffic patterns. By careful interpolation, judgments can be made about actual workloads at various workload levels.

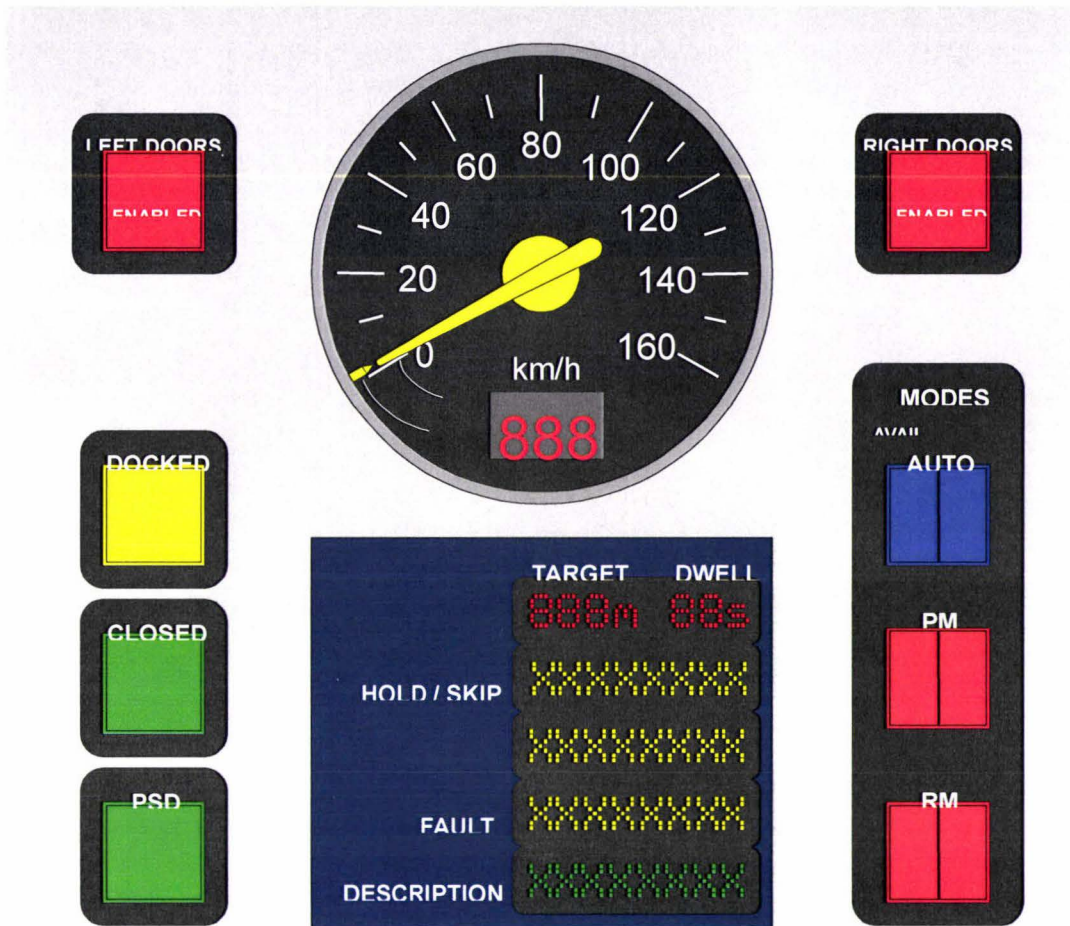


Figure 6. Schematic diagram of cab display unit (KCRC & Alcatel Seltrac, 2003)

10.3 Human Machine Interface (HMI) Design

In the design and development of human machine interface (HMI), task analysis had been adopted to provide information on the way in which equipment would be used. A thorough understanding of the way in which existing functions are carried out, combined with an understanding of the features offered by the new systems provide a vision for future operations. The predicted frequencies and sequences of use of such systems are particularly important to develop ergonomic and efficient workstation

layouts. The workstation can support and aid the operator rather than be a hindrance simply by following some simple rules such as high priority items being placed closed to the operator and screen and equipment arrangement should related to underlying sequences of use.

In the design of the interface usually refers to the system architecture diagram to determine the communication paths that occur between different members and interface connections between rail systems. Observation during both peak and off-peak hours reveal the nature of these paths (direct speech, intercom, paper, visual contact) and the nature of information being passed. From this, the design engineer can ensure that the grouping of workstation and the entire control room layout (figure 7) are designed to facilitate the important links and thus support the operators in the conduct of their duties.

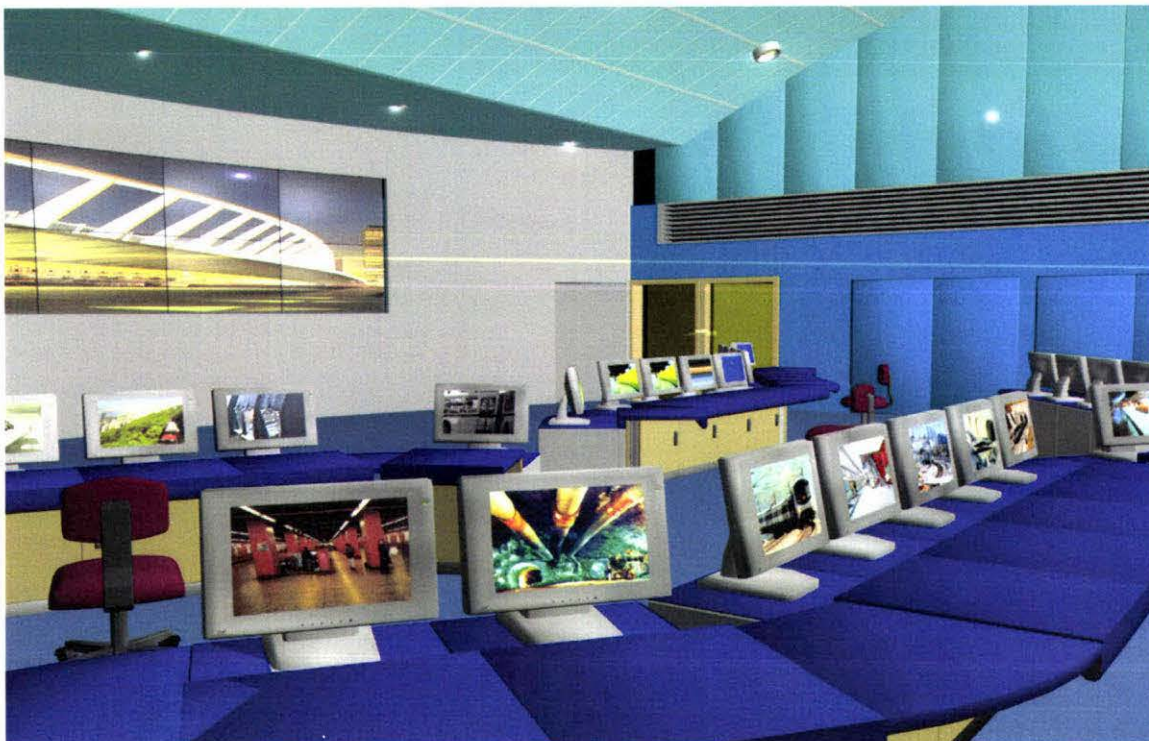


Figure 7. Schematic Operations Control Centre (OCC) Overview showing the importance of design and layout of important information.

10.4 Task effectiveness

Folkard's investigation report on road traffic accident (Folkard, 1997) suggests that there is a time factor on task effectiveness also. Generally, as more time was spent on repeatedly carrying out the same task, concentration and accuracy would decrease and the safety risks will increase. There is however, a significant increase in risk after spending two to four hours on the same task. This is unmatched by any other time interval other than by exceeding 12 hours on the same task. In order to reduce risk it was suggested that an eight to ten hour shift would be the most effective. It was also

suggested that the two to four hours effect may increased risk as the effort and attention required of guarding against risk fades, but the automatic reflexes have not been fully activated.

10.5 Train Control & Signalling System Design

It is essential that human factors should be taken into account in the development of railway systems. There is significant risk that human error resulting in catastrophic accidents can occur even where the design of the signalling system, and the training and management of drivers, appear to near optimum for a human factor point of view. The elimination of human error would require the elimination of the human element. The provision of a system of automatic train protection (ATP) is recommended as by far the most effective means of minimising the consequences of human error in the observance of signals. The consequence of a train driver misreading a signal could be as bad as the catastrophic accident at Ladbroke Grove Junction in UK.



Figure 8. Complexity of signalling layout at Ladbroke Grove Junction.

Note the complexity and density of junctions, which may easily result in disastrous consequences from one simple mistake

Human factor considerations in design need to be part of the high level design brief for a signalling scheme. The scope for adequate design of signals and other features with regard to human factors should not be constrained by prior decisions concerning train service performance, line capacity, and track layout. All new signalling schemes must have a prime objective- to achieve clearly visible and unambiguous signalling systems. All tracks, structures, and other infrastructure equipment must be designed to facilitate this objective so far as possible.

The involvement of the operators in signalling system design early in the project is important. Computer simulators can be used as demo tools to aid the design, sighting of signals and training of drivers. All technological solutions must be assessed for human factors risks in both normal and degraded modes of operation to ensure that any change does not create a greater overall risk. There is a need to ensure consistency in the human factors related features of signalling design to avoid confusion or ambiguity in the observance of signals.

It is important to consider the role that humans play within the system, and to design it accordingly. This is because for some types of errors, enabling automation does not necessarily eliminate the opportunity or the effects of human error, and may even make the situation worse. In other words, an overall systems approach must be taken in considering the effects of technical failures and interactions with staff, passengers and public.

From an engineering perspective, railway designers and testers require a considerable level of knowledge and expertise in order to apply design principles correctly. Historically, railway engineers have mainly been responsible for the safe control of the movement of trains. However, the introduction of modern technology has demands for a more rigorous approach to railway control, encompassing all aspects of customer

comfort and well-being. Therefore, safe control of operations must now be achieved without neglecting the operational requirements to keep passengers informed, regulate trains, save energy, manage train and crew allocation, enable and protection track work (close track or in place a temporary speed restriction) and generally provide optimum usage of the track. Dealing with adverse weather conditions and fine tuning systems for the best response may be necessary. In other words, railway control must ensure the safe and efficient transportation of people, so as to satisfy the expectations of customers, regulatory authorities and the railway operators.

The above showed that it is possible to apply knowledge about human behaviour, human physical and mental characteristics to the design of the system to increase crew efficiency and system user friendliness. It is necessary to consider both internal and external aspects of human capability such that machines can be an aid and not a hindrance to their workers.

10.6 The Trade-Off between Automatic and Manual Driving

As mentioned in section 3.2, Reason suggested three levels of performance corresponding to the familiarity with the task. As familiarity increases, arousal decreases and boredom increases. This in itself presents a safety risk as the driver

becomes less alert to surroundings when trains operate in automatic train driving mode.

This causes the skills of drivers and traffic controllers in the OCC to erode because most functions can be handled automatically. Under normal operating conditions they are only required to perform routine, basic tasks. This generates a low level of arousal, causing a decline in a person's ability to sustain attention and increase the probability of distraction.

One of the major problem facing training departments in the increasing sophistication of automatic train operations is to achieve the right balance between maintaining manual train driving skills to cope with the occasions when automation is not available and fully automated driving. In degraded operation from ATO to ATP, the train driver needs to perform frequent start/stop at stations with platform screen doors (PSD, shown in figure 89), which requires high skill to bring a train to stop from 50-60kph to 0 kph within stopping accuracy of 350mm-500mm margins to avoid PSD trapping hazard. The journey time for West Rail train trip is 30 minutes with 9 station stops. The platform dwell time is 20-30 seconds except at the terminus, where the layover time is 109 seconds. This means that on average the train driver has to perform a train stop every 5-6 minutes. That is a very routine and boring task if that is all that drivers have to do.

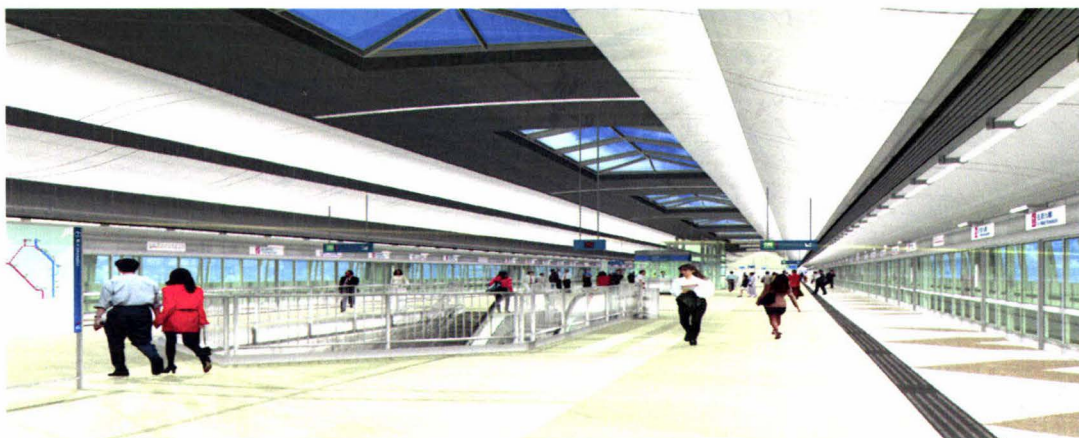


Figure 9. Typical station platform with Platform Screen Door (PSD) (adapted from KCRC Annual Report, 2004)

Skill-based training is more demanding on drivers since the automatic control capability reduces the time available for a train driver to manually practice basic skills.

Every train driver should therefore endeavour to set personal exercises to maintain and improve his/her own standard. This can be achieved by regular manual driving to maintain current skill during off-peak hours.

10.7 The Perspective of Train Driver

Train drivers are required to monitor the dynamic scene visually, both outside and inside the train cab. Poor performance on this task may lead to errors such as signal passed at danger (SPAD).

Driving in auto mode incurs long periods of inaction, which may induce inattention

and boredom. Curiosity of the driver attempting to alleviate boredom has caused fatal railway accidents in the past. Boredom on its own can lead to inattention, simple slips and even fatalities. In the face of fatigue, or sudden danger, drivers will tend to regress. Fatigue and sudden danger cause release of many tendencies that lie beneath the conscious mind. Fatigue in train drivers has been extensively studied and written to introduce working time limitations, but researchers are gained little ground in understanding it. Tiredness is as inescapable as it is intractable. What was also noted is that most engineering train (and also motor) accidents occur at junctions at dawn – at a time when it is likely that the train drivers will be tired after working overnight.

Shift workers may succumb to bouts of micro-sleep near the end of a night shift. Yet few TOCs are aware of the effect of circadian rhythms on crew physiology to effectively predict and manage the demands of shift work by considering a corporate review on shift roster design.

According to RSSB research (2003a) there are three key factors contribute to most railway accidents:

10.7.1 Individual factors

The attributes and capabilities of the person including their personal attributes, habits and personalities as well as their skills and competence.

10.7.2 Job factors

How the requirements of the task match the capabilities of the person undertaking the task including consideration of workplace and environmental factors.

10.7.3 Organisational factors

The organisation has a great impact on the performance of individuals, yet the importance of the health and safety culture has often been overlooked.

A poorly designed shift pattern or roster can adversely affect performance and morale, resulting in higher absenteeism and an increase in likelihood of errors and accidents. Fatigue in human impairs performance and can lead to reduced attention, poor decision making, delayed reaction time and human errors. All these types of impaired performance increase the likelihood of an accident occurring. Therefore in railways where humans perform key safety roles, it is important to manage fatigue as a source of safety risk. As defined by Murphy in 2002, fatigue is the product of intense and prolonged emotional strain, inadequate diet, strenuous physical exertion, unfavourable environmental conditions and sleep loss. Negotiating and minimising such sources naturally should reduce driver and crew fatigue.

10.8 Rule-Based Instructional Design

Railway systems depend upon the synergy between human beings and engineering assets to ensure that the latter can meet customer requirements, maintain safety of staff, the general public, and TOC expectations (Shepherd and Marsall, 2005). Instructional design provides assistance to the individual when they need to operate in “rule-based” mode. The rules or steps are presented in a written format to save the individual having to memorise them. When followed correctly, the chances for error will be minimised on the condition that they are well understood. Many basic errors are made with the presentation, language and format of procedures such that they are rendered unusable or ambiguous. The result is many unnecessary errors, indicating that procedures should be written for and with the intended users.

10.8.1 Emergency Planning

Mass transportation means that incidents and accidents can lead to many fatalities and severe disruption. The fire in tunnel incident is notoriously dangerous as hot toxic fumes remain trapped in the same tube as the passengers. Each emergency situation presents a fertile condition for human error. Train crews are working at high stress conditions with strict time constraints for making decisions. Continuous routine work under “knowledge-based” conditions decrease alertness and elevate boredom. It is essential to establish an emergency plan for such events and to provide adequate

training and drills for train crew such that they are able to perform their roles according to the emergency plan. The provision of well designed workstations and communication facilities, decision aids and training are all requirements of a sound emergency plan.

10.8.2 Alarm Management

The most significant distraction in rail operations are alarms. With a potential inventory of a hundred alarms providing feedback from thousand of sensors, filtering out important alarms and passing on the right message can be a significant task. A barrage of alarms could sound inappropriately if the alarms are poorly designed, prioritised or filtered. As many alarms are not true alarms but confirmatory statements of equipment status, confusion and delays in discerning the true alarms can be frustrating to staff and be costly if it causes a delayed response.

10.8.3 Benefits Gained

Benefits can be gained from introducing an appropriate human errors integrating human machine interfaces within West Rail project.

- Reduction of risks from human error source
- Buy-in from operating staff

- Minimising post implementation remedial measures
- Framework for change management

Chapter 11. Research Design

This research focuses on the adaptation of CRM and LOT for refresher training of train crew in KCRC West Rail, which began its revenue operations since December 2003. In 2005, there was a need to introduce for train crew annual refresher training. According to East Rail practices, all train crew are required to attend the three days annual refresher training. It is defined as conventional training for train crew. The adaptation of CRM and LOT for these refresher trainings was considered suitable.

11.1 Course Design for Human Factor Training

KCRC West Rail adapts CRM training concept for human factor training. Designing a CRM course involves a standard training design process (Goldstein and Ford, 2002, Patrick, 1992) starting with defining the training objectives, identifying the component skills, deriving the training content, designing the actual course and the evaluation methods (Seamster & Keampf, 2001; Helmreich *et al.*, 1999). The course is centred on six following categories:

(1) Situation awareness

- Plant status awareness- the current status and risks associated with the site/infrastructure
- Environmental awareness- the current status and risks associated with the immediate surroundings of the site/infrastructure
- Anticipation; concentration/avoiding distraction- drivers need to maintain alertness to spot and deal with potential dangerous situations
- Shared mental model

(2) Decision making

- Problem definition/diagnosis- immediate understanding of potential problem, its severity and suitable responses
- Risk and time assessment
- Recognition primed decision making/procedures/analytical
- Option generation/choice of appropriate actions and responses
- Outcome review

(3) Communication

- Assertiveness/speaking up
- Asking question
- Listening
- Giving appropriate feedback
- Attending to non-verbal signals

(4) Team working

- Maintaining team focus
- Considering others
- Supporting others
- Team decision making
- Conflict solving between different parties

(5) Personal resources

- Identifying and managing personal and team stress
- Reducing/coping with fatigue
- Physical and mental fitness

(6) Supervision/leadership

- Use of authority/assertiveness
- Maintaining standards
- Planning and Co-ordination; workload management

The course was designed and delivered with the following 6 work packages:

- situation awareness
- decision making
- communication
- team work
- fatigue and shift work
- stress

The course was delivered over 3 days using indoor lectures, practical exercises, case studies, video clips, simulation and IFT combined with outdoors wood climbing training workshops.

11.2 Defining Objectives

The overall training objective is to increase train crew's knowledge, skills, and/or attitudes toward specific job dimensions (Blanchard and Thacker, 1999). There are two perspectives that need to be discussed into when defining the objectives for CRM training.

11.2.1 Individual Objectives

The CRM course emphasises on the improvement of efficiency and reliability of people working in a system and minimise potential human errors. At the completion of the CRM program, the crew should be able to:

- Communicate clearly and apply learned knowledge to create shared understanding
- Seek to anticipate error-likely situations
- Seek to confirm the integrity defences
- Improve personal capabilities
- Facilitate open communication
- Promote teamwork to eliminate error-likely situation and strength defences
- Search for and eliminate organisational weaknesses that create conditions for error
- Reinforce expected standards and behaviours
- Demonstrate the value of preventing error

11.2.2 Management Objectives

CRM training is the refresher training which will not be successful if it is only conducted once or discretely without a continual effort. Therefore, the recognition of adapting CRM concept on top of traditional KCRC training culture will need to be

brought up to the Management level for their long term commitment. With this in mind, the course should be designed to get Management involvement and their appreciation, setting out the following management objectives:

- Foster a culture that values the prevention of error
- Strengthen the integrity of defences
- Preclude the development of error-likely situation
- Create a learning development that encourages continuous improvement
- Set clear standards in the key areas of rail operations in order to develop a culture of professionalism
- To raise awareness that we are all fallible and so we should all make attempts to eliminate error traps
- Listen to operator's concern and to provide quality systems and training that will help error producing condition

11.3 Teamwork Skill Dimensions

CRM is a concept, affecting the way that people think and the way they act by making the best use of available resources. It is intended to heighten existing attitudes and behaviour, not to change or create personalities. In KCRC application, these available resources are divided into four broad categories: people, rail systems (machines &

tools), time and information (rules and procedures, guidelines, instructions and situation status) as shown in figure 10. The figure shows the relative proportions of momentary investments into each category allocated by KCRC WR.

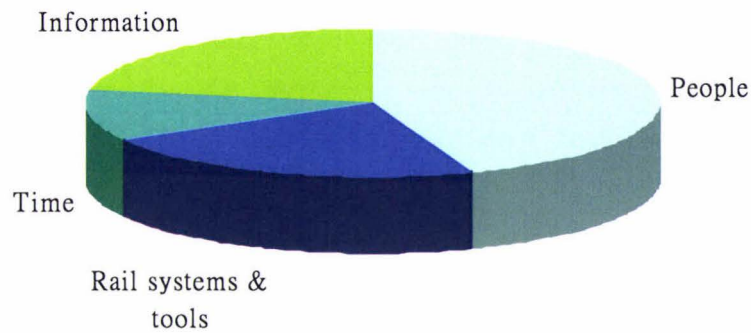


Figure 10. Resources categories and allocation in West Rail CRM (KCRC, 2006b)

The course is designed to optimise the human/machine interface and accompanying interpersonal activities including team building and maintenance, information transfer, problem solving, decision making, maintaining situational awareness and dealing with automated systems. The training will focus on the functioning of crew members as a team, rather than simply as a collection of technically competent individuals, and provide opportunities for them to practice their skills together in the roles they would normally perform in passenger services. It also lets them explore how to use their interpersonal and leadership styles in ways that foster their effectiveness. Under these resources categories, the following teamwork skill dimensions discussed will be summarised for training in table 6.

Table 6. Breakdown of teamwork skill dimensions to related CRM domains.

Dimensions	Explanations
Adaptability	The process of which a team is able to use information gathered from the task environment to adjust strategies through the use of compensatory behaviour and reallocation of intra team resources.
Shared situational awareness	The process by which team members develop compatible mental models of the team's internal and external environment; include skill at arriving at a common understanding of the situation and applying appropriate task strategies.
Performance monitoring and feedback	The ability of team members to give, seek and receive task clarifying feedback; including the ability to accurately monitor the performance of team mates, provide constructive feedback regarding errors and offer advice for improving performance. (workload management, mission analysis, resource management, or compensatory behaviour)
Interpersonal relations	The ability to optimise the quality of team members' interactions through resolution of dissent, utilization of cooperative behaviours, or use of motivational reinforcing statements.
Coordination	The process by which team resources, activities, and responses are organised to ensure that tasks are integrated, synchronised, and completed within established temporal constraints.
Leadership/Team management	The ability to direct and coordinate the activities of other team members, assess their performance, assign tasks, motivate team members, plan and organize, and establish a positive atmosphere.
Communication	The process by which information is clearly and accurately exchanged between two or more team members in the prescribed manner and with proper terminology; the ability to clarify or acknowledge the receipt of information.
Decision making	The ability to gather and integrated information, use sound judgment, identify alternatives, select the best solution, and evaluate the consequences within a limited timeframe.

Teamwork encompasses skills such as adaptability, coordination, cooperation, and communication. An effective team needs to develop competence along these tracks. Members of effective teams possess the basic skills required for the task but more importantly need to know how to co-ordinate their activities, communicate with each other, and respond effectively to changing conditions.

11.4 CRM Training Areas

Superseding the conventional courses, CRM/LOT type of training provides a more interactive and dynamic environment for learning. In KCRC model, its context can be illustrated by figure 11, which highlights key areas, partnerships and strategies it will involve and utilise to optimise results.

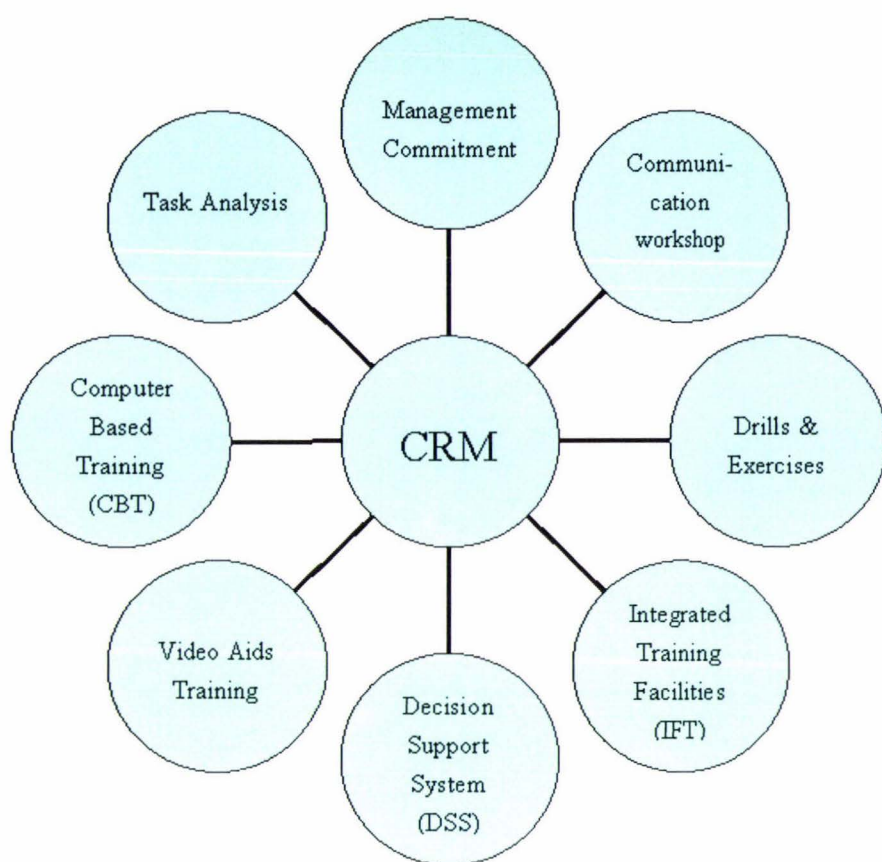


Figure 11. Context of CRM training in KCRC. CRM training will incorporate all aspects shown to make full use of existing facilities for safety oriented training.

A comparison of scopes between the conventional and CRM training approaches is listed in table 7 below:

Table 7. Comparison between Conventional and CRM/LOT Training.

	Conventional Training	CRM and LOT Training
Day 1	Class room lecture Rail systems refresher Rules & Procedures	Introduction to CRM and LOT Use computer-based training (CBT) for rail systems refresher and Decision Support System (DSS) as training tools for incident handling.
Day 2	Human factor introduction course in the form of lectures	Use VAT for case studies Outdoor team building workshop (1/2 day) to enhance the understanding in communication effectiveness and team working. The outdoor team building workshop was sponsored by KCRC at a recreation club with the participation of the Director of Transport, Director of Human Resource and the CEO)
Day 3	Incident handling exercises by using individual simulators	Incident handling exercises by using ITF, VAT and DSS. Use video from drill and TV news as media.

Chapter 12. Train Services Operating Principle

In West Rail, the train services are bound by a set of Standard Operating Policy (SOP).

The underlying principle is to ensure a safe and reliable train service to the passenger at all time. However, there are moments that systems may fail or accidents may happen. In the event of an abnormal situation (see Appendix A), normal operating mode falls back to degraded mode or even emergency operation mode if the impact becomes unrecoverable within the specified time.

12.1 Emergency operations

Under emergency operating mode, while maintaining a safe operating environment, the Traffic Controllers and the Train Drivers are required to:

- Keep trains moving along
- Stop or detrain at station if possible
- Temporary retire a few services if necessary
- Provide alternative connectivity to passenger
- Maintain normal train services as much as possible
- Provide emergency buses to affected link as an alternative service

12.2 Major Functions of Station Operations

On the other hand, the concerned staffs performing the station operations are required to:

- Maintain safe, tidy and efficient station environment
- Monitor equipment and railway systems and exercises control to secure passenger safety and enhance customer service
- Enforce operating rules and procedures on station operation and contingency plans during emergencies
- Provide ticketing services, handle & safeguard revenue

12.3 Incident / Emergency Handling

If incident does result unfortunately, designated staff will play special roles with an aim of resuming the operation as soon as possible:

- Station Controller acts as Incident Officer (IO)
- Coordinating with Incident Engineer (IE) who coordinates service recovery

12.4 West Rail SOP's Hierarchy

The West Rail Standard Operating Procedures capture all the necessary information for handling both normal and abnormal situations. The diagram below provides a hierarchy structure of the policy.

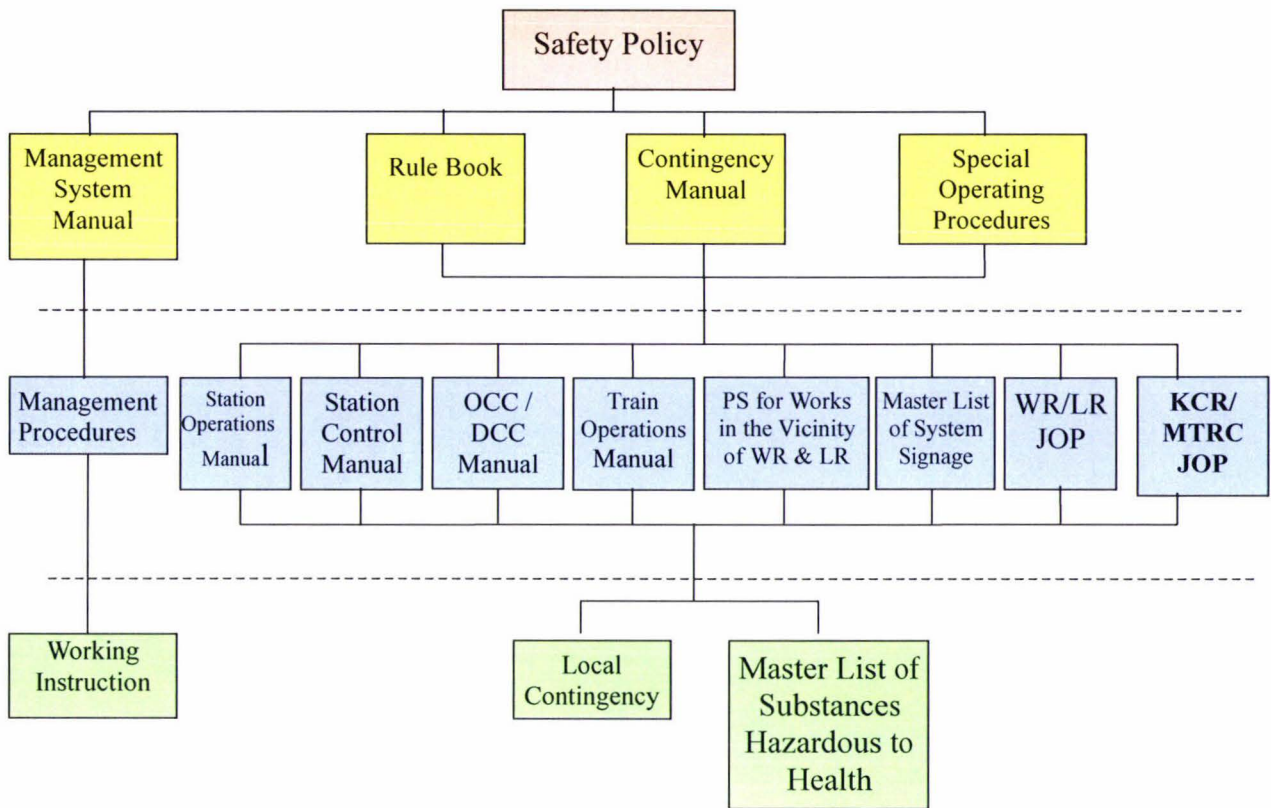


Figure 12. Schematic diagram of cab display unit (KCRC & Alcatel Seltrac, 2003)

. Hierarchy of West Rail SOP (KCRC, 2003b;c)

12.5 KCRC Rule Book Coverage

The KCRC Rule Book plays the most important role in the daily normal operations in governing the operation and procedures to be followed by staff members. It covers the following areas:

Table 8. WR Rule Book and key sections

Section	Glossary/ Abbreviations	Section	Glossary/ Abbreviations
Section A	Station Operations	Section F	Safety on Power Supply System
Section B	Signalling	Section G	Safety When Working on Electrical Equipment
Section C	Train Operations	Section H	Engineering Works
Section D	Degraded Train Operations	Section J	Safe Working Procedures and Permits-To-Work
Section E	Depot and Workshop Operations		

12.6 WR Contingency Manual Coverage

The WR Contingency Manual provides guidelines for various abnormal situations where no special operating procedures can be applied but a case dependent scenario identifiable. The manual will cover the steps and points of importance in dealing with such an event, as shown in the table below.

Table 9. WR Contingency Manual Coverage

Part 1		Part 2	
Section A	General	Section A	Detrainment
Section B	Part 1 Emergency Handling Organisation	Section B	Evacuations
Section C	Manpower Backup Plan	Section C	Fire Incident Handling and Control
Section D	Communicating Information During an Emergency	Section D	Emergency Ventilation
Section E	Injury Handling	Section E	Emergency Transport Services
Section F	Investigation and Reporting		
Section G	Training & Qualifications		
Part 3			
Section A	Malicious Acts	Section G	Collisions
Section B	Person / Object Hit By Train	Section H	External Incidents
Section C	Train Divided	Section J	Power Supply System Failures
Section D	Derailments	Section K	Flooding
Section E	Wheel Failures	Section L	Adverse Weather
Section F	Broken / Cracked Rail	Section M	Natural Disasters

12.7 WR Special Operating Procedures Coverage

The Special Operating Procedures manual covers the following event handling:

Table 10. WR SOP's Coverage section headings.

Section A	General Operating Procedures	Section B	WR Operating Procedures
101	Derailment Investigation Team	201	Rolling Stock Runaway
102	Signalling Configuration Committee	202	Depot Incident Requiring Evacuation of Train
103	Traffic Notice	203	Operation of the Electric Drop Barriers at Level Crossing in PMC
104	Procedure for Handling of Dangerous Goods	204	Defect on Train
105	Procedure for Confined Space Working	205	Instruction Relating to the Train Braking System
106	Staff Mobilisation Plan	206	Procedure for Dissemination of Information to Public via WR OCC in the Event of Emergency

Chapter 13. CRM Training Program: Method

The following provides the details of the actual CRM program used for this research.

Training activities included

- Presentations
- Case studies
- Experiential learning
- Discussion Group
- Role play
- Team building exercises
- Video exercises
- Social and leisure activities.

13.1 Course Participants

The trainee population consists of 120 participants: five trainers designated as CRM coordinators; 80 train drivers, which is 80% of West Rail working population; 20 station controllers (60% of WR population), 20 traffic controllers (60% of WR population) and 15 clerical and logistical support staff. The supporting staff is not within the population of this research. The actual male to female ratio is 1:0.15, which is about the existing ratio in the corporation.

Trainees were divided into four groups of 30 based upon age, education background and years of experience in the railway industry. Participants who satisfy any of the 3 factors listed below were accepted into the group, prioritising from group A to D.

Therefore, if a participant fitted multiple categories they simply would go into the higher ranking group.

Table 11. Criteria for sorting participants into groups.

Group qualification criteria	Age (years)	Highest Education Qualification	Railway Experience (yrs.)
A	>45	Degree or higher	>15
B	40-45	Diploma/certificate	10-15
C	35-40	Post Secondary	5-10
D	<35	Secondary	<5

13.2 Training Materials

The CRM will be supported by automated facilities including Integrated Training Facilities (ITF), Computer Based Training (CBT) and Decision Support System (DSS) as described in chapter 7.

13.3 Procedure

Two three-day CRM programs were designed, one class CRM instructor course was provided for CRM instructors and four CRM courses were provided for train crew. A rough outline is shown below, with more details in section 13.7 and 13.8.

Table 12. CRM/LOT Training Course Contents

Training	Contents
LOT	Use of CBT to refresh the use of rail system with emphasis on all the rarely used features Use of DSS to refresh their skills and test out their group exercises in incident handling. Use of video aids facilities including documentary videos of real incidents, animations and subsequent group discussions for case studies. In particular, the following questions formed the essence of the session: 1. Why human error is not the root cause of an accident? 2. Why throwing out a few bad apples do not get rid of the underlying error problem? 3. Why human error is not the conclusion, but the starting point of an investigation? 4. Why almost 100% of crashes are due to some kind of human performance failure, somewhere in the system, for some reason but it rarely to point out that 100% of successful outcomes are also due to human performance? 5. How crews can be encouraged to act and communicate as a team?
CRM	<i>Outdoor team building workshop</i> The first part is a series of warm-up competition type of team exercises to make everybody acquainted with each other, followed by a scenario analysis workshop to enhance the understanding in communication effectiveness, decision-making and team-working. The purpose of the workshop was to systematically assess the various aspects of crowd relocation including undesirable events/causal factors, controls that can be applied to reduce risk, behaviour influencing factors (BIF) and other factors pertinent to safety with an aim to allow open and frank discussion on the needs of each of the main functional groups: • short, medium and long termed operating concepts • definition of roles, responsibilities and number of staff working on the operations floor • emergency handling procedures • mental workload

Training	Contents
	• better understanding of safety culture. Integrated Training (following the above reinforcement): Exercises on incident handling (e.g. station fire, detrainment, tunnel emergency access and station emergency control) by the combined used of ITF, VAT, DSS and use of videos from drills and TV news as media.

13.4 Measurement of Effectiveness

Theoretically, the effectiveness of the program is measured by two perspectives: immediate outcomes from computer based training (CBT) workstations and subsequent team effort evaluation. The immediate results are mark scored in computer workstations according to ITF interactive responses. Team effort to be measured according to six teamwork processes:

- Adaptability-recognising problems and responding appropriately,
- Communication- the exchange of clear and accurate information,
- Coordination-organising team activities to complete a task on time,
- Decision making-using available information to make decisions,
- Interpersonal skills – inter-acting cooperatively with other team members,
- Leadership – providing structure and direction of the team.

As it is the purpose of the study to measure the actual effectiveness of CRM, Actual performances targets in 2005 were compared with performance targets in 2006:

- Use the West Rail Annual Performance Report 2005 and 2006 as references,

- Use the West Rail Failure and Delay Statistics in 2005 and 2006 as reference
- Compare the customer complaint and commendation records against patronage;
- Refer to observation reports from East Rail, West Rail train crew to deal with train fire inside tunnel drills.

13.5 Statistical Analysis

Inter group difference in CRM attitudes will be measured by T tests and ANOVA methods.

13.6 CRM Training for Train Crew

13.6.1 Day one Course Objectives

- To introduce the subject of human factors
- To introduce the subject of human error
- To demonstrate the approach taken by human factors specialists
- To introduce basic human factors techniques

Human Factor Training

- Module 1 Introduction of “Just” Culture
- Module 2 – What is human factors?

- Module 3 – The human factors approach
- Module 4 – Introduction to human error
- Module 5 –Task analysis techniques
- Module 6 – Human error identification
- Module 7 Summary

Day two Team building Exercises and Human Factor Case Studies

Team building and human factor case study training is independent of Day one training.

Between training sessions and alternating with VAT sessions were team building exercises designed not just as ice breakers amongst participants, but also to get crew to know one another and understand the value for teamwork. Exercises are similar to that used in other CRM programs and included games, workshops and an outdoor wood climbing exercise at the campsite which required three members to cooperate at a time to climb to the top.

Case Study King's Cross Fire

Video reference: The King's Cross Disaster (Discovery)

In England, over 30 people died in the devastating King's Cross underground fire in 1987 (Fennel, 1988). The fire was caused by a match discarded on the wooden escalator, which fell underneath and started ignited rubbish, dusts and oils accumulated. As similar fires have started in the past, and had self-extinguished most staff and

emergency services believed the fire was small and did not take appropriate caution. The fire started burning the escalator, and the ceiling, but staff failed to close off the station and evacuate passengers in time. The fire flashed over, extending to the upper concourse and lighting everything that could burn, resulting in over 30 dead and 60 injuries.

Lessons learned:

- Fire fighting facilities for underground station
- Inappropriate materials that may exist in station- wooden escalators and solvent paints may catch fire quickly
- Evacuation plan from tunnel and underground station
- Search and rescue
- Customer behaviour-when fire occurred, passengers were not aware for evacuation

13.6.2 Class Exercise

Human Factor Exercise 1

Based on lesson learned, brainstorm fire safety facilities for KCRC's new 2.2 km Chau Tau Tunnel and Lok Ma Chau new station

Objective

Use fatal lessons learnt from fire incidents to work out station and tunnel safety requirement and evacuation plan.

13.6.3 Day 3 CRM Exercises- Incident Handling Group Exercises-LOT

Group Members were selected from the group according to their discipline to participate in the exercise, which uses Integrated Training Facilities including Backup Control Centre, Station Controller Console and two Cab Simulators.

Two train drivers were assigned to work on two cab simulators, two traffic controllers, one traffic controller and one senior traffic controller and two station staff. The remaining team members were positioned in different training rooms to simulate following trains and different stations. The integrated facilities were partitioned such that all activities were invisible to other parties. All communications were made via telephones or radiophones. The exercise was taped for debriefing and erased after debriefing. Other team members were assigned to outdoor team building exercises in turn.

Four scenarios were designed to test the incident handling capability of train crew:

- Scenario one- Run under (a trespasser was knocked down by train)
- Scenario two – Station fire (Arson attacks at station)
- Scenario three- Train Fire inside tunnel
- Scenario four – Train Derailment in viaduct section

After the exercise there will be time allocated to discuss the activity. This includes a session to evaluate the effectiveness of each member and also the team in handling the situation, as well as inviting participants and observers for feedback. CRM data recording media and videos, and computer analysis programs may be consulted for evaluation. Results can be recorded for performance measurement in a later time period.

13.7 Emergency Drills

In order to compare the effectiveness of train crew post CRM training, two emergency drills of similar nature were arranged with the participation of Hong Kong Police, Fire Services, Hospital Authority and Civil Aid Services.

The performance of West Rail train crew post CRM training will be compared with East Rail train crew who had not received CRM training through drills and exercises. Two identical drills were select, “Train Fire inside Tunnel”. The drills were video recorded and the same team of observers were invited to evaluate the performance differences.

Emergency drill for West Rail– Train Fire inside Tai Lam Tunnel

All train crew members who attended CRM training were participated in this drill.

Emergency drill for East Rail – Train fire inside East Rail Beacon Hill Tunnel

All train crew members participated in this drill had not been received CRM training

Objectives:

- To test the effectiveness of co-operation, co-ordination and communication among Hong Kong Government Departments in incident handling with large number of casualties;
- To test the effectiveness and competency of KCRC engineering staff.
- To note if CRM training made any difference in the response and competency of KCRC staff

CRM trainers and supervisors from train crew were invited as Observers. West Rail train crew is allowed to use the prototype DSS developed for Main Control System.

Successful factors are to be compared according to the following criteria:

- Response time after train crew reported incident to OCC
- Actions taken

At Operations Control Centre:

- Incident reporting to internal and external parties;
- Train service regulation;
- Long line public addressing
- Incident reporting by telephone, radiophone and multi-FAX
- Incident Management Room, turn on all workstations in the Incident Management Centre (IMR)
- Use “all call”, “group call” and “zone call” to maintain communications with other train drivers.

At station

- Tunnel lighting
- Tunnel ventilation system –wind flow direction
- Public address announcement at station
- Passenger Information Display System
- Ticket gates

On Incident Train

- Communication with passenger who reported incident by train-borne intercom device
- Incident reporting- Emergency call made to OCC
- Broadcasting messages from train driver and long line public addressing from OCC

The session is to be evaluated by system playback from both main and train control and signalling systems. Data records of communications and voice messages between engineering and external parties are also used. Observers, CRM trainers, videos, video cameras and CCTV recorders are also used to provide feedback for the emergency drill exercises.

Chapter 14. Crew Performance Assessment

Traditionally, training and evaluation in aviation industry focused on a pilot's technical skills.

The introduction of line-oriented flight training (LOFT) in the 1980s and the Advanced Qualification Program (AQP) in the 1990s launched new requirements to train and assess complex crew resource management skills (Baker, 2002).

As mentioned previously, the effectiveness of training will be measured by two stages (a) immediate result from ITF, (b) Compare performance result in 2005 and 2006, service targets vs actual performance:

- Immediate post CRM training result- computer records from ITF interactive responses
- Performance appraisal- ride checks and workplace performance audits
- Overall performance result of West Rail (Failure and Delay Statistics)
- Complaint and Commendation from the customers vs passenger trips

14.1 Immediate post CRM training result- computer records from ITF responses

The computer records from ITF interactive responses were evaluated. The record showed that amongst all the 4 groups, overall mark scored from line oriented training performance was found to be satisfactory and there was basically not much difference amongst the groups, even though groups A and B were expected to be more prudent than groups C and D in the way of handling unexpected events because of their increased exposure and better education

background. From observation of human factor case studies and incident handling exercises by using ITF implies that younger group of crew can be brought to a similar level of performance with more experienced group given that they were suitably trained and provided with a realistic environment to practice the skills as a team. Younger crew may have had less on-the-job experiences, but they may be able for make up for this by being more capable to process and grasp new concepts and ideas to put them to use immediately. Although these are not real life situations and it is immature to conclude that the CRM programme was good enough to improve one’s efficiency and situational awareness, the CRM program does build a solid foundation for crew performance, particular for the younger groups both mentally and practically.

The ITF scoring was tabulated below in table 13[31]:

Table 13. Mean ITF scores between teams after CRM training.

Group	A	B	C	D
ITF Score after CRM training	84%	82%	83%	83%

Since CRM training is the first trial in West Rail. There is no president record in ITF for comparison between pre/post CRM training efforts. However, group performance from ITF shows that the mark scored between each group is not significant. .

14.2 Performance result- West Rail annual performance results and observations from drills

Along this second stage of assessment, the following measures were used to assess the selected trainees along their workplace.

- a) Use observation checklist to assess West Rail train crew with CRM training and East Rail train crew without CRM training in handling similar drills with similar incident scenario- train fire inside tunnel.
- b) Use West Rail Failure and Delay Statistics in 2005 and 2006 to compare actual performances
- c) Use summary of debriefings and observation reports from drills and exercises to review the effectiveness of CRM training;
- d) Use recorded messages from telephone and radio systems to evaluate effectiveness of communication;
- e) Use system playback from train control and signalling system and station control system to assess performance of traffic controllers and station controllers;

The observers, being their supervisors, concluded that train crew received CRM training perform better with high level of competency.

14.3 Performance Result of West Rail

In West Rail, there is an 8-minute reporting mechanism under which the Corporation is required to inform the Government and announce to the public should there be an event with a forecast delay of more than 8 minutes. This is a pre-warning mechanism of which the actual delay may not be that significant but it reflects the confidence level of the Train Crew when confronting an unexpected scenario. The number of 8-minute cases before and after CRM training may be considered as a meaningful parameter and chosen to measure another aspect of the CRM effectiveness since these are incident handling cases that required prudent decision and teamwork amongst all the crew involving in the incident. The better the performance, the less 8-minute cases incur. The monthly figures before and after CRM training are reflected in the following histogram.

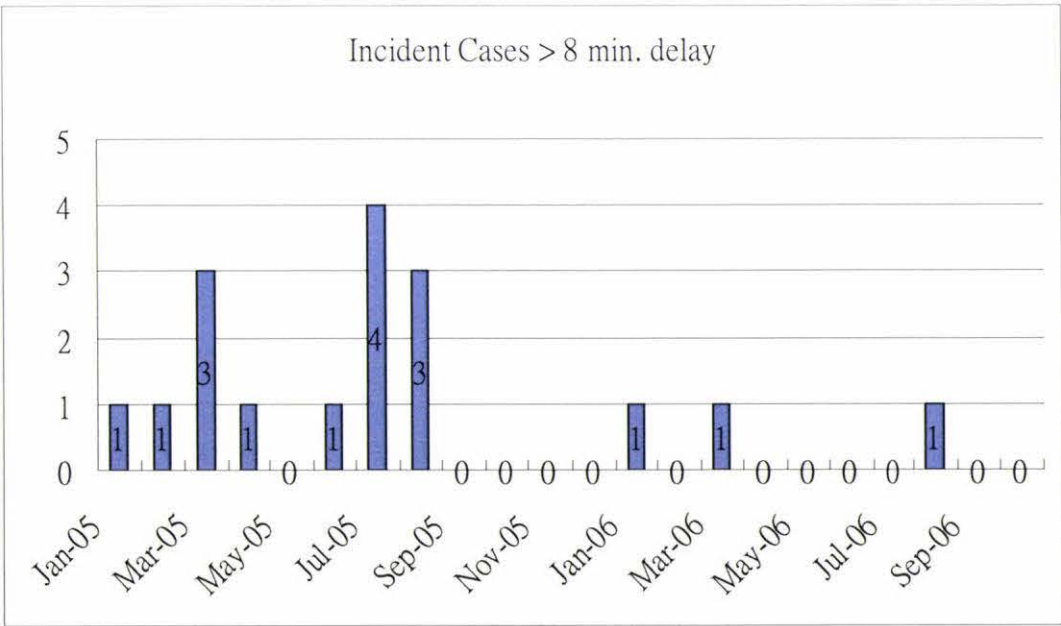


Figure 13. Monthly figures of incident incurring more than 8 minutes delay.

It can be seen that the number of incidents were less frequent in 2006 compared to 2005. The peak at July and August 2005 were due to special incidents. For incident if the initial delay of train service exceeding 8 minutes shall be reported to public media. Amber alert is the second class warning if the initial delay exceeding 10 minutes. Red Alert is the emergency class warning if the initial delay is exceeding 20 minutes. Once “Emergency” is declared by STC, all on-call officers have to report to the incident control point (ICP) immediately.

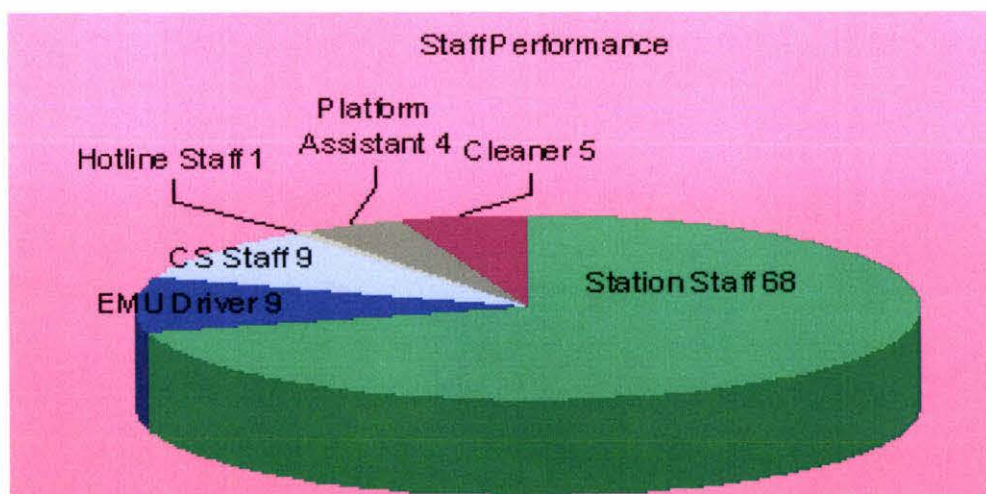
The student's t-test was used to analyse the changes in monthly means of the number of incidents before and after the training period, which occurred in July 2005. The mean number of incidents (SD) from Jan-Jul 2005 was $= 1.6 \pm 1.4$. The mean from Aug 2005 to Oct 2006 was 0.3 ± 0.8 . The 2 tailed t-test showed that the results were significantly different before and after the training ($t = 1.78$, 2 tailed, $\alpha \leq 0.05$). This suggests that CRM may have better equipped staff to deal with incidents promptly such that it is controlled within the eight minutes period. Data from this test are shown in appendix C2.

Given that rail system failures (in particular the signalling system) are of random nature, inevitable, and may happen from time to time, it is crucial to gauge how well and effectively the crew can handle these scenarios. Although CRM training had been carried out for only a year at the time of publication, the data suggests that the train crew may have become more confident and prudent to handle unexpected situations. However, this could also be attributed to the fact that crew become more experienced after an additional year of operation, and that most of the

fine tuning/ adjustments of the rail network and administration issues have been completed in the 2004-2005 period.

14.4 Staff Commendations

The number of commendations in 2005 was found to have increased by 20% compared to 2004. The staff performance as indicated in figure 13 is dominated by the number of positive feedback from the customers for station staff (students of the CRM programme). There is also an unexpected increase that 9 cases of commendation were granted to the train drivers (another set of CRM students) who are dealing with the customers in normal operations. As these are preliminary figures it is not yet assessable if they fully reflect CRM effectiveness, but it is most probable that CRM had some influence.



Legend :

EMU-Electro Multiple Unit

CS-Customer Services Centre

Figure 14. Pie chart showing breakdown of staff commendations (96 in total) (KCRC, 2005e, 2006b).

14.5 Staff Complaints

Apart from the customer’s commendation, complaint was another parameter for measuring staff performance. Figure 14 of complaints in year 2004 and 2005 were collected and illustrated in the following tables.

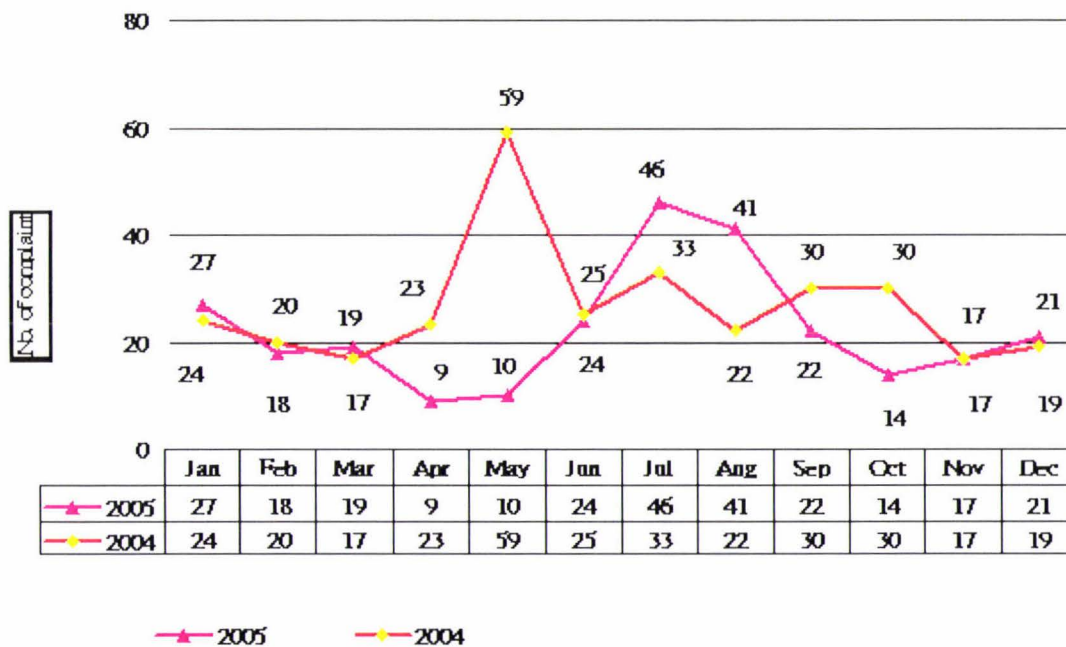


Figure 15. Number of staff complains from 2004 and 2005 period (KCRC 2005e, 2006b).

Analysis by Student t-test of pre and post training data revealed that the number of customer complaints pre and post CRM training were non-significant ($t=0.172, \alpha>0.05$). Raw data and details are shown in appendix C3. Results showed that CRM training made no difference as yet to the number of customer complaints received. More results may be required to confirm findings.

Unfortunately, the complaints were increased significantly in the months of July 2005 and August 2005, right after the CRM training session. The undesirable figures were actually due to special incidents as a result of persistent signalling equipment failure and longer than expected system recovery time. This may bias the results to some extent. Alternatively, the lack of significance may allude that the number of customer complaints may take longer to respond to the effects of CRM training.

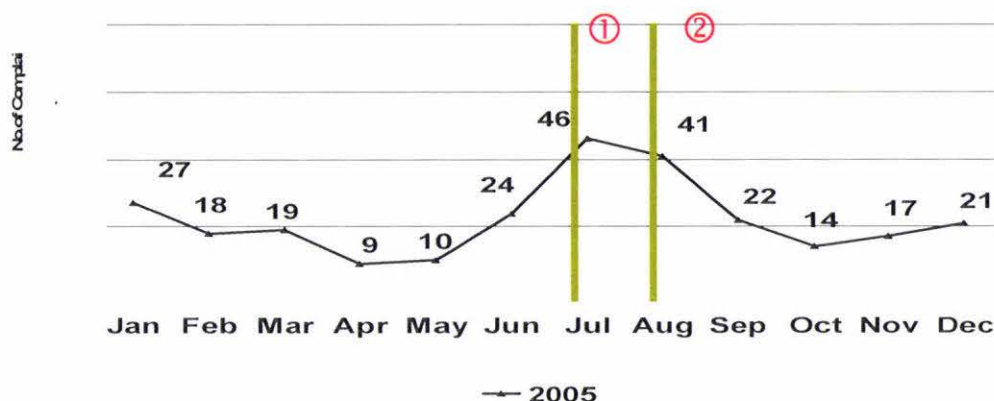


Figure 16. Trends in staff complaints in 2005 (KCRC 2005e, 2006b).

①&② denotes Service disruption due to signalling failure on 21/7/05 (17 cases); 17 & 19/8/05 (9 cases)

Major Areas of Concern:

- (1) Insufficient notices and announcements at stations;
- (2) Not enough information about the disrupted service;

Overall the above statistics suggest preliminary pointers that CRM may have reduced the number of incidents and increase staff commendations. As the program was introduced only recently, and there may be other compounding variables not controlled, these figures should only be taken as a rough guide. Nevertheless, the TOC can monitor such figures in the long term as possible indicators of program effectiveness.

14.6 Performance Result in 2005 and 2006

West Rail CRM training was completed in the fourth quarter in 2005. The following figures provide more solid evidences to show that CRM training is effective because West Rail average daily patronage increased by 11.7% (KCRC 2006c).

14.6.1 Pre/Post CRM Performance Analysis

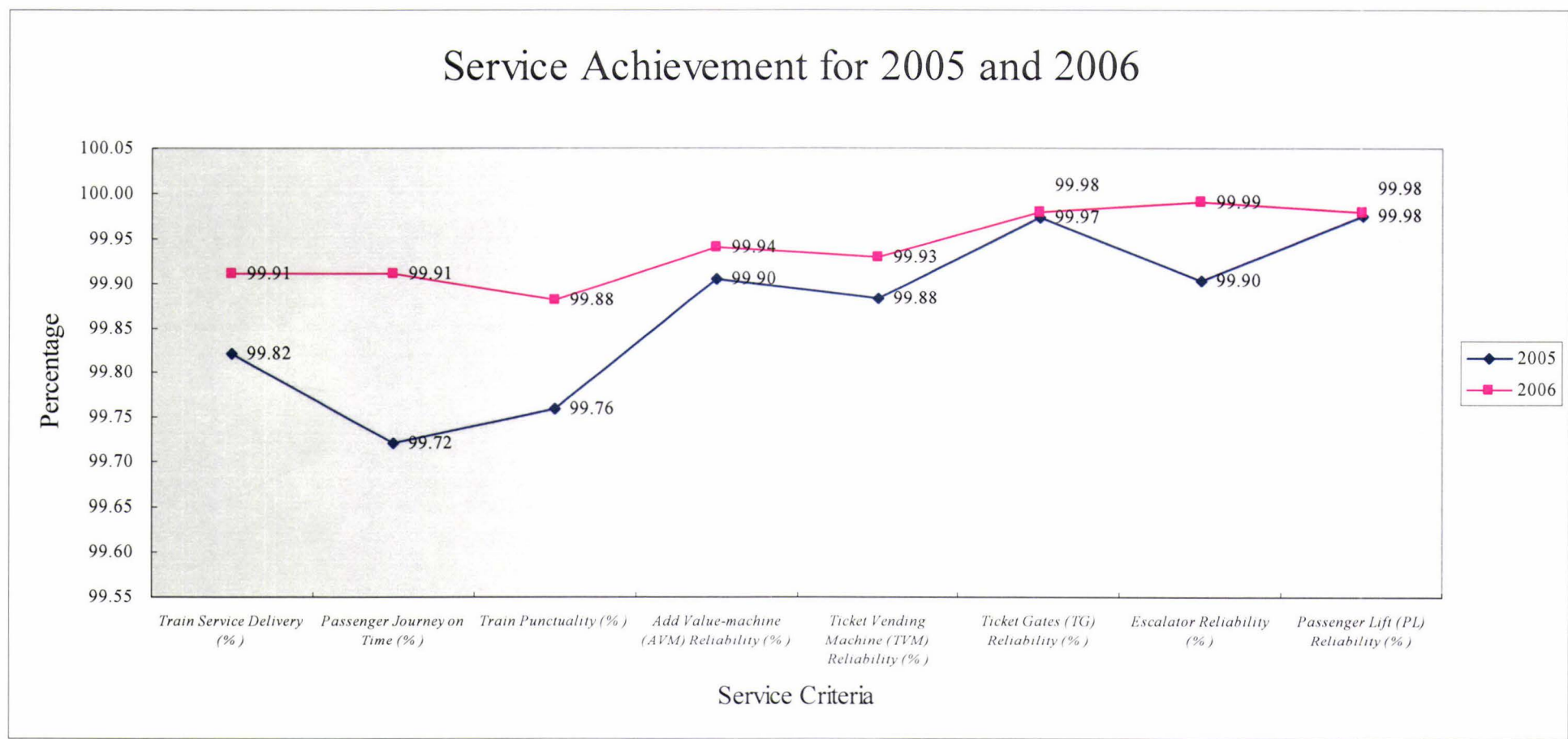


Figure 17. West Rail Service Achievement for 2005 and 2006 (Data source: West Rail annual performance review reports 2005 and 2006)

Weekly Impact 2005/2006

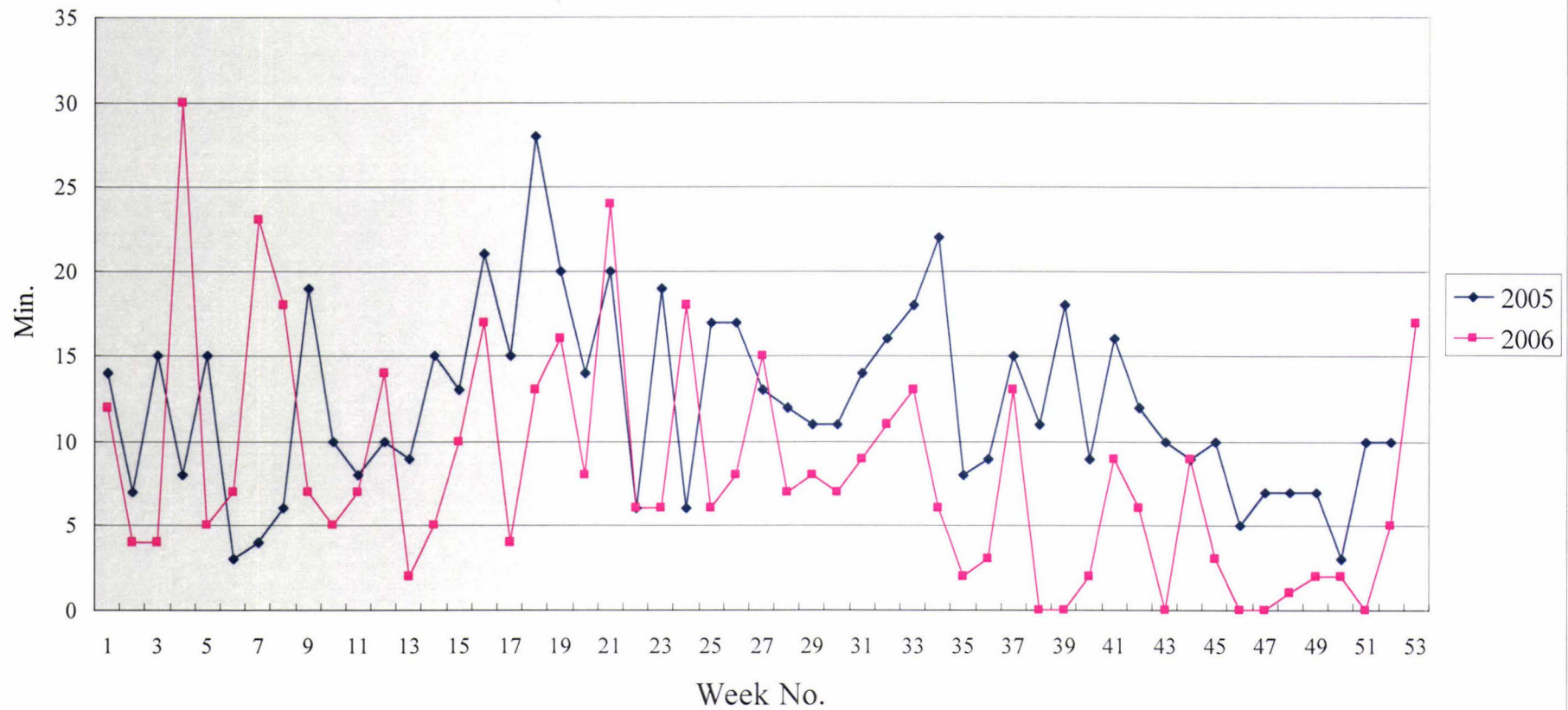


Figure 18. West Rail Weekly Service Impacts (Data source: Failure and Delay Statistics 2005 and 2006)

14.7 Change in Safety Attitude

Before and after CRM training, train crew were asked to do an attitude survey [J36] on safety climate. Twenty questions focus on safety awareness and safety practices in the organization were designed for the trainees to complete before and after CRM training. The purpose of this attitude test aim to measure the change in attitudes i.e. behaviour change and transfer to actual behaviour on the job. Tangible evidences of success can be seen from Figure 16 service achievements in 2005 and 2006. The results were analysed to measure the change in attitude after CRM training. T Test and ANOVA were used for data analysis.

Table 14. Attitude Survey Questions for Crew Resource Management Training

		A	B	C	D	E
		Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly
1	I am encouraged to report concerns regarding passenger safety.					
2	Train crew has effective handover between shifts.					
3	Supervisors are always aware of individual's workload.					
4	Management responds only after accidents have occurred.					
5	Safety is considered something that is everyone's responsibility.					
6	Effective communication channels exist between traffic controls, train crew and maintenance crew.					

		A	B	C	D	E
		Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly
7	I am involved in informing management of important safety issues.					
8	Line oriented training that I get has given me the confidence to undertake all my tasks safety.					
9	KCRC provides adequate safety training for all staff.					
10	I feel that I have the responsibility to enhance the safety of my job.					
11	Information on enhancing passenger safety is effectively disseminated to all appropriate staff.					
12	The health & safety rules and procedures in safety manual are not really practical.					
13	I receive regular feedback from supervisors on my safety performance.					
14	Management gives active and visible support to incident investigation.					
15	I feel that sometimes there are “short cuts” that can get a job done better.					
16	Standard Operating Procedures (SOP) and rule					

		A	B	C	D	E
		Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly
	book make me aware of the safety problems that I may encounter while undertaking my tasks.					
17	Safety is our main concern in our interaction with passengers.					
18	Operational targets conflict with safety measures.					
19	Because of experience, I feel confident to take “short cuts” in undertaking my job.					
20	Management adopts a “no-blame” approach to investigate all accidents.					

:

☐ Group A

☐ Group C

☐ Group B

☐ Group D

14.8 Research Results

Statistical analysis by of pre/post CRM attitude change analysis as detailed in Appendix E.

14.8.1 Methodology

(a) T-Tests [J38]for paired samples to compare each item pre and post for all 120 subjects

(b) Multivariate Analysis of Variance with one between subject factor (Group) and one within subject factor (pre and post CRM).

14.8.2 Findings

The subjects show better safety-related attitudes after the training on 16 of 20 items (except item 1, 10, 11,17)

There is a strong within subject effect for the attitude items. All changes in the desired safety related direction. There is only a small between subject (group) factor and no interaction of both.

In conclusion, the attitude questionnaire is showing positive changes of safety attitudes of the trained subjects from before to after the training.

Table 15. West Rail Service Pledge and Actual Performance (Data source: West Rail Annual Performance Review Reports 2005/2006)

KCRC ER/WR Service Performance in 2005/2006

Railway Services	West Rail			
	2005		2006	
Item	Target	Performance	Target	Performance
Service Delivery	99.0%	99.82%	99.0%	99.91%
Punctuality	99.0%	99.76%	99.0%	99.88%
Availability of Passenger Information Displays	99.0%	99.81%	99.0%	99.72%
Availability of Ticket Vending Machines	99.0%	99.88%	99.0%	99.93%
Availability of Octopus Equipment	99.0%	99.95%	99.0%	99.94%
Availability of Ticket Gates	99.0%	99.97%	99.0%	99.98%
Availability of Escalators	99.0%	99.99%	99.0%	99.99%
Availability of Lifts	99.0%	99.98%	99.0%	99.98%
External Train Cleanliness (Washed every 2 days)	99.0%	99.60%	99.0%	100.00%
Response to Passengers' Enquires and Opinions				
Phone (Reply within 2 working day)	99.0%	100.00%	99.0%	100.00%
Letter (Reply within 6 working day)	99.0%	99.60%	99.0%	100.00%
No. of Major Delays (20 mins or more)	Minimize	6	Minimize	1
On-train air-conditioning failures per month	Less than 3 times per month	0	Less than 3 times per month	0

14.9 Performance Observations from Drills

Two train crew teams were assigned to participate in train fire inside tunnel drills. The train crew from West Rail received CRM training while East Rail train crew team has not been received CRM training. Same team of observers were invited to evaluate the performance between two train crew teams.

14.9.1 Summary of Observations

14.9.1.1 West Rail Train Crew

West Rail train crew used standard communication protocol to maintain effective communications;

- Train crew and maintenance crew working cohesively as a team according to instructions given by Incident Officer and Incident Engineer;
- West Rail train crew used radio “emergency channel 1” for train crew operations while the maintenance team used radio “emergency channel2” for engineering functions;
- DSS is an threat management tools to support train crew and maintenance crew in incident handling and decision making;
- Train crew and maintenance crew adopted “readback message” practice before execution of safety critical commands;
- According to voice communications records from radio and telephone recorders, train crew and maintenance crew communicated twice as much as East Rail train crew and maintenance crew.

1.4.9.1.2 East Rail Train Crew

- Train crew and maintenance crew are using the common emergency channel, there is no dedicated channel assigned for train crew and maintenance crew;
- Train crew used non standard communication protocol;
- Maintenance crew often used cell phones to make private calls with no communication records from voice recorders;
- There is no DSS features for East Rail operation and station control systems to support in incident handling and decision. Incident Officer and Incident Engineer relied on hardcopy rule book which is less efficient,

In conclusion, train crew attended CRM training can work cohesively as a team and maintain stronger situation awareness and adopt “readback message” as double confirmation before execution of safety critical commands. Further details of observation from drill refers to Appendix

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 香港鐵路有限公司
 課程評估表

Course Title: 課程名稱 _____

Course Date: 課程日期 _____

Instructor (Internal): 導師 (公司內部課程) _____

Name of Participant: 學員姓名 _____

Organizer (External): 舉辦機構 (外間舉辦課程) _____

This post course evaluation form is designed to help us assess the quality and usefulness of the training course. The following statements address your reactions to this course. Please use this scale to respond to each statement.

此課程問卷旨在協助我們評估課程的質素及效用。下列項目反映出席學員對課程的意見。請用以下的標準等額作答。

	SA Strongly Agree 十分同意	A Agree 同意	D Disagree 不同意	SD Strongly Disagree 十分不同意
A. Course Design 課程設計				
1. The course content was well organised 課程內容安排很有組織	☐	☐	☐	☐
2. The topics were stimulating 課程很有刺激性	☐	☐	☐	☐
3. The topics were appropriate to my level of understanding 課程的程度恰當	☐	☐	☐	☐
4. The course materials were useful aids to learning 所用教材對學習有幫助	☐	☐	☐	☐
B. Course Leader 課程導師				
1. The course leader was knowledgeable on the subject 導師對課程具有專業知識	☐	☐	☐	☐
2. The presentation was well organised and clear 導師的敷設方式很有條理以及清楚易明	☐	☐	☐	☐
3. The course leader was able to handle questions skilfully 導師能技巧地處理學員的問題	☐	☐	☐	☐
C. Training Methods 訓練方法				
1. Which training method(s) used in this training programme could assist your learning? 在此課程內，下列那種訓練方式，會對你的學習有所幫助				
☐ Lecturing 講授	☐ Case studies 個案研究	☐ Group discussions 小組討論		
☐ Games 遊戲	☐ Role plays 角色扮演	☐ Videos 錄影帶		
☐ Others 其他 _____				
D. Overall Comments 整體評核				
1. Duration 課程時間	☐	☐	☐	☐
2. Course content could meet objectives 課程內容達到預期目的	☐	☐	☐	☐
3. Overall, I am satisfied with the course 整體而言，我對課程很滿意	☐	☐	☐	☐
4. The course can be applied to my job 課程所學到的知識/技巧能應用在我的日常工作上	☐	☐	☐	☐
5. Will you recommend other staff to attend this programme 你會推薦其他課程給其他人嗎？	☐	☐		
E. Other Comments 其他意見				

Figure 19. Training Course Evaluation Form[42]

Table 16. Post CRM Course Evaluation Score [J43]

Course Evaluation Results				
Course Titles: CRM Training for West Rail				
A. Course Design	SA	A	D	SD
1. The course content was well organised	35	80	5	0
2. The topics were stimulating	30	80	8	2
3. The topics were designed appropriate to my level of understanding.	35	78	7	0
4. The course materials were useful aids to learning	40	77	3	0
B. Course Leader				
1. The course leader was knowledgeable on the subject	20	80	15	5
2. The presentation was well organized and clear	18	92	7	3
3. The course leader was able to handle questions skillfully	5	105	7	3
C. Training Methods				
1. Which training methods used in the training programme could assist your learning?				
	SA	A	D	SD
Lecturing	10	70	15	5
Case studies	35	78	3	4
Group discussion	25	87	5	3
Games	35	80	5	0
Role plays	30	80	8	2
Videos	25	90	5	0
Others				
D. Overall Comments				
1. Duration	Too Long	Appropriate	Too Short	
	10	95	15	
	SA	A	D	SD
2. Course content could meet objectives	35	79	6	0
3. Overall, I am satisfied with the course	37	81	2	0
4. The course can be applied to my job	42	73	3	2
5. Will you recommend other staff to attend this programme	117 YES		3 NO	
E. Other Comments (new training topics)				
Human factor training	10			
Radio communication training	25			
Team building workshop	50			
Trauma Counselling (Post incidents- suicide, assault, train fire etc.)	35			

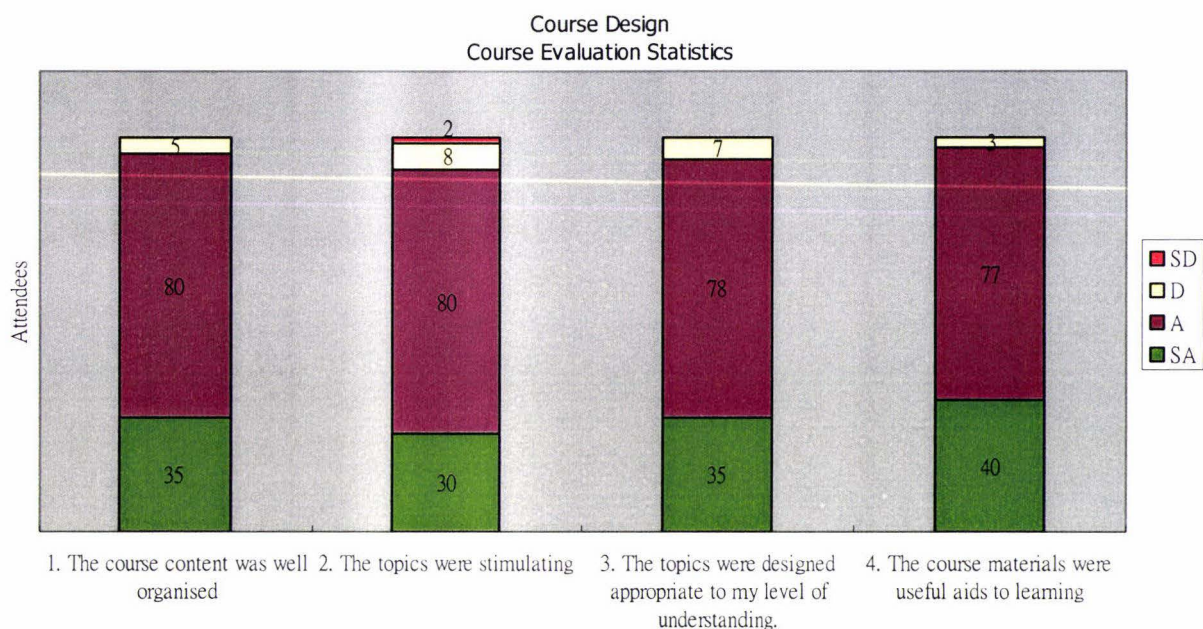


Figure 20. Course Feedback on Course Design

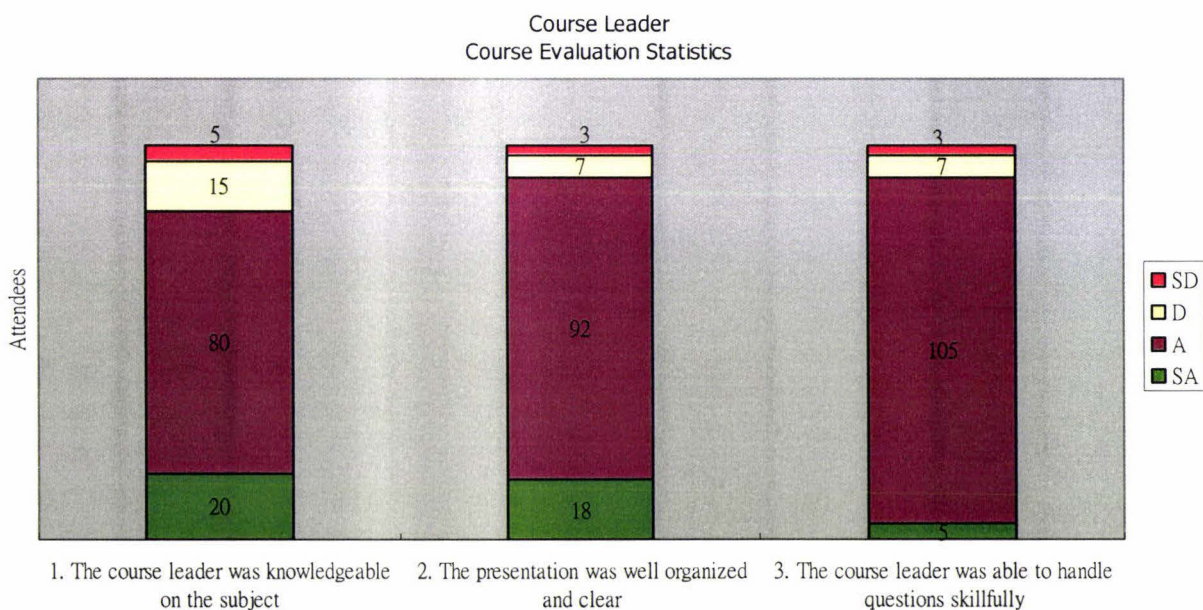


Figure 21. Course Feedback on Course Leader

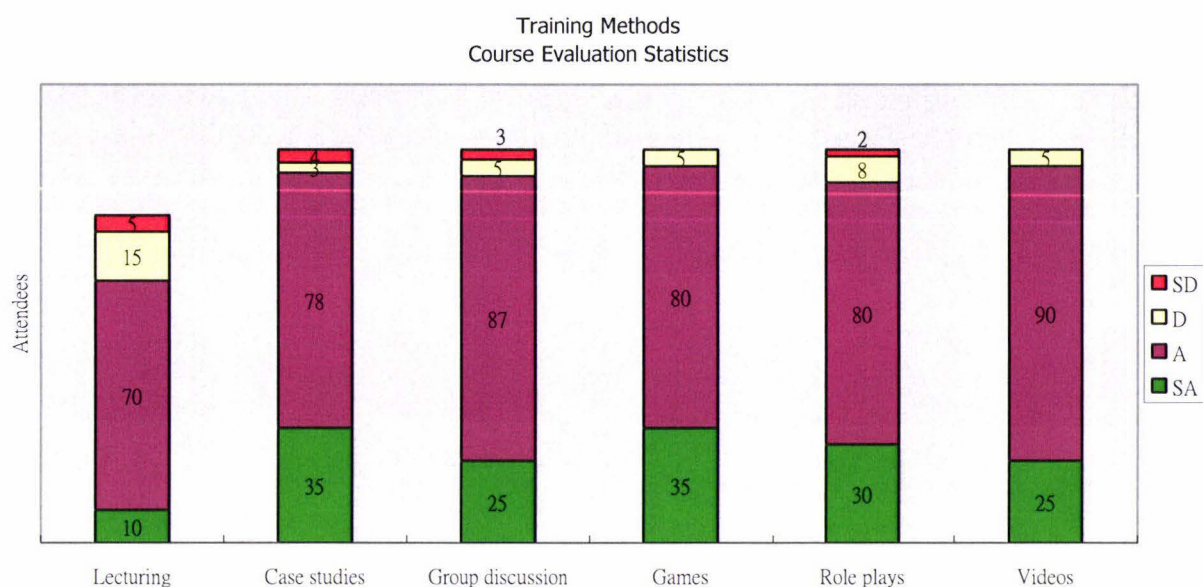


Figure 22. Course Feedback on Training Method

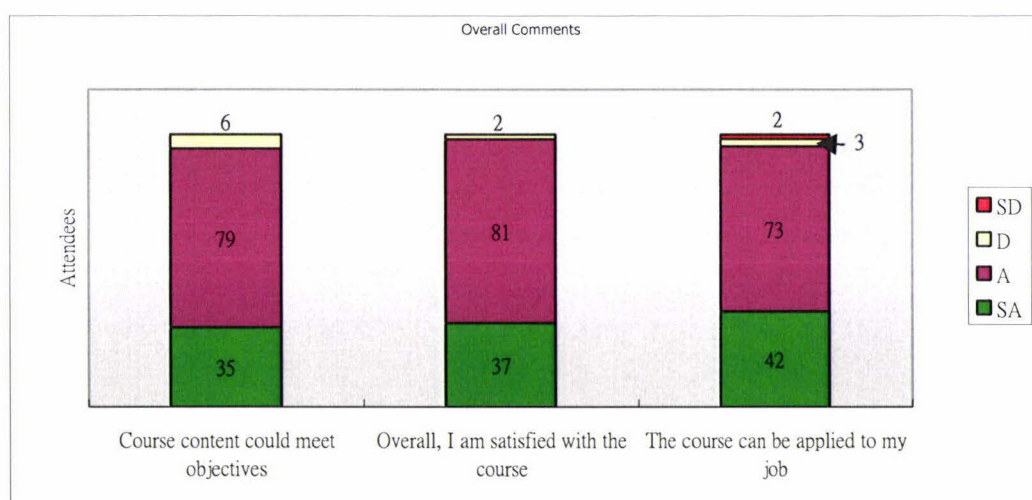


Figure 23. Overall Comment

Will you recommend other staff to attend this programme?

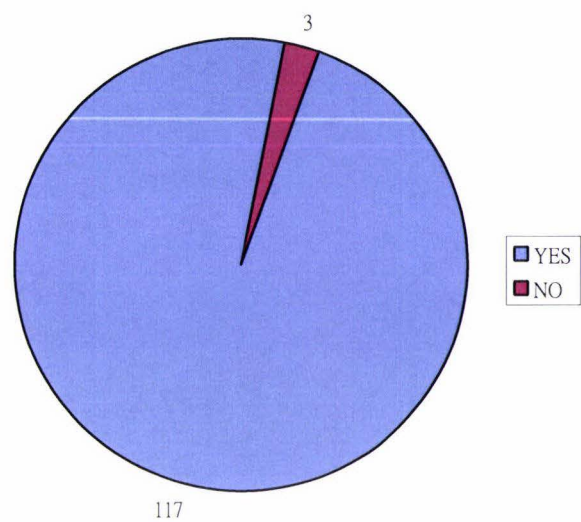


Figure 24. Course Feedback on Recommendation

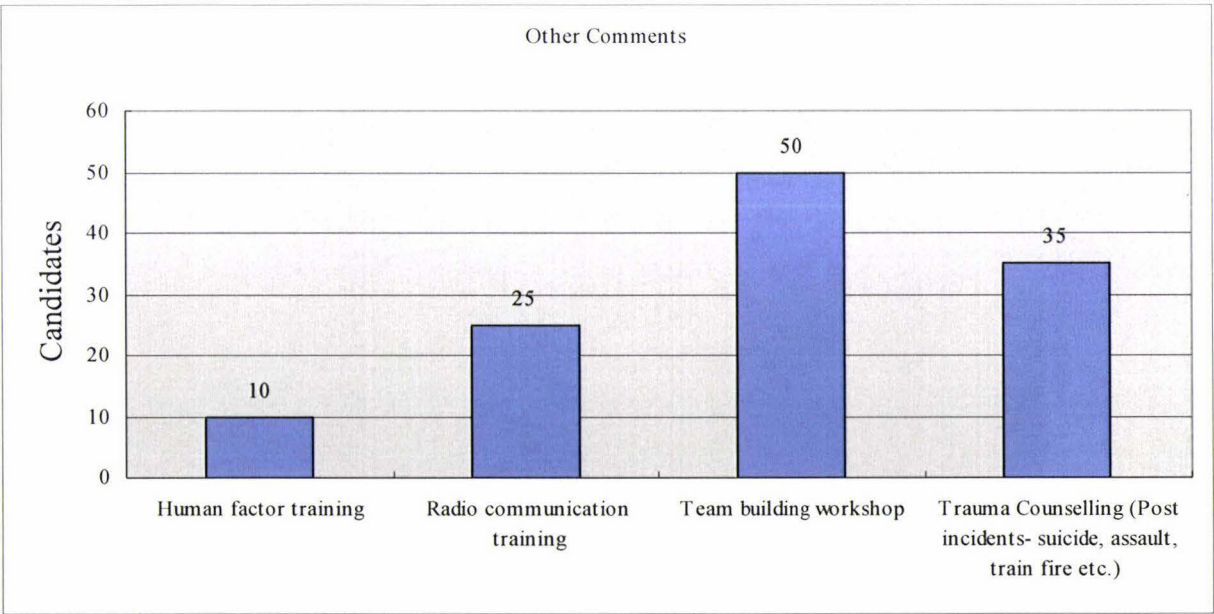


Figure 25. – Course Feedback on suggestion for other courses

Chapter 15. Discussion of CRM Effectiveness in KCRC

The KCRC CRM programme was designed to incorporate models of effective CRM behaviours, allow the crew to engage in role-playing exercises during which such behaviours are practiced, and provide feedback to the crew for evaluation of their performance.

As in aviation, accident and near-miss statistics were not found to be useful in assessing the effect of CRM training as they were too low to be interpretable for training evaluation. Therefore, an alternative evaluation approach was used which consisted of several method of assessment as outlined below.

Incorporating known principles of practice and feedback into the design and delivery of training programmes can strengthen CRM training. Here active practice and remedial feedback (Salas & Cannon-Bowers, 1997) was solicited from participants for the purpose of improving or fine tuning the course. The scope of CRM effectiveness to be measured by course evaluation questionnaires, safety attitude change studies and West Rail performance review results. .

15.1 Post Training Performance

15.1.1 Course feedback questionnaire

Feedback was obtained regarding the relevance, interest, standard of teaching, exercises, videos and course exercises from all 120 train crew who participated in the course.

Although the feedback was generally positive, it was recognised that there was a need to place further emphasis on skills, rather than the theoretical background for it to be more directly applicable. It was also suggested that the course should lengthen to 4 days and place more emphasis on outdoor workshop (making it one whole day) for concepts to consolidate further.

In conclusion, the CRM courses were well-accepted by the course participants. Based on post course survey results, more management attentions have been brought at corporate level to provide more teambuilding workshops, more consultancy studies on human factor aspects such as fatigue awareness and safety awareness training for all level of KCRC staff in 2007.

Positive critique from course survey:

- 95% of the course participants experienced the course well organised;
- 91.6% of the course participants agreed the topics were stimulating;
- 94% of the course participants agreed the topics were designed appropriate to their level of understanding;

- 97.5% of the course participants agreed the course materials were useful aids to learning;
- 83% of the course participants agreed the course leader was knowledgeable on the subject;
- 91.6% of the course participants agreed the presentation was well organized and clear;
- 91.6% of the course participants agreed the course leader was able to handle questions skilfully;
- 66.7% of the course participants were in favour of lecturing;
- 94.2% of the course participants were in favour of case studies;
- 93% of the course participants were in favour of group discussion;
- 95.8% of the course participants were in favour of games;
- 91.6% of the course participants were in favour of role plays;
- 95.8% of the course participants were in favour of video;
- 95% of the course participants agreed the course content could met objectives
- 98.3% of the course participants satisfied with the course;
- 95.8% of the course participants agreed the course can be applied to their jobs;
- 97.5% of the course participants will recommend other staff to attend this course;
- 8.3% of the course participants recommended to provide other training on

human factor;

- 20.8% of the course participants recommended to provide other training on radio communications;
- 41.6% of the course participants recommended to provide more team building workshops;
- 29% of the course participants recommended to provide trauma counselling training post incidents such as suicide, assault and train fire etc.

Negative critique:

- Course materials, presentation materials and video in mother tongue would be beneficial;
- Video duration should not exceed 30 min. (Partly possible due to English language);
- Training should have been conducted after the recurrent ride check or performance appraisal. Train crew would have been more receptive.

Refer to analysis of the safety attitude change results by using T-Tests for paired samples to compare each item pre and post CRM for all 120 CRM course participants and by using Multivariate Analysis of Variance with one between-subject factor (Group) and one within-subject factor (pre and post CRM). The CRM course participants show better safety-related attitudes after the training on 16 of 20 items (except item 1, 10, 11, 17). There is a strong within-subject effect for the attitude items. All changes in the desired safety-related direction. There is only a small between group factor and no interaction of both. In conclusion, the attitude questionnaire is showing positive changes of safety attitudes of the trained subjects from before and after the training.

Crew displayed an increase in safety oriented attitudes after the course probably because of the new concept of CRM stimulating new ideas in their way of thinking. This indicates that CRM was able to introduce the safety critical concepts and ways of thinking that crew should adopt in their day to day roles.

15.1.2 Accident Scenario Identification

Trainees were given two written accident scenarios and asked to think of possible causes of disaster and categorise such errors on the basis of behavioural skills framework. All trainees were able to correctly match causes to the defined categories with very few explanations as non-human factors. Human factor videos were used as training media. The findings made by the trainees were compared with the investigation results from

videos. This show that crew were able to think more on the basis of human factor errors and recognise their importance and consequences.

15.2 Workplace Performance

Two methods were adopted to measure the workplace performance post CRM training to check information retention and if skills learnt were applied on the job. The first involved a six months workplace performance summary report feedback from General Manager of West Rail Operations Department. The criteria of measurement include:

- Immediate result- computer records from ITF interactive responses
- Performance result- ride checks and workplace performance audits
- Overall performance result of West Rail (accident rate)
- Complaint and Commendation from the customers
- CRM and computer-based training (CBT) computer records;
- Use post-training questionnaires to measure post-training feedback;
- Use data from the train-borne computer (black box) and ride checks by train crew inspectors to monitor train drivers performance.

The second, as discussed above, consists of an emergency drill exercise with external parties. Two similar emergency drills- “Train Fire inside tunnel” were arranged at East

Rail Beacon Hill Tunnel (2.75 km in length) and West Rail Tai Lam Tunnel (5.5 km in length) respectively to measure the incident handling, decision making in term of immediate response, co-ordination and communication skills. East Rail train crew (without CRM training) and West Rail train crew who attended CRM training. Observers were invited from KCRC engineering departments.

Non-numerical results and feedback provided by independent partners and corporal supervisors suggested that CRM-trained participants' were able to offer a larger number of possible explanations for the simulated 'incident', with an increase in the number of explanations classified as situation awareness, decision-making, communication, and supervision. Therefore there is some tentative evidence of the effect of the training with a slight increase in the frequency of human factors explanations (table XX refers). The use of similar accident scenarios to evaluate CRM training had been used for air traffic controllers (Andersen & Bove, 2000) with similar indicators. The post training evidences does suggest that it should help to address non-technical skills which contribute to safe and efficient performance in railway environment.

Although it would have been advantageous to record and utilise numerical data in the assessment and comparison of the two drill exercises, several difficulties exist. Firstly the exercises were held at different locations- one at the ER line and the other in WR. East Rail

has been labelled as a 'control' (non CRM trained) group, but it is not necessary an equivalent comparison, as the histories and backgrounds of East Rail and West Rail are quite different, as stated in section 6.7. As the train line, infrastructure, facilities training budget, operations, tunnel length, passenger number and numbers of crew involved are quite different, it was difficult to quantify and negate variables for a fair comparison. West Rail may have more modern technologies and systems, but East Rail has been established for a longer period and both management and staff are more experienced with the train line.

Verbal feedback was solicited from sources within the company and from external participants and represented the majority of inputs and comments received. Data recorded on ITF and computer equipment represent a list of response times and decision making scenarios that changed in the course of the drill exercise and it was ill suitable for numerical tests because it was difficult to categorise according to identifiable factors. The development of a suitable comparative system in the future between the two rail lines may allow for a more quantifiable description, but it is not without its difficulties.

The development and global implementation of CRM implementation by the railway industry represents one of the most significant examples of team performance research translated into policy and practice. The widespread adoption of CRM training in railway industry is encouraging. If successful CRM training programme is to be successfully

adapted, the training materials must be customised for the railway domain, on the basis of the requisite psychological research. The program also needs sustained management efforts to build the just culture in the company and increase staff safety awareness. This research only documents the first CRM session in KCRC West Rail, and the program aims to be rerun approximately every 6 months to refresh and reinforce its teachings. As CRM implementation time increases, methods to measure long term effectiveness will need to be introduced. According to West Rail Overall Performance Review Report 2006, the performance and achievements are remarkable. It is envisioned that such evaluative means can again look to aviation practices as a rough guideline and adopted it for railway use.

15.3 Research Observations

Some points of interests have also been noted in this research that may hold relevance for further studies.

Firstly, train crew with more working experience/ qualifications were noted to have better knowledge of concepts and work related issues, and presented themselves as more emotionally stable in incident handling. Therefore, it is probably of benefit of the team to assign them as team leaders such that they may remain calm in the face of danger and issue strategic orders for the rest of the team.

According to observations from KCRC drills and exercises, it was also observed that as a whole, female train crews have better written and verbal communication skills, being able to describe situations more vividly to ensure others have a clear understanding. Those with this skill would function well when posted in the Incident Control Point (ICP) to observe and report to internal and external parties of any incidents. The written incident reports submitted by female members all included more details, observations and descriptions than their male counterparts, providing the reader with a better picture of the scenario after the incident.

Train crew with a better education background and qualifications displayed better cognitive skills automatically with the human machine interface. This may be due to their existing familiarity with computerised equipment and procedures. This means that they are able to learn and remember equipment/ machinery operation procedures more quickly and be at ease in such posts.

The Video Aided Training (VAT) portal, as part of CRM training platform is now becoming a knowledge portal in all of KCRC to cover East Rail, MOS Rail and Light Rail training centres, such that they are able to draw upon the experiences and knowledge from West Rail. Since the training and drills exercise, the VAT now can be accessed through

KCRC intranet, serving as an effective tool to refresh and aid crew in retaining learnt information after the training.

As a result of training and team building exercise, there is now increased synergy between crew members and most can work better and more effectively as a team. West Rail launched the campaign to enforce “readback message” for safety critical instruction. Radio communication had increased amongst West Rail members compared to East Rail crew which received no CRM training.

15.4 Post CRM action plan

A number of points, changes in company policy and action plans were effected upon internal review of the CRM program and its achievements. The program was successful in bringing management attention to implement a series of safety actions using VAT concepts. In the KCRC 2006 Transport Division Training Plan (KCRC, 2006a) the “Safety and risk awareness in work culture” is now ranked as the number 1 goal, reflecting its importance and influences of the CRM objectives. A target plan had also been devised to focus on this aspect. An excerpt of the goal statement reads:

To achieve a high level of safety and risk awareness, Transport Division is dedicated to sustain and promote a good safety culture that encourages the vigilance needed to recognise actual or potential safety hazards and the communication and commitment needed to address them. Our objective is to –

- *Demonstrate a visible and consistent commitment to safety and security from senior management;*
- *Establish a work environment in which people are encouraged to take an interest in safety issues;*
- *Assure effective implementation of the Transport Division Safety Management System with a view to achieving and maintaining high standards of safety performance; and*
- *Cultivate an attitude calling for constant vigilance on safety matters, avoiding complacency and maintaining a willingness to improve safety. (KCRC, 2005a. p.1)*

In addition, KCRC implemented Change Impact Risk Assessment Procedures in December 2005 aiming at identification of any impact or risk and measures to control the risk arisen from foreseeable potential hazard to as low as reasonably practicable region due to change in major equipment, system, service or operating environment.

(KCRC, 2005b).

Other modifications/ lessons learnt from CRM and the drill exercise include:

- Based on observation from East Rail drill, mandate requirements implemented on message concerning train movements and line safety shall be “Read Back” by the receiver to ensure no misunderstanding will result (KCRC, 2005c)
- Based on positive results of WR CRM, KCRC launched several teambuilding cultural workshops for East Rail train crew and engineering staff.
- According to observation summary from train fire inside tunnel drills, West Rail Decision Support System (DSS) features are proven useful in incident handling

and decision making. Nowadays DSS are becoming mandatory features for KCRC new railway extensions. (KCRC, 2006)

- Based on lesson learnt from Kaprun Tunnel Fire, East Rail Beacon Hill Tunnel (2.75km) has been equipped with tunnel ventilation systems and commissioned [147]in April 2007.
- Research to be conducted for system safety in reaction to improvement measures triggered from incidents, accidents, productivity enhancements, hardware and software modifications etc.
- Enhance and improve emergency preparedness of East Rail staff members through CRM training, drills and exercises.
- East Rail employs consultant to carry out human factor studies in East Rail Control Centre

Chapter 16. Conclusions

The development and implementation of CRM programme by the author in KCRC represents a significant example of team performance research being translated into practice and an industry other than aviation as long as the training materials can be customized for the required domains, on the basis of requisite psychological research.

Apart from the training materials, the effectiveness of CRM training also relies on suitable training facilities. It can be concluded that:

- CBT and VAT can be extended to form knowledge portals to support operations and maintenance functions
- ITF as a whole is a good tool in actualising CRM training model and equipping crew for unexpected scenarios
- DSS is an effective resource being able to augment incident handling response

In other words, the implementation of CRM has achieved the following:

- The training resources have been optimised effectively;
- The training of train drivers, station controllers and traffic controllers has been optimised efficiently.

The concept that single voice is effective and prevents accidents has been embedded into the trainees' mind as reflected in the questionnaire after the training and observations in their workplace. Performance in the subsequent months was measurement and improvements have been noted, specifically on:

- The job skills for train drivers, station controllers and traffic controllers
- The communication and coordination skills in incident handling
- The ability to reduce operational impacts due to equipment failure

From the organization point of view, the implementation of CRM has put the focus on the expectation of better performance. With preliminary figures obtained in the research and the workplace observation (chapter 14 and 15), there is an explicit tendency of working towards a higher level of safety and risk awareness in KCRC work culture, and a higher standard of occupational safety and health at workplace and a stronger sense of safety awareness.

It seems to be too early at this stage to draw a definitive conclusion of how successful it is in adapting the concept of CRM training in KCRC as it is still in its infancy, requiring more time and practice for it to grow and mature. However, at the very least, it is a very good start to satisfying the safety needs as demanded currently in modern railways and

hopefully mitigating to some degree human factor error when emergency situations do arise. The study has proved that

- CRM and LOT training model can be adapted effectively in railway industry
- CRM and LOT training will narrow (if not bridge) the gap between the performance of experienced and in-experienced, as well as highly educated and fairly educated.

Chapter 17. Recommendations

There is yet a bright future ahead of CRM being applied in rail industry. The adaptation of CRM concept signify a new era in KCRC training philosophy, and it is expected that more scenario-based training under the platform of CRM will soon be evolving and emerging. The increased commitment from senior management has given a green signal to such applications with an aim of increasing the safety level and confidence in service reliability to the stakeholder. This trial of CRM revealed that set on top of traditional training, the effectiveness of CRM has been strengthened and the coverage has been widened giving the crew a more in-depth realisation to various incidents and the efficiency of team work as a whole.

CRM was found to be cost effective in KCRC West Rail because the ITF is already part of the West Rail infrastructure, eliminating the need for extra capital investments on training facilities. The CBT and simulator training programs managed to save a lot of traction power energy and train path than hands-on train driving, and was thought to be just as effective. Teambuilding workshops were completed using only a fraction of the allocated training budget.

It is believed that behaviour changes in any environment cannot be accomplished in a short period of time, even if the training is very well organised and designed. Trainees need time, awareness, practice and feedback, and continual reinforcement to learn lessons that will long endure. To continue being effective, CRM training must be accomplished in several phases of regular refreshing and over several years[J48]. It is expected that the incident handling skills of train crews as a team and the WR safety level will be progressively increasing over time.

Notwithstanding the CRM effectiveness, railway operation as a whole should not merely rest on the situational awareness and decision making of operational staff. In this research the target groups setting for the CRM programme are front-line operational staff directly rendering the train operations and customer services. It was believed initially that this arrangement is adequate to evaluate the outcome. However, the performance figures obtained in the research convey another side of the fact that achieving perfection is not unidirectional but multifaceted. It depends on the team working amongst every level and discipline in the organisation. In this respect, training the situational awareness and decision making of maintenance and supporting staff will be equally important to the management commitment.

At the time of writing, the author has also recommended and promoted the concept of extending the CRM coverage to all the front-line maintenance staff on top of the operational crew. With more CRM trainers and staff already committed to CRM philosophy, it is envisioned that CRM will indeed optimise all resources to all its staff members to commit to a safe, team oriented working environment. Following on the successful team building and CRM training of West Rail in 2005, 10 more classes of teambuilding workshops were provided for East Rail, Ma On Shan Rail and Light Rail train crew in 2006. More teambuilding workshops will be provided for train crew and maintenance crew^[J49] in 2007.

If proven effective, it may also be of interest to run CRM with intercity train crew between Hong Kong and mainland China, as the corporate facilities, safety awareness and working cultures may have different foci, and may need to be unified so staff from both sides may cooperate well in case any emergencies arise.

The next step will also include the development of robust methods of ensuring that what is taught in CRM courses actually transfers to the control-decks and workplaces, and a systematic mechanism to ensure CRM effectiveness e.g. by establishing a database and a skill matrix competency evaluation system to regular review the behavioural skill levels of operational as well as maintenance staff.

Last but not least, a thorough review protocol of CRM enhancement programme should be developed to ensure the above improvement ideas are on the right track[150].

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Appendix A. KCRC Protocols to Handling Abnormal Operations

A1. Definitions of Normal and other conditions

When a railway is operating normally, i.e. under conditions that it is designed to accommodate, the safety risks are identified, managed and controlled. If the operating conditions of the railway change (e.g. operating with degraded equipment), the associated risks will also change. RSSB research (RSSB 2003) found that there is considerable variation in the understanding and interpretation of the terms under “normal”, “abnormal” and “emergency” and “degraded modes”. Therefore, it is necessary to unify such definitions and develop appropriate scenarios for train crew to adopt the right rule and procedures in the event of incident handling and emergency operations. The conditions are defined below in table X. At any point of time, the operation will be within one of the conditions or on the transition between one and another.

Table A1. Railway operating conditions as defined by the RSSB

Normal conditions	The conditions that the railway is designed to accommodate. This includes the diurnal fluctuations in demand and volume (e.g. rush hours).
Degraded conditions	The state of the part of the railway system when it continues to operate in a restricted manner due to the failure of one or more components.
Abnormal conditions	Extreme loading on a part of the railway system. For example, this may be the result of extended delays on one part of the service impinging on another.
Emergency situation	A current unforeseen or unplanned event which has life threatening or extreme loss implications and requires immediate attention, e.g. a fire.

Operating Modes

Under different operation conditions/situation, there will be respective operating modes to deal with:-

Table A2. Railway operating modes as defined by the RSSB

Normal operating mode	Operation when all the system and subsystems are working normally as designed and no failure, natural hazard or any other outside failure occurs.
Degraded operating mode	Operation during periods when some systems or subsystems are not functioning as designed or when human errors or natural hazards or other factors require an operational response, but without presenting a threat to safety of people or threat of serious property damage.
Emergency operating mode	Operation after an accident has happened or in an “emergency”. An “accident” is defined as an abnormal operation that results in damage to equipment and/or harm to personal health or safety. An “emergency” is defined as an unplanned event that generally has life threatening or extreme loss implications and requires immediate attention. Very serious accidents fall within the definition of “emergency”.

In order to prepare staff and crew for unexpected and abnormal situations, some scenarios have been pre-identified for study and preparation. If any of these scenarios arise, staff would have already been briefed with the appropriate measures and responses necessary to ensure safety and order. The pre-identified abnormal, degraded or emergency modes for train drivers, traffic and station controllers are summarised below in tables A3.

Table A3. Pre-identified abnormal, degraded or emergency operations for operation centres.

Operations for traffic controllers	Operations for train drivers
Disruption to normal timetabled or planned operations	Train door failure
Train delays	Train brake failure
Unplanned shunting;	No Propulsion (motor fault)
Use of temporary speed restrictions;	Wheel Slip/Slide
Use of emergency speed restrictions;	No docking signal
Running off the “normal” route;	Pantograph (unable to lift or retract)
Train movements affect by possessions;	On-board computer failure
Equipment, systems or subsystem operating at degraded modes	Air Pressure Dropped
Equipment failure (e.g. track circuit, point, axle counter etc.)	Train fire
Routine seasonal timetable changes	Train derailment
	Signal passed at danger (SPAD)
	Skip Station Stop

Station operators need to assist in crowd control and environmental control due to planned or unplanned incidents listed below:

Planned events:

- Large public events as horse racing, music concerts, celebrations etc.
- Engineering works

Unplanned events:

- Engineering work over-run
- Bomb threat
- Adverse weather conditions
- Vandalism
- Equipment Failure
- Terrorist/ other attacks
- Flooding

Appendix B. Current driver and crew training in KCRC

B1. Training facilities

The following sections will present the current training program for different safety critical members of the team.

B2. Train Driver

Each train driver need to go through two modes of fundamental training- the Electric Multiple Units (EMU) training and on-the-job training for a period totalling 13 weeks.

Part I: Classroom and Lecture Training (8 weeks)

Part I training consists of six module as shown in table B1. Trainees are assessed by a written test immediately after each training module as well as by overall written and oral tests after the full 8 weeks of training.

Table B1. Learning modules for KCRC train drivers

Module	Training Descriptions	Duration
Module 1	Basic training course for new recruit Introduction to railway infrastructure and station facilities	8 days
Module 2	EMU Equipment and systems –train door, braking system, propulsion systems	10 days
Module 3	Rules and Procedures	6 days
Module 4	Cab Simulator Training	2-3 days
Module 5	Defect Handling on EMU	2 days
Module 6	Stock Training (Practical training in depot)	5-6 days

Part II: On-Job-Training

At the successful completion of part I modules, trainees have to perform five to seven weeks of hands-on driving. The training instructor will endorse the trainee’s logbook

for driving hours as well as monitoring each individual’s driving performance. At the end of part II, line manager or delegates will arrange for a qualifying examination for each driver. A certificate of competence will be issued to each train driver when all requirements have been satisfied.

B3. Traffic Controller

The fundamental training requirements for Traffic Controller are set out as follows in table B2:

Table B2. Fundamental Training for Traffic Controller

Training Description	Duration
Operations Control Centre (OCC) operations	2 weeks
Classroom training for manipulating train control and signalling system	10 days
Rules and procedures	6 days
Classroom training for manipulating main control system and telecommunications systems	6 days
On-Job-Training -Line training and coaching by the senior train controllers	1 day

At the end of the training period, line manager or delegates will arrange a qualifying examination for each trainee. A certificate of competence will be issued to each train driver when all requirements have been satisfied.

B4. Station Staff

The fundamental training for Station Staff focusing on the use of station equipment (via Main Control System which monitors and control all the station facilities, and telecommunication systems) consists of the following:

Table B3. Training for Station Staff

Training Description	Duration
Classroom training for main control system and telecommunication systems	5 weeks
Classroom training for ticketing system and telecommunication systems	6 days
Rules and Procedures	6 days
Line training and coaching by station manager	1 day

At the end of the training period, the line manager or delegates will arrange a qualifying examination for each trainee. A certificate of competence will be issued to each train driver when all requirements have been satisfied.

Appendix C. Train Course for CRM Instructor

C1. Training Objectives

- Understand the importance of a new leadership focus in building a good performance team
- To develop and motivate performance by appreciating different values, style, thoughts, dealings and needs of the staff
- Awareness training for CRM

Day one: Human Factor Assessment Training

Module 1 Introduction to Human Factors Assessment

The early decades of the 20th century saw a very rapid decrease in the number of industrial injuries per million man hours. This was mainly due to advance in industrial safety engineering, with technical designs being continually refined based upon the lessons learned from previous accidents. This approach, while initially successful, start to falter in the 1960s when accident rated started to level out and even increase. This was because the root causes of accidents were no longer predominantly caused by hardware failures, but rather those introduced by the people operating the equipment – “the human factor”. The rise in the importance of this aspect of industrial operations was for two main reasons:

1. The increasing complexity of operating plants

2. The general lack of significance attached to the operator in ensuring safe operations.

Module 2 Understanding Human Error

A fundamental assumption in the psychological study of human error is that error and correct behaviour stem from the same source. The resulting action is judged to be a success or a failure by its effect on a system.

The significance of a human error will depend upon its social and economic consequences, where forgetting to bring a train ticket might delay your journey but forgetting train operating procedures could result in a collision. The psychological roots of these errors may be very similar but the circumstances of the second scenario have a greater potential for disaster (Norman, 1981; Reason & Mycielska, 1982).

Video “Fall from Grace”

This video produced by BBC is a case study on human aspects leading to fatal accidents in Tenerife.

Module 3 Hierarchy Task Analysis

HTA is the most often used task analysis techniques as it is relatively straightforward to apply and can be used as a basis for addressing a large range of problems (Kirwan &

Ainsworth, 1992). In addition, HTAs are able to assimilate a large amount of information relatively quickly, whereas certain other techniques require more intensive scrutiny. The HTA example used for CRM training was train driving with station stopping.

Module 4 Predictive Human Error Identification

Techniques for Human Error Rate Prediction (THERP) and Hazard and Operability Study (HAZOP) were introduced for predictive human error identification (Kletz, 1974). THERP is straightforward to use and can potentially model all errors affecting a system. THERP provides a structured, logical, documented record of the factors and errors defined. HAZOP is a technique which is used in engineering risk assessment to systematically identify potential problem in a system design and operational intent. Usually HAZOP studies are undertaken in the early stages of railway system design, but they may also be used at later stages to identify potential problems in existing design (Kletz, 1974, Reason, 1987).

Module 5 Human Reliability Quantification

Probabilistic approaches to the assessment of safety involve the application of Quantified Risk Assessment (QRA). This requires the identification of all potential

hazards and a calculation of both their frequency and severity in order than an overall risk level may be estimated (Kirwan, 1988).

When humans form part of the system under analysis, the probability that they will commit errors is often a significant contributor to risk levels (Kirwan, Embrey & Rea 1988). Under such circumstances, calculations must not only take into account the likelihood and consequences of equipment failures, but must also include the influence of human error if realistic results are to be attained. Example used for QRA training was “Driver misreads signal aspect” (Kirwan, cited in Wilson & Corlette 1995).

Module 6 Overview of Human Error Reduction Approaches Ergonomics

Design Principles

After understanding the ways in which human error can be modelled and predicted, and understanding the errors which could cause serious harm to the system, it is then necessary to identify measures to either prevent the error occurring, make the system tolerant to the error or mitigate the consequences of the error. It is necessary to consider both internal and external aspects of human capability. Internal aspects include skills, knowledge, work load and stress. External aspects include interface design, procedures, communications, workstation design and work environment.

Module 7 Emergency Response Planning

Emergency situations present a wealth of conditions which contribute to human error, for example; high stress, strict time constraints in which to make decisions, working in “knowledge based” mode and communication problems (Bailey, 1982). It is essential therefore to plan for such events and to provide all train crew with training such that they are able to perform their roles according to that plan in the event of an emergency. Thus, the provision of well designed workstations and communication facilities, decision aids and training are all requirements of a good emergency plan (Grandjean, 1987).

Module 8 Principles of Incident Investigation

Typically an incident report will provide an organization with a description of events which principally focuses on the status of the system at discrete times along a timeline (Armstrong, 1989). Reports also usually place the emphasis on developing a description of the consequences rather than causes of the incident, explaining what happened, but not why it happened. Such analyses are almost invariably technically orientated involving detailed descriptions of plant, equipment, reactions and their governing logic systems.

In the majority of investigations where human error is implicated, rather than identifying the mismatch between the operator and the working environment, responsibility is duly assigned and the investigation closed. Such a sequence is a reflection of the attitude that human error is both an acceptable cause and explanation of incidents. Consequently any recommendations relating to the human component in the system tend to be a vague and ineffectual. For example, provide more training, exhortation to follow procedures or work more safety, and most typically reprimand the individual/s involved (Kjellen & Larsson 1981).

Day two

CRM Induction training

A general introduction for CRM training currently used in aviation and railway industries aims to improve the design and delivery of CRM training in KCRC with better access to VAT and DSS resources.

Coaching for Performance

A briefing introduction to learn effective coaching skills and motive performance by appreciating different values, styles, thought, feelings and needs of the team. It is a way of building a “community of practice” and reinforcing desirable behaviours in your organization.

Day Three: Learning effective coaching skills in building good performance teams

Deficiencies in communications have been identified as a major contributory factor in rail incidents. TOC has identified the need to enforce safety critical communications training to bring about a target level of improvement in the quality and safety of safety critical communications between train crew and establish code of practices in performance coaching and assessment of team performance..

- Module 1 - People Management in Leading Change
- Module 2 – Performance Management
- Module 3 Performance Coaching
- Module 4 Assessing Your Team
- Module 5 Safety Critical Communications

13.6 CRM Training Course for Train Crew

Case one -Kaprun Tunnel Fire Video produced by Discovery Channel

Website: BBC News for case background information.

13.2.1 Background of Case 1

A tunnel fire occurred in the Austrian ski resort of Kaprun killed 155 people. Only 12 people survived. The Kaprun disaster brought the safety of funicular trains in Austrian resorts sharply into focus.

Lessons learnt:

- Facilities design and maintenance

- The essential of safety management system
- Fire Evacuation
- Incident Handling and co-ordination
- Co-ordination for search and rescue

Class exercises

Based on the tunnel fire scenario and lesson learned from this case study, participants are required to review KCRC Beacon Hill Tunnel (5.5 km) design and facilities. Be familiar with appropriate evacuation rules and procedures with action plan.

13.7.1 Case 2- Gare De Lyon, Paris, France Train Crash on June 27 1988 produced by National Geographic

Keith Eastlake (1997) Great Train Disasters published by Universal International Pty Ltd. pp.55-56

Background of Case 2

Two trains collided on the Paris underground system. The fatal collision involved a runaway train hit another train at the evening rush hour. Nearly 60 passengers were killed and 32 serious injured.

The trial called for long sentences on conviction of charges of manslaughter to be imposed on a driver of the runaway train involved, a woman who had pulled a

communication cord, a train guard who had been late on duty of the crash, and station supervisor who had apparently failed to order the evacuation of the public from the station.

Lessons Learned:

- Violation of rules - a passenger took the wrong train and pushed the emergency stop for alighting;
- Competence – train driver wrongly isolated the by-passed the braking devices after reset for emergency stop
- Incident handling-traffic controller failed to prevent the incident train going to the pre-occupied platform with another train
- Signalling system design- Once the “emergency button” on train control centre is activated, all switches within that area were unable to move;
- Train Braking Indication-human machine interfaces were improperly designed
- Non effective safety critical communication between train crew

13.7.2 CRM Awareness Training-Crew Resource Management (CRM) History

The roots of CRM training in the aviation industry are usually traced back to a resource Management workshop on the Flight deck sponsored by the National Aeronautics and Administration in 1979 for the research into the causes of air transport accidents.

Objectives

- CRM programs aim to provide the team members, such as those in a cockpit the skills to provide countermeasures against risk and error;
- Using the form of training to enable threat identification and error avoidance, detection, and management;
- For best results require careful consideration of cultural influencing factors. These may be organizational, hierarchical, geographical or functional e.g. operations and maintenance.

13.7.3 Fatal Lessons learnt from disasters-

Aviation Case

In 1980, Saudia Flight 163 had an onboard cabin fire. Due to communication break down between flight deck and cabin crew, although the plane landed in apparent safety, none escaped emergency evacuation after landing. The cabin crew were not prepared to evacuate on landing; the crew were not told to wear their oxygen masks, and once the aircraft had been brought down to a safe landing, they were all left on the ground to perish because the order to evacuate was still not given. All 301 people onboard had died of smoke inhalation or burns, even though all were alive and unhurt when the aircraft landed.

Lessons learned:

- Importance of communication amongst crew members at all times
- Each staff member must be competent in communication (all staff on Flight 163 had learning difficulties)
- The need for unified safety procedures and training in evacuation procedures such that all staff can work as a team to carry out tasks effectively rather than relying on one another

Railway case: Two Trains Collides in Severn Tunnel

In December 1991, two passenger trains collided in the 6.5 km-long tunnel under the River Severn in England and 185 people were injured. Rescuers did not reach the train until two hours after the incident because safety procedures fell like dominoes. Communication efforts were confusing and incorrect, compounding the situation and rescue efforts. There was no clear decision-making authority among emergency services, complicating and delaying rescue attempts.

Contributing factors:

- Maintenance technician reset the axle counter by negligence, the train stopped inside tunnel was remain undetected by the signalling system;
- The hand signalman deployed on site was off duty;

- Traffic controller sent another train to the tunnel section causing head-to-tail collision;
- No one reported for mishap until two hours later, when the injured train guard trigger the alarm wire inside tunnel.

Lessons Learned:

- All safety procedures exist not to burden staff or waste time, but in ensuring system safety
- Methodologies should exist to prevent the over riddance of safety procedures.
- In case of incidents communication channels must always remain open for prompt and appropriate action
- CRM Case studies

Appendix D. Statistical data and calculations

D1. Raw Data and t-test analysis for CRM effect on the number of over 8 minute delays experienced in WR.

Table D1. Raw data of the number of incidents over 8 minutes in 2005-2006.

No. of incidents		
		Post
Pre training	Training	
	1	3
	1	0
	3	0
	1	0
	0	0
	1	1
	4	0
		1
		0
		0
		0
		0
		1
		0
		0
Average	1.57	0.40
St. Dev.	1.40	0.83

$$T = \frac{(\bar{x} - \bar{y})\sqrt{(n_x + n_y - 2)n_x n_y}}{\sqrt{(n_x \sigma_x^2 + n_y \sigma_y^2)(n_x + n_y)}},$$

where x and y represent the two groups, $\bar{x}$, $\bar{y}$ represent means, n represents the number of samples and σ represent standard deviation.

T(calculated) = 2.338, degree of freedom = 20

T level of significance = 2.09, $p \leq 0.05$, 2- tailed

As T (calc.) < T (sign.), there is a significant difference before and after CRM effects.

D2. Raw Data and t-test analysis for CRM effect on the number of customer complaints in WR.

Table D2. Raw data of the number of customer complaints pre and post CRM training, 2005-2006.

No. of complaints		
	Pre training	Post Training
	27	41
	18	22
	19	14
	9	17
	10	21
	24	24
	45	20
		17
		23
		59
		25
		33
		22
		30
		30
		17
		19
Average	21.71428571	25.52941176
St. Dev.	12.21630448	10.99498549

T calc. = 0.716, degree of freedom = 22.

T Level of significance = 2.07, $p \leq 0.05$, 2- tailed

As $T(\text{calc.}) < T(\text{sign.})$, CRM had no influence on the number of customer complaints pre and post training.

Appendix E. Pre/Post CRM Attitude Change Data Analysis

Table E1. Pre-CRM Training Score between Group A, B,C,D

	Group A					Group B					Group C					Group D				
	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly
1	0	0	2	23	5	0	0	4	23	3	0	0	2	20	8	0	0	2	18	10
2	0	0	0	20	10	0	0	0	23	7	0	0	0	18	12	0	0	0	25	5
3	0	3	2	20	5	0	3	0	24	3	0	1	0	24	5	0	2	2	22	4
4	0	0	0	20	10	0	2	1	19	8	0	2	2	18	8	0	2	3	19	6
5	0	5	2	23	0	0	4	2	21	3	0	1	3	22	4	0	2	4	21	3
6	0	3	2	23	2	0	2	1	25	2	0	3	0	23	4	0	0	2	23	5
7	3	2	0	21	4	2	2	2	21	3	3	2	1	23	4	4	2	2	18	4
8	2	2	4	18	4	1	3	4	19	3	0	2	2	24	2	0	3	2	22	3
9	3	1	0	24	2	2	2	0	22	4	1	2	0	24	3	2	2	0	24	2
10	0	0	0	25	5	0	1	1	24	4	0	2	2	22	4	0	3	2	23	2
11	0	0	0	24	6	0	0	1	25	4	0	2	2	23	3	0	2	2	22	4
12	0	0	0	20	10	0	0	0	22	8	0	2	2	14	12	0	2	3	14	11
13	4	2	1	23	0	2	1	2	23	2	3	2	1	20	4	1	2	3	19	5
14	3	2	4	19	2	2	3	5	20	0	2	2	3	21	2	2	1	4	21	2
15	0	2	3	23	2	1	3	2	21	3	2	3	2	21	2	1	3	1	22	3
16	0	2	2	20	6	0	3	2	20	5	2	2	3	17	6	3	1	3	15	8
17	0	0	0	23	7	0	0	0	21	9	0	2	2	21	5	0	3	1	19	7
18	0	2	3	15	10	0	2	2	15	11	1	3	3	19	4	2	2	2	19	5
19	6	15	1	8	0	8	15	2	5	0	6	17	2	5	0	5	19	1	5	0
20	0	3	2	20	5	1	2	1	19	7	3	2	2	23	0	1	2	2	25	0

Pre-CRM Training Score

Table E2. Post CRM Training Score between Group A, B, C, D

	Group A					Group B					Group C					Group D				
	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly
1	0	0	0	23	7	0	0	2	23	5	0	0	0	22	8	0	0	0	20	10
2	0	0	0	18	12	0	0	0	20	10	0	0	0	16	14	0	0	0	22	8
3	0	0	0	22	8	0	0	0	28	2	0	0	0	25	5	0	2	2	23	7
4	0	0	0	18	12	0	0	0	21	9	0	0	0	20	10	0	0	1	23	6
5	0	2	2	23	3	0	2	0	23	5	0	0	1	23	6	0	0	2	23	5
6	0	1	1	24	4	0	1	0	25	4	0	1	1	22	6	0	0	0	24	6
7	0	1	0	24	5	0	1	1	25	3	0	2	1	22	5	1	1	2	18	8
8	0	1	2	23	4	0	2	2	19	7	0	1	1	25	3	0	2	2	23	3
9	1	1	1	25	2	1	0	2	22	5	0	1	2	24	3	0	0	2	25	3
10	0	0	2	24	4	0	0	1	24	5	0	1	1	24	4	0	1	2	25	2
11	0	0	2	24	4	0	1	0	24	5	0	1	1	23	5	0	1	2	23	4
12	4	1	0	20	5	2	2	0	21	5	3	4	0	13	10	2	3	0	15	10
13	0	1	1	26	2	0	1	0	25	4	1	3	2	21	3	0	1	1	23	5
14	1	1	2	20	6	0	2	3	23	2	1	1	1	21	6	1	2	1	22	4
15	6	4	1	17	2	4	6	0	19	1	7	2	1	20	0	5	5	1	18	1
16	0	0	0	20	10	0	1	1	20	8	1	1	0	18	10	1	1	1	16	11
17	0	0	0	21	9	0	0	0	20	10	0	1	1	21	7	0	1	1	19	9
18	4	6	0	17	3	8	6	0	15	1	3	3	2	19	3	5	4	1	19	1
19	10	17	0	3	0	8	18	0	3	1	7	20	1	2	0	8	16	2	4	0
20	0	1	1	23	5	1	1	0	20	8	1	2	1	23	3	1	1	1	24	3

Post CRM Training Score

Table E3. Pre CRM Training Score Group A

Pre CRM Training Score Sheet

		CRM Safety Altitude Questions																			
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
STC-1	A	5	5	5	5	4	5	5	5	4	5	5	5	4	5	5	5	5	5	1	5
TC-1	A	4	5	5	4	4	3	4	4	5	5	5	5	4	4	4	4	4	5	1	5
TC-2	A	4	5	2	5	4	5	5	3	4	4	4	4	4	4	4	5	5	5	1	4
TC-3	A	5	5	4	4	4	4	4	4	4	5	5	5	4	3	4	4	5	5	3	4
TC-4	A	5	5	4	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	2	4
SC-1	A	4	4	5	5	4	4	4	3	4	5	4	4	4	3	3	4	4	4	4	4
SC-2	A	5	5	2	5	2	3	2	2	4	4	5	5	3	4	4	5	5	5	1	5
SC-3	A	5	5	4	5	4	4	4	4	4	4	4	5	4	5	5	5	5	5	1	5
SC-4	A	4	4	2	4	2	4	2	2	2	4	4	4	1	1	2	2	4	4	1	3
SC-5	A	4	4	5	4	4	4	5	5	5	4	4	5	2	2	4	4	4	4	4	4
TD-1	A	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	2	4
TD-2	A	4	4	4	4	4	4	4	5	4	4	4	4	4	3	4	4	4	4	2	2
TD-3	A	3	4	4	4	4	4	4	4	4	5	5	5	4	4	4	5	4	4	4	4
TD-4	A	4	5	3	4	3	2	1	1	1	4	4	4	1	1	3	3	4	4	4	4
TD-5	A	4	5	4	5	4	4	4	4	4	4	4	5	4	4	4	4	5	5	2	5
TD-6	A	4	4	3	5	4	4	4	4	4	4	4	5	2	3	4	4	4	4	4	4
TD-7	A	4	4	4	5	3	4	4	3	4	4	4	4	4	4	4	4	4	4	2	4
TD-8	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4
TD-9	A	4	4	4	4	2	4	1	1	1	4	4	4	1	1	2	2	4	4	4	3
TD-10	A	4	4	4	5	4	4	4	4	4	4	5	5	4	4	4	4	4	4	2	2
TD-11	A	4	4	4	4	2	2	4	3	4	4	4	4	4	4	4	4	4	4	2	4
TD-12	A	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4
TD-13	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2

CRM Safety Attitude Questions																					
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
TD-14	A	4	4	4	5	2	2	1	4	1	4	4	4	1	2	3	3	4	4	4	4
TD-15	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
TD-16	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4
TD-17	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4
TD-18	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4
TD-19	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4
TD-20	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4

Legends:	STC	Senior Traffic Controller = 1
Disagree Strongly = 1	TC	Traffic Controller = 4
Disagree Slightly = 2	SC	Station Controller = 5
Neutral = 3	TD	Train Driver = 20
Agree Slightly = 4		
Agree Strongly = 5		

Group Profile			
Group	Age	Education	Railway Experiences
A	>45	Degree or higher	>15 Years
B	40-45	Diploma/Certificate	10-15 Years
C	40	Post Secondary	5-10 Years
D	<35	Secondary	<5 years

Table E4. Post CRM Training Score Group B

Post CRM Training Score Sheet

		CRM Safety Altitude Questions																			
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
STC-1	A	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	1	1	5
TC-1	A	5	5	5	5	4	4	4	4	5	5	5	5	4	4	4	4	4	2	1	5
TC-2	A	4	5	5	5	4	5	5	3	4	4	4	4	5	4	4	5	5	4	1	4
TC-3	A	5	5	4	4	4	5	5	4	4	5	5	4	4	5	4	4	5	1	2	4
TC-4	A	5	5	5	5	4	5	5	5	4	4	4	1	4	4	3	5	5	4	2	5
SC-1	A	4	5	5	5	5	4	4	4	4	5	4	4	4	3	4	4	4	2	2	4
SC-2	A	5	5	4	5	4	3	2	4	4	4	4	4	3	4	4	4	5	1	1	5
SC-3	A	5	5	4	5	5	4	4	4	4	4	4	5	4	5	5	5	4	5	1	5
SC-4	A	4	4	4	4	4	4	4	3	3	4	4	4	4	4	4	4	5	5	1	4
SC-5	A	4	4	5	4	4	4	5	5	4	4	5	5	4	4	1	5	4	4	2	4
TD-1	A	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	5	1	4
TD-2	A	4	4	4	4	4	4	4	5	4	4	4	4	5	4	2	4	4	4	2	4
TD-3	A	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	5	4	4	4	4
TD-4	A	4	5	4	4	3	2	4	2	2	3	4	4	4	4	4	4	5	1	2	4
TD-5	A	4	5	5	5	4	4	5	4	4	4	4	2	4	4	4	4	4	4	2	5
TD-6	A	4	5	4	5	4	4	4	4	4	4	4	5	4	3	1	4	4	4	2	4
TD-7	A	4	4	4	5	3	4	4	4	4	4	4	4	4	4	2	4	4	4	1	4
TD-8	A	4	4	4	4	4	4	4	4	4	4	4	1	4	4	4	4	4	2	1	4
TD-9	A	4	4	4	4	2	4	4	4	1	3	4	4	4	4	4	4	4	4	4	4
TD-10	A	4	4	4	5	4	4	4	4	4	4	4	5	4	5	2	4	4	5	2	4
TD-11	A	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	5	4	2	2	4
TD-12	A	4	4	4	4	4	4	4	4	4	4	3	4	4	5	1	4	4	4	2	4
TD-13	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4

CRM Safety Attitude Questions																					
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
TD-14	A	4	4	4	5	4	4	4	4	4	4	4	4	2	1	4	4	5	4	2	4
TD-15	A	4	4	4	4	4	4	4	4	4	4	4	1	4	4	1	5	4	4	4	2
TD-16	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	4
TD-17	A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	4	4	4	2	4
TD-18	A	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	4	4	4	2	4
TD-19	A	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	2	2	4
TD-20	A	4	4	4	4	4	4	4	4	4	4	4	1	4	4	1	5	5	4	1	3

Legends:	STC	Senior Traffic Controller = 1
Disagree Strongly = 1	TC	Traffic Controller = 4
Disagree Slightly = 2	SC	Station Controller = 5
Neutral = 3	TD	Train Driver = 20
Agree Slightly = 4		
Agree Strongly = 5		

Group Profile			
Group	Age	Education	Railway Experiences
A	>45	Degree or higher	>15 Years
B	40-45	Diploma/Certificate	10-15 Years
C	40	Post Secondary	5-10 Years
D	<35	Secondary	<5 years

Table E5. Pre Training Score Group B

Pre CRM Training Score Sheet

		CRM Safety Altitude Questions																			
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
STC-1	B	5	5	4	4	4	4	4	4	4	5	4	5	5	5	5	5	5	5	1	5
TC-1	B	4	4	4	4	4	4	5	4	5	4	4	4	4	4	4	4	4	5	1	5
TC-2	B	4	4	4	3	4	5	3	3	4	5	4	4	4	4	4	5	5	5	1	4
TC-3	B	3	4	5	4	2	4	4	4	2	5	4	4	5	1	4	4	5	5	4	4
TC-4	B	4	5	4	4	4	5	5	5	4	4	4	4	4	4	4	4	4	4	2	4
SC-1	B	4	4	2	5	4	4	4	2	4	5	4	5	4	3	2	4	4	4	4	4
SC-2	B	3	5	4	4	4	3	3	3	5	4	4	5	3	4	5	5	5	5	1	5
SC-3	B	4	5	4	2	2	4	1	4	4	4	4	4	4	5	4	5	5	2	1	5
SC-4	B	4	4	4	4	3	4	3	3	1	4	4	4	4	4	3	2	4	4	1	3
SC-5	B	5	4	5	5	4	4	5	5	5	4	4	5	4	2	4	4	4	4	4	4
TD-1	B	4	5	4	4	4	4	4	4	4	4	4	4	4	3	4	5	5	5	2	3
TD-2	B	4	4	4	2	5	5	4	2	4	4	4	4	4	2	4	4	4	4	2	2
TD-3	B	4	4	4	4	2	4	4	4	4	4	5	4	4	4	4	5	4	2	3	4
TD-4	B	4	5	2	4	4	4	2	4	1	4	4	4	4	2	3	3	4	4	3	3
TD-5	B	4	5	4	5	4	4	4	4	5	4	4	5	4	4	4	4	5	5	2	5
TD-6	B	5	4	4	4	4	4	1	4	4	4	4	5	2	3	5	4	4	4	2	4
TD-7	B	4	4	4	4	2	3	4	5	4	4	4	4	4	4	4	4	4	4	2	4
TD-8	B	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	1	4
TD-9	B	4	4	4	5	4	4	2	4	2	4	4	4	1	1	2	3	4	5	4	4
TD-10	B	3	4	2	5	4	4	4	5	4	4	5	5	4	4	4	4	4	4	2	1
TD-11	B	4	4	4	4	3	2	4	3	4	3	4	4	4	4	4	4	5	3	2	4
TD-12	B	4	4	4	4	4	4	4	4	4	4	4	5	4	3	4	4	4	4	2	4
TD-13	B	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2

CRM Safety Attitude Questions																					
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
TD-14	B	4	4	4	5	4	4	2	4	1	4	4	4	1	1	2	2	4	5	2	4
TD-15	B	4	4	5	4	5	4	4	4	4	4	5	4	4	4	4	4	5	4	4	5
TD-16	B	4	4	4	5	4	4	4	2	4	4	4	4	3	4	4	4	4	5	2	5
TD-17	B	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4
TD-18	B	4	4	4	4	5	4	4	1	4	4	4	4	4	3	4	2	4	4	2	4
TD-19	B	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4
TD-20	B	4	4	4	4	4	2	4	4	4	2	5	4	4	4	1	4	4	5	1	1

Legends:	STC	Senior Traffic Controller = 1
Disagree Strongly = 1	TC	Traffic Controller = 4
Disagree Slightly = 2	SC	Station Controller = 5
Neutral = 3	TD	Train Driver = 20
Agree Slightly = 4		
Agree Strongly = 5		

Group Profile			
Group	Age	Education	Railway Experiences
A	>45	Degree or higher	>15 Years
B	40-45	Diploma/Certificate	10-15 Years
C	40	Post Secondary	5-10 Years
D	<35	Secondary	<5 years

Table E6. Post CRM Training Score Group B

Post CRM Training Score Sheet

CRM Safety Altitude Questions																					
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
STC-1	B	5	5	5	5	4	5	4	4	5	4	4	4	4	4	5	5	4	1	2	5
TC-1	B	4	5	4	4	5	4	4	4	5	4	4	4	4	5	4	4	4	2	2	5
TC-2	B	4	4	4	5	4	4	5	4	4	4	4	4	5	4	4	4	5	4	2	4
TC-3	B	4	5	4	4	4	4	4	4	4	5	4	5	4	5	4	4	5	1	2	5
TC-4	B	4	5	4	4	4	5	4	5	4	5	4	4	4	4	3	4	5	4	2	5
SC-1	B	5	4	4	4	4	4	4	5	5	5	4	4	4	2	4	4	4	2	2	4
SC-2	B	5	5	5	4	4	4	4	3	4	4	4	4	1	4	4	4	5	1	1	5
SC-3	B	5	5	4	4	4	4	2	4	4	4	5	5	4	5	4	5	4	5	2	5
SC-4	B	4	4	2	4	4	4	4	3	3	3	4	4	4	4	4	4	5	5	1	4
SC-5	B	4	4	4	5	4	4	5	5	4	4	5	5	4	4	4	5	5	4	2	4
TD-1	B	4	5	4	4	4	4	4	4	5	4	4	4	4	4	4	5	4	2	1	4
TD-2	B	4	4	4	4	5	4	4	5	1	4	4	1	4	3	2	4	5	4	2	4
TD-3	B	4	4	4	5	4	4	4	4	4	5	5	5	4	4	4	5	4	4	4	4
TD-4	B	4	5	4	4	4	2	4	2	3	4	4	4	4	4	1	4	5	1	2	4
TD-5	B	4	5	4	5	4	4	4	4	4	4	4	2	4	4	2	4	4	4	2	5
TD-6	B	4	4	4	4	4	4	4	4	4	4	4	5	5	2	4	3	4	2	2	4
TD-7	B	5	4	4	5	5	4	4	4	4	5	5	1	4	4	4	5	4	4	2	4
TD-8	B	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	1	1	4
TD-9	B	4	5	4	4	4	5	4	5	4	4	4	4	5	4	2	4	4	4	4	4
TD-10	B	4	4	4	5	4	4	4	4	4	4	5	5	4	3	2	4	4	5	1	5
TD-11	B	4	4	4	4	5	4	3	2	4	4	4	4	4	4	4	5	4	1	2	4
TD-12	B	3	4	4	4	2	4	4	4	4	4	3	4	4	4	1	4	4	2	2	4

CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
TD-13	B	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	1	4
TD-14	B	4	4	4	4	2	4	4	4	4	4	4	4	4	1	4	4	5	4	2	4
TD-15	B	4	4	4	4	4	4	5	4	3	4	4	1	4	4	4	4	4	4	4	1
TD-16	B	2	4	4	5	4	4	4	5	4	4	4	2	5	4	4	4	4	1	1	4
TD-17	B	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	2	4	2	2	4
TD-18	B	4	4	4	4	4	5	4	4	4	4	4	4	4	3	2	5	4	4	1	4
TD-19	B	3	4	4	5	4	4	4	5	4	4	3	4	4	4	1	4	4	1	2	4
TD-20	B	4	4	4	4	5	4	4	4	5	4	4	4	4	4	2	5	5	4	4	2

Legends:

Disagree Strongly = 1
Disagree Slightly = 2
Neutral = 3
Agree Slightly = 4
Agree Strongly = 5

STC	Senior Traffic Controller = 1
TC	Traffic Controller = 4
SC	Station Controller = 5
TD	Train Driver = 20

Group Profile

Group	Age	Education	Railway Experiences
A	>45	Degree or higher	>15 Years
B	40-45	Diploma/Certificate	10-15 Years
C	40	Post Secondary	5-10 Years
D	<35	Secondary	<5 years

Table E7. Pre CRM Training Score Group C

Pre CRM Training Score Sheet

		CRM Safety Altitude Questions																			
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
STC-1	C	5	5	4	5	5	5	5	4	4	5	5	5	5	5	5	5	5	4	1	4
TC-1	C	4	5	4	4	4	3	4	4	5	5	4	5	4	4	4	4	4	5	1	4
TC-2	C	4	5	2	5	5	5	5	4	4	4	4	4	4	4	4	5	5	4	1	4
TC-3	C	5	5	5	4	4	4	4	4	4	5	4	5	5	4	4	4	5	5	2	4
TC-4	C	5	5	5	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	2	4
SC-1	C	4	4	5	5	4	4	4	4	4	5	4	4	4	4	2	4	4	4	2	4
SC-2	C	5	5	2	5	4	3	2	4	4	4	5	5	3	4	4	5	5	5	1	4
SC-3	C	5	5	4	5	5	4	4	4	4	4	2	5	4	5	5	5	5	5	2	4
SC-4	C	4	4	2	4	4	5	2	4	1	4	4	4	5	2	1	1	4	4	1	2
SC-5	C	4	4	5	4	4	4	5	4	4	4	2	5	1	1	4	4	4	4	2	4
TD-1	C	3	5	5	4	5	4	4	4	4	2	4	4	4	4	4	5	4	4	2	4
TD-2	C	4	4	4	4	4	4	1	5	4	4	4	4	4	2	4	4	4	2	2	3
TD-3	C	4	4	4	4	4	4	4	4	4	5	5	5	4	4	4	5	3	4	2	1
TD-4	C	4	5	2	4	2	5	2	2	4	4	1	4	2	2	2	2	4	4	4	4
TD-5	C	5	5	4	2	4	4	4	4	4	4	4	5	5	4	4	4	4	5	2	4
TD-6	C	4	4	3	3	4	4	5	4	4	3	4	5	1	3	3	4	4	4	4	4
TD-7	C	4	4	4	2	3	5	4	3	4	4	4	4	4	4	4	4	3	2	3	4
TD-8	C	5	5	4	4	4	2	4	4	4	4	1	4	4	4	4	4	2	4	3	4
TD-9	C	4	4	4	4	3	4	4	2	2	2	4	4	2	1	1	1	4	4	4	3
TD-10	C	4	4	4	3	4	4	3	4	4	2	4	5	4	4	4	3	4	1	2	2
TD-11	C	5	4	4	4	3	4	4	3	4	4	4	2	5	4	3	4	4	4	2	4
TD-12	C	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	2	3	2	4

CRM Safety Attitude Questions																					
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
TD-13	C	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	2	3
TD-14	C	4	4	4	5	2	4	1	4	2	4	1	2	2	3	2	2	4	4	4	4
TD-15	C	3	4	4	4	4	4	4	4	5	4	4	4	1	4	4	3	4	3	4	1
TD-16	C	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4
TD-17	C	4	4	4	4	4	2	4	4	4	4	3	3	4	3	4	3	4	4	2	4
TD-18	C	4	4	4	5	4	4	4	4	5	4	4	4	4	4	4	4	4	3	2	4
TD-19	C	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4
TD-20	C	4	4	4	5	4	2	1	4	4	4	4	3	4	4	4	4	4	2	1	1

Legends:

Disagree Strongly = 1

Disagree Slightly = 2

Neutral = 3

Agree Slightly = 4

Agree Strongly = 5

STC

Senior Traffic Controller = 1

TC

Traffic Controller = 4

SC

Station Controller = 5

TD

Train Driver = 20

Group Profile

Group	Age	Education	Railway Experiences
A	>45	Degree or higher	>15 Years
B	40-45	Diploma/Certificate	10-15 Years
C	40	Post Secondary	5-10 Years
D	<35	Secondary	<5 years

Table E8. Post CRM Training Score Group C

Post CRM Training Score Sheet

		CRM Safety Altitude Questions																			
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
STC-1	C	5	5	5	5	5	5	5	5	4	5	5	4	4	5	4	5	5	4	2	5
TC-1	C	5	5	5	5	4	4	4	4	5	4	5	5	4	4	4	4	4	2	2	5
TC-2	C	4	5	5	5	4	5	4	3	4	4	4	4	5	4	4	5	5	4	2	4
TC-3	C	5	5	4	4	4	5	5	4	4	5	5	4	4	5	4	4	5	1	2	4
TC-4	C	5	5	5	5	4	5	5	4	4	4	4	1	4	4	1	4	5	4	2	5
SC-1	C	4	5	5	5	5	4	2	4	4	5	4	4	4	4	4	4	4	2	2	4
SC-2	C	5	5	4	5	4	4	4	4	4	4	4	4	2	4	4	4	5	1	1	5
SC-3	C	5	5	4	5	5	4	4	4	4	4	4	5	4	5	4	5	4	5	1	4
SC-4	C	4	4	4	4	4	4	4	2	2	4	4	4	3	4	4	4	5	5	1	4
SC-5	C	4	4	4	4	4	4	5	5	4	4	5	5	4	4	1	5	4	4	2	4
TD-1	C	5	5	4	4	4	4	2	4	4	4	4	2	4	4	4	5	4	5	1	4
TD-2	C	4	4	4	4	4	4	4	4	4	4	4	4	5	4	3	4	2	4	2	4
TD-3	C	4	4	4	4	3	2	4	4	4	4	4	5	4	4	4	5	4	4	4	4
TD-4	C	5	5	4	4	4	3	4	2	3	2	4	4	4	4	4	2	5	1	2	4
TD-5	C	4	5	4	5	4	4	5	4	4	4	4	2	4	4	4	4	4	4	2	4
TD-6	C	4	5	4	5	4	4	4	4	4	4	4	5	3	3	1	4	4	4	2	4
TD-7	C	4	4	4	5	5	4	4	4	4	4	4	4	4	4	2	4	4	4	1	3
TD-8	C	4	4	4	4	4	4	4	4	4	4	4	2	3	4	4	4	4	2	1	4
TD-9	C	4	5	4	4	2	4	4	4	3	4	4	4	2	4	4	1	3	4	3	4
TD-10	C	4	5	4	4	4	4	4	4	4	4	4	5	4	5	2	4	4	4	2	2
TD-11	C	4	4	4	4	4	4	4	4	4	3	4	5	5	4	4	5	4	3	2	4

CRM Safety Attitude Questions

CRM Trainees Group		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
TD-12	C	4	4	4	4	5	4	4	5	4	4	3	4	4	5	1	4	4	4	2	4
TD-13	C	4	4	4	4	4	4	4	4	4	4	4	4	4	1	4	4	4	4	2	4
TD-14	C	4	4	4	4	5	4	4	4	4	4	5	1	1	4	4	4	4	4	2	4
TD-15	C	4	4	4	4	4	4	4	4	5	4	4	1	4	5	1	5	4	4	4	1
TD-16	C	4	4	4	4	4	5	4	4	4	4	4	5	4	4	4	4	4	2	2	4
TD-17	C	4	4	4	4	4	4	3	4	4	4	4	5	2	4	1	4	4	4	2	4
TD-18	C	4	4	4	4	4	4	4	4	5	4	4	4	4	2	4	5	4	4	2	4
TD-19	C	4	4	4	4	4	4	4	4	4	5	2	5	4	4	4	4	4	3	2	4
TD-20	C	4	4	4	4	4	5	4	4	4	4	4	2	4	4	1	5	4	4	1	2

Legends:

STC

Senior Traffic Controller = 1

Disagree Strongly = 1

TC

Traffic Controller = 4

Disagree Slightly = 2

SC

Station Controller = 5

Neutral = 3

TD

Train Driver = 20

Agree Slightly = 4

Agree Strongly = 5

Group Profile

Group	Age	Education	Railway Experiences
A	>45	Degree or higher	>15 Years
B	40-45	Diploma/Certificate	10-15 Years
C	40	Post Secondary	5-10 Years
D	<35	Secondary	<5 years

Table E9. Post CRM Training Score Group C

Pre CRM Training Score Sheet

CRM Safety Altitude Questions

CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
STC-1	D	5	5	5	5	5	5	5	5	4	4	4	5	4	5	5	5	5	5	1	4
TC-1	D	4	4	5	4	4	3	4	4	5	4	5	5	4	4	4	4	4	4	2	4
TC-2	D	4	5	3	5	4	5	5	3	4	4	4	4	4	4	4	5	5	5	1	4
TC-3	D	5	4	4	4	5	4	4	4	4	5	5	5	5	3	4	5	5	5	2	4
TC-4	D	5	5	4	4	4	4	5	5	4	4	4	4	4	4	4	5	4	4	2	4
SC-1	D	4	4	5	5	4	4	4	3	4	5	4	4	5	3	2	4	4	4	4	4
SC-2	D	5	5	3	5	3	3	3	2	4	4	5	5	3	4	4	5	5	5	1	4
SC-3	D	5	5	4	5	4	4	4	4	4	4	4	3	4	5	5	5	5	5	2	4
SC-4	D	4	4	2	4	2	4	3	2	5	4	4	4	3	4	2	2	4	4	1	2
SC-5	D	4	4	5	4	4	5	5	5	2	2	4	5	2	3	4	4	4	4	4	4
TD-1	D	4	4	4	3	5	4	4	4	4	4	4	4	4	4	4	5	5	4	2	4
TD-2	D	4	4	4	4	4	4	4	4	4	4	4	5	2	3	4	4	4	4	2	2
TD-3	D	3	4	4	4	4	4	4	4	4	4	5	3	4	4	4	5	4	2	4	4
TD-4	D	4	4	2	4	2	3	4	2	2	4	4	4	1	2	3	1	4	4	4	4
TD-5	D	5	4	4	2	4	4	4	4	4	4	4	5	5	4	4	4	5	4	2	5
TD-6	D	4	4	2	5	4	5	2	4	4	2	4	5	2	3	4	4	2	4	4	4
TD-7	D	4	4	4	4	2	4	4	3	4	4	3	4	4	4	4	2	4	4	2	4
TD-8	D	5	4	4	2	4	4	4	4	4	4	4	4	4	4	4	4	4	1	2	4
TD-9	D	4	4	4	4	3	5	1	2	2	4	4	4	2	1	2	1	2	4	2	1
TD-10	D	4	4	4	4	4	4	4	3	4	4	4	5	4	4	4	4	4	3	2	3
TD-11	D	5	4	4	3	3	3	2	4	4	2	4	2	4	4	4	3	4	4	2	4

CRM Safety Attitude Questions

CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
TD-12	D	4	4	4	4	4	4	1	4	4	4	4	5	4	4	4	4	2	1	2	4
TD-13	D	3	4	4	4	4	4	4	3	4	4	2	4	4	4	4	4	4	4	2	3
TD-14	D	4	4	4	3	3	4	1	4	4	4	4	3	3	1	1	1	4	4	3	4
TD-15	D	5	4	4	4	4	4	4	4	4	3	4	4	5	4	4	4	3	4	1	4
TD-16	D	4	4	4	4	5	4	1	4	1	4	3	2	5	4	4	4	4	4	2	4
TD-17	D	4	4	4	4	4	4	4	2	4	4	4	4	4	4	5	3	4	2	2	4
TD-18	D	5	4	4	4	5	4	4	4	1	4	4	5	4	4	4	4	4	4	2	4
TD-19	D	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	2	4
TD-20	D	4	4	4	4	4	4	1	4	4	4	2	4	4	4	4	3	4	3	2	4

Legends:

STC

Senior Traffic Controller = 1

Disagree Strongly = 1

TC

Traffic Controller = 4

Disagree Slightly = 2

SC

Station Controller = 5

Neutral = 3

TD

Train Driver = 20

Agree Slightly = 4

Agree Strongly = 5

Group Profile

Group	Age	Education	Railway Experiences
A	>45	Degree or higher	>15 Years
B	40-45	Diploma/Certificate	10-15 Years
C	40	Post Secondary	5-10 Years
D	<35	Secondary	<5 years

Table E10. Post CRM Training Score Group D

Post CRM Training Score Sheet

CRM Trainees	Group	CRM Safety Altitude Questions																			
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
STC-1	D	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	1	1	5
TC-1	D	5	5	5	4	4	4	4	4	5	5	5	5	4	4	4	4	4	3	2	5
TC-2	D	4	4	5	4	4	5	5	2	4	4	4	4	5	4	4	5	5	4	4	4
TC-3	D	5	5	4	4	4	5	5	4	4	5	5	4	4	5	4	4	5	1	2	4
TC-4	D	5	4	5	5	4	5	5	5	4	4	4	5	4	4	3	5	5	4	2	5
SC-1	D	4	5	5	5	5	4	4	4	4	4	4	4	4	2	4	4	4	2	2	4
SC-2	D	5	5	4	5	4	4	3	4	4	4	5	4	2	4	4	4	5	1	1	5
SC-3	D	5	5	4	4	5	4	4	4	4	4	4	5	4	5	5	5	4	5	1	5
SC-4	D	4	4	4	4	4	4	4	2	3	4	4	4	4	4	4	4	5	5	1	2
SC-5	D	4	4	5	4	4	4	5	5	4	4	5	5	4	4	1	5	4	5	2	4
TD-1	D	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	5	1	4
TD-2	D	4	4	4	4	4	4	3	5	4	4	4	4	5	4	2	1	4	4	2	4
TD-3	D	4	4	3	4	4	4	4	4	4	4	4	5	4	4	4	5	4	4	3	4
TD-4	D	4	5	4	4	4	4	4	3	3	3	4	4	4	4	4	4	5	1	2	4
TD-5	D	4	4	4	3	4	4	5	4	4	4	4	4	5	4	4	4	4	4	2	4
TD-6	D	4	4	2	4	4	5	4	4	4	4	4	5	4	1	1	4	3	4	2	4
TD-7	D	4	4	4	4	3	4	2	4	4	4	4	4	4	4	2	2	4	4	1	4
TD-8	D	5	4	4	4	4	4	4	4	4	4	3	2	4	4	4	4	4	1	1	4
TD-9	D	4	4	4	4	2	4	5	4	5	2	4	4	5	4	4	4	2	4	3	4
TD-10	D	4	4	4	5	4	4	4	3	4	4	4	5	4	5	2	4	4	5	2	4
TD-11	D	4	4	2	4	3	4	4	4	4	4	4	1	5	4	4	5	4	2	2	4
TD-12	D	5	4	4	4	4	5	4	4	4	4	2	5	4	4	1	4	4	5	2	4
TD-13	D	4	4	4	5	4	4	1	4	4	4	4	5	4	4	2	3	4	5	2	4

CRM Safety Attitude Questions																					
CRM Trainees	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
TD-14	D	5	4	4	4	4	4	4	4	4	4	4	5	3	2	4	4	5	5	2	4
TD-15	D	4	4	3	4	5	4	5	4	4	4	4	5	4	4	1	5	4	5	4	3
TD-16	D	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	4
TD-17	D	4	4	4	4	4	4	4	5	4	3	4	1	4	4	1	4	4	4	2	4
TD-18	D	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	5	4	4	4	4
TD-19	D	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	2	4	4
TD-20	D	4	4	4	4	5	4	4	4	4	4	4	2	4	4	4	5	5	4	1	1

Legends:	STC	Senior Traffic Controller = 1
Disagree Strongly = 1	TC	Traffic Controller = 4
Disagree Slightly = 2	SC	Station Controller = 5
Neutral = 3	TD	Train Driver = 20
Agree Slightly = 4		
Agree Strongly = 5		

Group Profile			
Group	Age	Education	Railway Experiences
A	>45	Degree or higher	>15 Years
B	40-45	Diploma/Certificate	10-15 Years
C	40	Post Secondary	5-10 Years
D	<35	Secondary	<5 years

Table E11. General Linear Model

Between-Subjects				
Factors				
		N		
Group	A	30		
	B	30		
	C	30		
	D	30		
Descriptive Statistics				
	Group	Mean	Std. Deviation	N
Q1A	A	4,10	,481	30
	B	3,97	,490	30
	C	4,20	,551	30
	D	4,27	,583	30
	Total	4,13	,533	120
Q1B	A	4,23	,430	30
	B	4,03	,615	30
	C	4,27	,450	30
	D	4,33	,479	30
	Total	4,22	,505	120
Q2A	A	4,33	,479	30
	B	4,23	,430	30
	C	4,40	,498	30
	D	4,17	,379	30
	Total	4,28	,453	120
Q2B	A	4,40	,498	30
	B	4,33	,479	30
	C	4,47	,507	30
	D	4,27	,450	30
	Total	4,37	,484	120
Q3A	A	3,90	,803	30
	B	3,90	,712	30
	C	3,87	,860	30
	D	3,87	,776	30
	Total	3,88	,780	120
Q3B	A	4,27	,450	30
	B	4,00	,455	30
	C	4,17	,379	30

Descriptive Statistics

	Group	Mean	Std. Deviation	N
	D	4,03	,765	30
	Total	4,12	,537	120
Q4A	A	4,33	,479	30
	B	4,10	,759	30
	C	4,07	,785	30
	D	3,97	,765	30
	Total	4,12	,712	120
Q4B	A	4,40	,498	30
	B	4,30	,466	30
	C	4,33	,479	30
	D	4,17	,461	30
	Total	4,30	,478	120
Q5A	A	3,60	,770	30
	B	3,77	,817	30
	C	3,90	,712	30
	D	3,83	,834	30
	Total	3,78	,783	120
Q5B	A	3,90	,662	30
	B	4,03	,669	30
	C	4,10	,607	30
	D	4,03	,615	30
	Total	4,02	,635	120
Q6A	A	3,80	,714	30
	B	3,90	,662	30
	C	3,90	,803	30
	D	4,03	,556	30
	Total	3,91	,686	120
Q6B	A	4,03	,556	30
	B	4,07	,521	30
	C	4,10	,607	30
	D	4,20	,407	30
	Total	4,10	,525	120
Q7A	A	3,70	1,119	30
	B	3,60	1,037	30
	C	3,63	1,189	30
	D	3,43	1,305	30
	Total	3,59	1,156	120

Descriptive Statistics

	Group	Mean	Std. Deviation	N
Q7B	A	4,13	,571	30
	B	4,00	,525	30
	C	4,00	,695	30
	D	4,03	,890	30
	Total	4,04	,679	120
Q8A	A	3,67	1,028	30
	B	3,70	,952	30
	C	3,87	,629	30
	D	3,60	,894	30
	Total	3,71	,883	120
Q8B	A	4,00	,587	30
	B	4,07	,785	30
	C	3,93	,640	30
	D	3,97	,718	30
	Total	3,99	,680	120
Q9A	A	3,70	1,022	30
	B	3,70	1,119	30
	C	3,87	,819	30
	D	3,67	,994	30
	Total	3,73	,985	120
Q9B	A	3,87	,730	30
	B	3,97	,765	30
	C	3,97	,556	30
	D	4,03	,414	30
	Total	3,96	,627	120
Q10A	A	4,17	,379	30
	B	4,03	,556	30
	C	3,93	,785	30
	D	3,80	,714	30
	Total	3,98	,635	120
Q10B	A	4,07	,450	30
	B	4,13	,434	30
	C	4,03	,556	30
	D	3,97	,556	30
	Total	4,05	,500	120
Q11A	A	4,20	,407	30
	B	4,13	,346	30

Descriptive Statistics

	Group	Mean	Std. Deviation	N
	C	3,63	1,098	30
	D	3,93	,691	30
	Total	3,98	,727	120
Q11B	A	4,07	,450	30
	B	4,10	,481	30
	C	4,07	,583	30
	D	4,03	,615	30
	Total	4,07	,530	120
Q12A	A	4,33	,479	30
	B	4,27	,450	30
	C	4,20	,847	30
	D	4,13	,860	30
	Total	4,23	,683	120
Q12B	A	3,73	1,230	30
	B	3,70	1,208	30
	C	3,77	1,331	30
	D	4,03	1,129	30
	Total	3,81	1,218	120
Q13A	A	3,43	1,104	30
	B	3,73	,907	30
	C	3,63	1,189	30
	D	3,70	1,022	30
	Total	3,62	1,054	120
Q13B	A	3,97	,490	30
	B	4,03	,669	30
	C	3,70	,915	30
	D	4,07	,583	30
	Total	3,94	,690	120
Q14A	A	3,50	1,075	30
	B	3,40	1,102	30
	C	3,57	1,006	30
	D	3,63	,928	30
	Total	3,52	1,020	120
Q14B	A	3,93	,828	30
	B	3,77	,858	30
	C	4,00	,830	30
	D	3,87	,860	30

Descriptive Statistics

	Group	Mean	Std. Deviation	N
	Total	3,89	,838	120
Q15A	A	3,83	,648	30
	B	3,73	,907	30
	C	3,60	1,003	30
	D	3,77	,898	30
	Total	3,73	,867	120
Q15B	A	3,17	1,341	30
	B	3,20	1,215	30
	C	3,13	1,306	30
	D	3,20	1,297	30
	Total	3,18	1,275	120
Q16A	A	4,00	,743	30
	B	3,93	,828	30
	C	3,77	1,073	30
	D	3,73	1,230	30
	Total	3,86	,981	120
Q16B	A	4,33	,479	30
	B	4,20	,664	30
	C	4,17	,874	30
	D	4,17	,913	30
	Total	4,22	,747	120
Q17A	A	4,23	,430	30
	B	4,30	,466	30
	C	3,97	,718	30
	D	4,00	,830	30
	Total	4,13	,643	120
Q17B	A	4,30	,466	30
	B	4,33	,479	30
	C	4,13	,629	30
	D	4,20	,664	30
	Total	4,24	,565	120
Q18A	A	4,27	,450	30
	B	4,17	,834	30
	C	3,77	,971	30
	D	3,77	1,040	30
	Total	3,99	,874	120
Q18B	A	3,33	1,322	30

Descriptive Statistics

	Group	Mean	Std. Deviation	N
	B	2,90	1,470	30
	C	3,47	1,167	30
	D	3,50	1,480	30
	Total	3,30	1,370	120
Q19A	A	2,37	1,098	30
	B	2,13	1,008	30
	C	2,20	,961	30
	D	2,20	,925	30
	Total	2,23	,991	120
Q19B	A	1,87	,860	30
	B	2,00	,910	30
	C	1,93	,740	30
	D	2,07	,944	30
	Total	1,97	,859	120
Q20A	A	3,90	,803	30
	B	3,80	1,095	30
	C	3,47	1,008	30
	D	3,73	,785	30
	Total	3,73	,935	120
Q20B	A	4,10	,607	30
	B	4,10	,845	30
	C	3,87	,860	30
	D	3,97	,809	30
	Total	4,01	,783	120

Table E12. Multivariate Tests

			Multivariate Tests(d)						
Effect			Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter Power(a)
Between Subjects	Intercept	Pillai's Trace	,998	1970,882(b)	20,000	97,000	,000	,998	39,417,634
		Wilks' Lambda	,002	1970,882(b)	20,000	97,000	,000	,998	39,417,634
		Hotelling's Trace	406,367	1970,882(b)	20,000	97,000	,000	,998	39,417,634
		Roy's Largest Root	406,367	1970,882(b)	20,000	97,000	,000	,998	39,417,634
	GROUP	Pillai's Trace	,668	1,417	60,000	297,000	,032	,223	85,004
		Wilks' Lambda	,463	1,424	60,000	290,229	,031	,226	84,878
		Hotelling's Trace	,896	1,429	60,000	287,000	,030	,230	85,727
		Roy's Largest Root	,455	2,251(c)	20,000	99,000	,005	,313	45,016
Within Subjects	PREPOST	Pillai's Trace	,699	11,277(b)	20,000	97,000	,000	,699	225,549
		Wilks' Lambda	,301	11,277(b)	20,000	97,000	,000	,699	225,549
		Hotelling's Trace	2,325	11,277(b)	20,000	97,000	,000	,699	225,549
		Roy's Largest Root	2,325	11,277(b)	20,000	97,000	,000	,699	225,549
	PREPOST * GROUP	Pillai's Trace	,382	,723	60,000	297,000	,936	,127	43,353
		Wilks' Lambda	,658	,728	60,000	290,229	,931	,130	43,424
		Hotelling's Trace	,460	,734	60,000	287,000	,926	,133	44,019
		Roy's Largest Root	,283	1,400(c)	20,000	99,000	,141	,220	27,992

a Computed using alpha = ,05

b Exact statistic

c The statistic is an upper bound on F that yields a lower bound on the significance level.

d Design: Intercept+GROUP

Within Subjects Design: PREPOST

Table E13. Mauchly's Test of Sphericity

Mauchly's Test of Sphericity(b)							
Within Subjects Effect	Measure	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon(a)	
						Greenhouse-Geisser	Huynh-Feldt Lower-bound
PREPOST	Q1	1,000	,000	0	,	1,000	1,000 1,000
	Q2	1,000	,000	0	,	1,000	1,000 1,000
	Q3	1,000	,000	0	,	1,000	1,000 1,000
	Q4	1,000	,000	0	,	1,000	1,000 1,000
	Q5	1,000	,000	0	,	1,000	1,000 1,000
	Q6	1,000	,000	0	,	1,000	1,000 1,000
	Q7	1,000	,000	0	,	1,000	1,000 1,000
	Q8	1,000	,000	0	,	1,000	1,000 1,000
	Q9	1,000	,000	0	,	1,000	1,000 1,000
	Q10	1,000	,000	0	,	1,000	1,000 1,000
	Q11	1,000	,000	0	,	1,000	1,000 1,000
	Q12	1,000	,000	0	,	1,000	1,000 1,000
	Q13	1,000	,000	0	,	1,000	1,000 1,000
	Q14	1,000	,000	0	,	1,000	1,000 1,000
	Q15	1,000	,000	0	,	1,000	1,000 1,000
	Q16	1,000	,000	0	,	1,000	1,000 1,000
	Q17	1,000	,000	0	,	1,000	1,000 1,000
	Q18	1,000	,000	0	,	1,000	1,000 1,000
	Q19	1,000	,000	0	,	1,000	1,000 1,000
	Q20	1,000	,000	0	,	1,000	1,000 1,000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b Design: Intercept+GROUP

Within Subjects Design: PREPOST

Table E14. Tests of Within-Subjects Effects

Tests of Within-Subjects Effects								
Multivariate(d,e)								
Within Subjects Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
PREPOST	Pillai's Trace	,699	11,277(b)	20,000	97,000 ,000	,699	225,549	1,000
	Wilks' Lambda	,301	11,277(b)	20,000	97,000 ,000	,699	225,549	1,000
	Hotelling's Trace	2,325	11,277(b)	20,000	97,000 ,000	,699	225,549	1,000
	Roy's Largest Root	2,325	11,277(b)	20,000	97,000 ,000	,699	225,549	1,000
PREPOST * GROUP	Pillai's Trace	,382	,723	60,000	297,000 ,936	,127	43,353	,883
	Wilks' Lambda	,658	,728	60,000	290,229 ,931	,130	43,424	,882
	Hotelling's Trace	,460	,734	60,000	287,000 ,926	,133	44,019	,888
	Roy's Largest Root	,283	1,400(c)	20,000	99,000 ,141	,220	27,992	,868
a Computed using alpha = ,05								
b Exact statistic								
c The statistic is an upper bound on F that yields a lower bound on the significance level.								
d Design: Intercept+GROUP								
Within Subjects Design: PREPOST								
e Tests are based on averaged variables.								

Table E15. Unit Univariate Tests

Univariate Tests									
Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
PREPOST	Sphericity Assumed	,417	1	,417	2,354 ,128	,020		2,354	,331
	Greenhouse-Geisser	,417	1,000	,417	2,354 ,128	,020		2,354	,331
	Huynh-Feldt	,417	1,000	,417	2,354 ,128	,020		2,354	,331
	Lower-bound	,417	1,000	,417	2,354 ,128	,020		2,354	,331
	Sphericity Assumed	,417	1	,417	5,642 ,019	,046		5,642	,654
	Greenhouse-Geisser	,417	1,000	,417	5,642 ,019	,046		5,642	,654
	Huynh-Feldt	,417	1,000	,417	5,642 ,019	,046		5,642	,654
	Lower-bound	,417	1,000	,417	5,642 ,019	,046		5,642	,654
	Sphericity Assumed	3,267	1	3,267	9,227 ,003	,074		9,227	,854
	Greenhouse-Geisser	3,267	1,000	3,267	9,227 ,003	,074		9,227	,854
	Huynh-Feldt	3,267	1,000	3,267	9,227 ,003	,074		9,227	,854
	Lower-bound	3,267	1,000	3,267	9,227 ,003	,074		9,227	,854
	Sphericity Assumed	2,017	1	2,017	8,160 ,005	,066		8,160	,809
	Greenhouse-Geisser	2,017	1,000	2,017	8,160 ,005	,066		8,160	,809
	Huynh-Feldt	2,017	1,000	2,017	8,160 ,005	,066		8,160	,809
	Lower-bound	2,017	1,000	2,017	8,160 ,005	,066		8,160	,809
	Sphericity Assumed	3,504	1	3,504	9,056 ,003	,072		9,056	,847
	Greenhouse-Geisser	3,504	1,000	3,504	9,056 ,003	,072		9,056	,847
	Huynh-Feldt	3,504	1,000	3,504	9,056 ,003	,072		9,056	,847
	Lower-bound	3,504	1,000	3,504	9,056 ,003	,072		9,056	,847
	Sphericity Assumed	2,204	1	2,204	7,690 ,006	,062		7,690	,785
	Greenhouse-Geisser	2,204	1,000	2,204	7,690 ,006	,062		7,690	,785
	Huynh-Feldt	2,204	1,000	2,204	7,690 ,006	,062		7,690	,785
	Lower-bound	2,204	1,000	2,204	7,690 ,006	,062		7,690	,785
	Sphericity Assumed	12,150	1	12,150	16,510 ,000	,125		16,510	,981
	Greenhouse-Geisser	12,150	1,000	12,150	16,510 ,000	,125		16,510	,981
	Huynh-Feldt	12,150	1,000	12,150	16,510 ,000	,125		16,510	,981
	Lower-bound	12,150	1,000	12,150	16,510 ,000	,125		16,510	,981
	Sphericity Assumed	4,817	1	4,817	12,085 ,001	,094		12,085	,932
	Greenhouse-Geisser	4,817	1,000	4,817	12,085 ,001	,094		12,085	,932

Univariate Tests									
Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Q9	Huynh-Feldt	4,817	1,000	4,817	12,085	,001	,094	12,085	,932
	Lower-bound	4,817	1,000	4,817	12,085	,001	,094	12,085	,932
	Sphericity Assumed	3,038	1	3,038	7,685	,006	,062	7,685	,785
	Greenhouse-Geisser	3,038	1,000	3,038	7,685	,006	,062	7,685	,785
	Huynh-Feldt	3,038	1,000	3,038	7,685	,006	,062	7,685	,785
	Lower-bound	3,038	1,000	3,038	7,685	,006	,062	7,685	,785
	Sphericity Assumed	,267	1	,267	1,100	,297	,009	1,100	,180
	Greenhouse-Geisser	,267	1,000	,267	1,100	,297	,009	1,100	,180
	Huynh-Feldt	,267	1,000	,267	1,100	,297	,009	1,100	,180
	Lower-bound	,267	1,000	,267	1,100	,297	,009	1,100	,180
	Sphericity Assumed	,504	1	,504	1,418	,236	,012	1,418	,219
	Greenhouse-Geisser	,504	1,000	,504	1,418	,236	,012	1,418	,219
Q10	Huynh-Feldt	,504	1,000	,504	1,418	,236	,012	1,418	,219
	Lower-bound	,504	1,000	,504	1,418	,236	,012	1,418	,219
	Sphericity Assumed	10,838	1	10,838	14,564	,000	,112	14,564	,966
	Greenhouse-Geisser	10,838	1,000	10,838	14,564	,000	,112	14,564	,966
	Huynh-Feldt	10,838	1,000	10,838	14,564	,000	,112	14,564	,966
	Lower-bound	10,838	1,000	10,838	14,564	,000	,112	14,564	,966
	Sphericity Assumed	6,017	1	6,017	9,147	,003	,073	9,147	,851
	Greenhouse-Geisser	6,017	1,000	6,017	9,147	,003	,073	9,147	,851
	Huynh-Feldt	6,017	1,000	6,017	9,147	,003	,073	9,147	,851
	Lower-bound	6,017	1,000	6,017	9,147	,003	,073	9,147	,851
	Sphericity Assumed	8,067	1	8,067	13,081	,000	,101	13,081	,948
	Greenhouse-Geisser	8,067	1,000	8,067	13,081	,000	,101	13,081	,948
Q11	Huynh-Feldt	8,067	1,000	8,067	13,081	,000	,101	13,081	,948
	Lower-bound	8,067	1,000	8,067	13,081	,000	,101	13,081	,948
	Sphericity Assumed	18,704	1	18,704	14,515	,000	,111	14,515	,965
	Greenhouse-Geisser	18,704	1,000	18,704	14,515	,000	,111	14,515	,965
	Huynh-Feldt	18,704	1,000	18,704	14,515	,000	,111	14,515	,965
	Lower-bound	18,704	1,000	18,704	14,515	,000	,111	14,515	,965
	Sphericity Assumed	7,704	1	7,704	16,383	,000	,124	16,383	,980
	Greenhouse-Geisser	7,704	1,000	7,704	16,383	,000	,124	16,383	,980
	Huynh-Feldt	7,704	1,000	7,704	16,383	,000	,124	16,383	,980
	Lower-bound	7,704	1,000	7,704	16,383	,000	,124	16,383	,980
	Sphericity Assumed	7,704	1	7,704	16,383	,000	,124	16,383	,980
	Greenhouse-Geisser	7,704	1,000	7,704	16,383	,000	,124	16,383	,980
	Huynh-Feldt	7,704	1,000	7,704	16,383	,000	,124	16,383	,980

Univariate Tests									
Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
PREPOST * GROUP	Greenhouse-Geisser	7,704	1,000	7,704	16,383	,000	,124	16,383	,980
	Huynh-Feldt	7,704	1,000	7,704	16,383	,000	,124	16,383	,980
	Lower-bound	7,704	1,000	7,704	16,383	,000	,124	16,383	,980
	Sphericity Assumed	,817	1	,817	3,658	,058	,031	3,658	,475
	Greenhouse-Geisser	,817	1,000	,817	3,658	,058	,031	3,658	,475
	Huynh-Feldt	,817	1,000	,817	3,658	,058	,031	3,658	,475
	Lower-bound	,817	1,000	,817	3,658	,058	,031	3,658	,475
	Sphericity Assumed	28,704	1	28,704	18,711	,000	,139	18,711	,990
	Greenhouse-Geisser	28,704	1,000	28,704	18,711	,000	,139	18,711	,990
	Huynh-Feldt	28,704	1,000	28,704	18,711	,000	,139	18,711	,990
	Lower-bound	28,704	1,000	28,704	18,711	,000	,139	18,711	,990
	Sphericity Assumed	4,004	1	4,004	7,355	,008	,060	7,355	,767
	Greenhouse-Geisser	4,004	1,000	4,004	7,355	,008	,060	7,355	,767
	Huynh-Feldt	4,004	1,000	4,004	7,355	,008	,060	7,355	,767
	Lower-bound	4,004	1,000	4,004	7,355	,008	,060	7,355	,767
	Sphericity Assumed	4,817	1	4,817	10,190	,002	,081	10,190	,886
	Greenhouse-Geisser	4,817	1,000	4,817	10,190	,002	,081	10,190	,886
	Huynh-Feldt	4,817	1,000	4,817	10,190	,002	,081	10,190	,886
	Lower-bound	4,817	1,000	4,817	10,190	,002	,081	10,190	,886
	Sphericity Assumed	5.00E+01	3	1.67E+01	,094	,963	,002	,282	,067
	Greenhouse-Geisser	5.00E+01	3,000	1.67E+01	,094	,963	,002	,282	,067
	Huynh-Feldt	5.00E+01	3,000	1.67E+01	,094	,963	,002	,282	,067
	Lower-bound	5.00E+01	3,000	1.67E+01	,094	,963	,002	,282	,067
	Sphericity Assumed	1.67E+01	3	5.56E+00	,075	,973	,002	,226	,063
	Greenhouse-Geisser	1.67E+01	3,000	5.56E+00	,075	,973	,002	,226	,063
	Huynh-Feldt	1.67E+01	3,000	5.56E+00	,075	,973	,002	,226	,063
	Lower-bound	1.67E+01	3,000	5.56E+00	,075	,973	,002	,226	,063
	Sphericity Assumed	,667	3	,222	,628	,599	,016	1,883	,178
	Greenhouse-Geisser	,667	3,000	,222	,628	,599	,016	1,883	,178
	Huynh-Feldt	,667	3,000	,222	,628	,599	,016	1,883	,178
	Lower-bound	,667	3,000	,222	,628	,599	,016	1,883	,178

Univariate Tests									
Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Q4	Sphericity Assumed	,317	3	,106	,427,734	,011		1,281	,133
	Greenhouse-Geisser	,317	3,000	,106	,427,734	,011		1,281	,133
	Huynh-Feldt	,317	3,000	,106	,427,734	,011		1,281	,133
	Lower-bound	,317	3,000	,106	,427,734	,011		1,281	,133
Q5	Sphericity Assumed	,112	3	3.75E+01	,097,962	,003		,291	,067
	Greenhouse-Geisser	,112	3,000	3.75E+01	,097,962	,003		,291	,067
	Huynh-Feldt	,112	3,000	3.75E+01	,097,962	,003		,291	,067
	Lower-bound	,112	3,000	3.75E+01	,097,962	,003		,291	,067
Q6	Sphericity Assumed	4.58E+01	3	1.53E+01	,053,984	,001		,160	,059
	Greenhouse-Geisser	4.58E+01	3,000	1.53E+01	,053,984	,001		,160	,059
	Huynh-Feldt	4.58E+01	3,000	1.53E+01	,053,984	,001		,160	,059
	Lower-bound	4.58E+01	3,000	1.53E+01	,053,984	,001		,160	,059
Q7	Sphericity Assumed	,483	3	,161	,219,883	,006		,657	,090
	Greenhouse-Geisser	,483	3,000	,161	,219,883	,006		,657	,090
	Huynh-Feldt	,483	3,000	,161	,219,883	,006		,657	,090
	Lower-bound	,483	3,000	,161	,219,883	,006		,657	,090
Q8	Sphericity Assumed	,950	3	,317	,795,499	,020		2,384	,217
	Greenhouse-Geisser	,950	3,000	,317	,795,499	,020		2,384	,217
	Huynh-Feldt	,950	3,000	,317	,795,499	,020		2,384	,217
	Lower-bound	,950	3,000	,317	,795,499	,020		2,384	,217
Q9	Sphericity Assumed	,612	3	,204	,517,672	,013		1,550	,153
	Greenhouse-Geisser	,612	3,000	,204	,517,672	,013		1,550	,153
	Huynh-Feldt	,612	3,000	,204	,517,672	,013		1,550	,153
	Lower-bound	,612	3,000	,204	,517,672	,013		1,550	,153
Q10	Sphericity Assumed	,600	3	,200	,825,483	,021		2,474	,224
	Greenhouse-Geisser	,600	3,000	,200	,825,483	,021		2,474	,224
	Huynh-Feldt	,600	3,000	,200	,825,483	,021		2,474	,224
	Lower-bound	,600	3,000	,200	,825,483	,021		2,474	,224
Q11	Sphericity Assumed	2,746	3	,915	2,574,057	,062		7,722	,621
	Greenhouse-Geisser	2,746	3,000	,915	2,574,057	,062		7,722	,621
	Huynh-Feldt	2,746	3,000	,915	2,574,057	,062		7,722	,621

Univariate Tests									
Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Q12	Lower-bound	2,746	3,000	,915	2,574	,057	,062	7,722	,621
	Sphericity Assumed	2,346	3	,782	1,051	,373	,026	3,153	,279
	Greenhouse-Geisser	2,346	3,000	,782	1,051	,373	,026	3,153	,279
	Huynh-Feldt	2,346	3,000	,782	1,051	,373	,026	3,153	,279
	Lower-bound	2,346	3,000	,782	1,051	,373	,026	3,153	,279
Q13	Sphericity Assumed	1,683	3	,561	,853	,468	,022	2,559	,231
	Greenhouse-Geisser	1,683	3,000	,561	,853	,468	,022	2,559	,231
	Huynh-Feldt	1,683	3,000	,561	,853	,468	,022	2,559	,231
	Lower-bound	1,683	3,000	,561	,853	,468	,022	2,559	,231
	Sphericity Assumed	,400	3	,133	,216	,885	,006	,649	,090
Q14	Greenhouse-Geisser	,400	3,000	,133	,216	,885	,006	,649	,090
	Huynh-Feldt	,400	3,000	,133	,216	,885	,006	,649	,090
	Lower-bound	,400	3,000	,133	,216	,885	,006	,649	,090
	Sphericity Assumed	,313	3	,104	,081	,970	,002	,243	,064
	Greenhouse-Geisser	,313	3,000	,104	,081	,970	,002	,243	,064
Q15	Huynh-Feldt	,313	3,000	,104	,081	,970	,002	,243	,064
	Lower-bound	,313	3,000	,104	,081	,970	,002	,243	,064
	Sphericity Assumed	,246	3	8.19E+01	,174	,914	,004	,523	,081
	Greenhouse-Geisser	,246	3,000	8.19E+01	,174	,914	,004	,523	,081
	Huynh-Feldt	,246	3,000	8.19E+01	,174	,914	,004	,523	,081
Q16	Lower-bound	,246	3,000	8.19E+01	,174	,914	,004	,523	,081
	Sphericity Assumed	,283	3	9.44E+01	,423	,737	,011	1,269	,132
	Greenhouse-Geisser	,283	3,000	9.44E+01	,423	,737	,011	1,269	,132
	Huynh-Feldt	,283	3,000	9.44E+01	,423	,737	,011	1,269	,132
	Lower-bound	,283	3,000	9.44E+01	,423	,737	,011	1,269	,132
Q17	Sphericity Assumed	10,846	3	3,615	2,357	,075	,057	7,070	,578
	Greenhouse-Geisser	10,846	3,000	3,615	2,357	,075	,057	7,070	,578
	Huynh-Feldt	10,846	3,000	3,615	2,357	,075	,057	7,070	,578
	Lower-bound	10,846	3,000	3,615	2,357	,075	,057	7,070	,578
	Sphericity Assumed	1,346	3	,449	,824	,483	,021	2,472	,224
Q19	Greenhouse-Geisser	1,346	3,000	,449	,824	,483	,021	2,472	,224

Univariate Tests									
Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
	Huynh-Feldt	1,346	3,000	,449	,824	,483	,021	2,472	,224
	Lower-bound	1,346	3,000	,449	,824	,483	,021	2,472	,224
	Sphericity Assumed	,350	3	,117	,247	,863	,006	,740	,096
	Greenhouse-Geisser	,350	3,000	,117	,247	,863	,006	,740	,096
	Huynh-Feldt	,350	3,000	,117	,247	,863	,006	,740	,096
	Lower-bound	,350	3,000	,117	,247	,863	,006	,740	,096
	Sphericity Assumed	20,533	116	,177					
	Greenhouse-Geisser	20,533	116,000	,177					
	Huynh-Feldt	20,533	116,000	,177					
	Lower-bound	20,533	116,000	,177					
	Sphericity Assumed	8,567	116	7.39E+01					
	Greenhouse-Geisser	8,567	116,000	7.39E+01					
	Huynh-Feldt	8,567	116,000	7.39E+01					
	Lower-bound	8,567	116,000	7.39E+01					
Error(PREP OST)	Sphericity Assumed	41,067	116	,354					
	Greenhouse-Geisser	41,067	116,000	,354					
	Huynh-Feldt	41,067	116,000	,354					
	Lower-bound	41,067	116,000	,354					
	Sphericity Assumed	28,667	116	,247					
	Greenhouse-Geisser	28,667	116,000	,247					
	Huynh-Feldt	28,667	116,000	,247					
	Lower-bound	28,667	116,000	,247					
	Sphericity Assumed	44,883	116	,387					
	Greenhouse-Geisser	44,883	116,000	,387					
	Huynh-Feldt	44,883	116,000	,387					
	Lower-bound	44,883	116,000	,387					
	Sphericity Assumed	33,250	116	,287					
	Greenhouse-Geisser	33,250	116,000	,287					
	Huynh-Feldt	33,250	116,000	,287					
	Lower-bound	33,250	116,000	,287					
Q20	Sphericity Assumed	85,367	116	,736					
	Greenhouse-Geisser	85,367	116,000	,736					

Univariate Tests									
Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Q8	Greenhouse-Geisser	85,367	116,000	,736					
	Huynh-Feldt	85,367	116,000	,736					
	Lower-bound	85,367	116,000	,736					
	Sphericity Assumed	46,233	116	,399					
	Greenhouse-Geisser	46,233	116,000	,399					
	Huynh-Feldt	46,233	116,000	,399					
	Lower-bound	46,233	116,000	,399					
	Sphericity Assumed	45,850	116	,395					
	Greenhouse-Geisser	45,850	116,000	,395					
	Huynh-Feldt	45,850	116,000	,395					
	Lower-bound	45,850	116,000	,395					
	Sphericity Assumed	28,133	116	,243					
Q9	Greenhouse-Geisser	28,133	116,000	,243					
	Huynh-Feldt	28,133	116,000	,243					
	Lower-bound	28,133	116,000	,243					
	Sphericity Assumed	41,250	116	,356					
Q10	Greenhouse-Geisser	41,250	116,000	,356					
	Huynh-Feldt	41,250	116,000	,356					
	Lower-bound	41,250	116,000	,356					
	Sphericity Assumed	86,317	116	,744					
Q11	Greenhouse-Geisser	86,317	116,000	,744					
	Huynh-Feldt	86,317	116,000	,744					
	Lower-bound	86,317	116,000	,744					
	Sphericity Assumed	76,300	116	,658					
Q12	Greenhouse-Geisser	76,300	116,000	,658					
	Huynh-Feldt	76,300	116,000	,658					
	Lower-bound	76,300	116,000	,658					
	Sphericity Assumed	71,533	116	,617					
Q13	Greenhouse-Geisser	71,533	116,000	,617					
	Huynh-Feldt	71,533	116,000	,617					
	Lower-bound	71,533	116,000	,617					
	Sphericity Assumed	71,533	116,000	,617					
Q14	Greenhouse-Geisser	71,533	116,000	,617					
	Huynh-Feldt	71,533	116,000	,617					
	Lower-bound	71,533	116,000	,617					
	Sphericity Assumed	71,533	116,000	,617					

Univariate Tests									
Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Q15	Sphericity Assumed	149,483	116	1,289					
	Greenhouse-Geisser	149,483	116,000	1,289					
	Huynh-Feldt	149,483	116,000	1,289					
	Lower-bound	149,483	116,000	1,289					
Q16	Sphericity Assumed	54,550	116	,470					
	Greenhouse-Geisser	54,550	116,000	,470					
	Huynh-Feldt	54,550	116,000	,470					
	Lower-bound	54,550	116,000	,470					
Q17	Sphericity Assumed	25,900	116	,223					
	Greenhouse-Geisser	25,900	116,000	,223					
	Huynh-Feldt	25,900	116,000	,223					
	Lower-bound	25,900	116,000	,223					
Q18	Sphericity Assumed	177,950	116	1,534					
	Greenhouse-Geisser	177,950	116,000	1,534					
	Huynh-Feldt	177,950	116,000	1,534					
	Lower-bound	177,950	116,000	1,534					
Q19	Sphericity Assumed	63,150	116	,544					
	Greenhouse-Geisser	63,150	116,000	,544					
	Huynh-Feldt	63,150	116,000	,544					
	Lower-bound	63,150	116,000	,544					
Q20	Sphericity Assumed	54,833	116	,473					
	Greenhouse-Geisser	54,833	116,000	,473					
	Huynh-Feldt	54,833	116,000	,473					
	Lower-bound	54,833	116,000	,473					

a Computed using alpha = ,05

Table E16. Tests of Within Subject Contrasts

Tests of Within-Subjects Contrasts										
Source	Measure	PREPOST	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
PREPOST	Q1	Linear	,417	1	,417	2,354	,128	,020	2,354	,331
	Q2	Linear	,417	1	,417	5,642	,019	,046	5,642	,654
	Q3	Linear	3,267	1	3,267	9,227	,003	,074	9,227	,854
	Q4	Linear	2,017	1	2,017	8,160	,005	,066	8,160	,809
	Q5	Linear	3,504	1	3,504	9,056	,003	,072	9,056	,847
	Q6	Linear	2,204	1	2,204	7,690	,006	,062	7,690	,785
	Q7	Linear	12,150	1	12,150	16,510	,000	,125	16,510	,981
	Q8	Linear	4,817	1	4,817	12,085	,001	,094	12,085	,932
	Q9	Linear	3,038	1	3,038	7,685	,006	,062	7,685	,785
	Q10	Linear	,267	1	,267	1,100	,297	,009	1,100	,180
	Q11	Linear	,504	1	,504	1,418	,236	,012	1,418	,219
	Q12	Linear	10,837	1	10,837	14,564	,000	,112	14,564	,966
	Q13	Linear	6,017	1	6,017	9,147	,003	,073	9,147	,851
	Q14	Linear	8,067	1	8,067	13,081	,000	,101	13,081	,948
	Q15	Linear	18,704	1	18,704	14,515	,000	,111	14,515	,965
	Q16	Linear	7,704	1	7,704	16,383	,000	,124	16,383	,980
	Q17	Linear	,817	1	,817	3,658	,058	,031	3,658	,475
	Q18	Linear	28,704	1	28,704	18,711	,000	,139	18,711	,990
	Q19	Linear	4,004	1	4,004	7,355	,008	,060	7,355	,767
	Q20	Linear	4,817	1	4,817	10,190	,002	,081	10,190	,886
PREPOST *	Q1	Linear	5.00E+01	3	1.67E+01	,094	,963	,002	,282	,067
GROUP	Q2	Linear	1.67E+01	3	5.56E+00	,075	,973	,002	,226	,063
	Q3	Linear	,667	3	,222	,628	,599	,016	1,883	,178
	Q4	Linear	,317	3	,106	,427	,734	,011	1,281	,133
	Q5	Linear	,112	3	3.75E+01	,097	,962	,003	,291	,067
	Q6	Linear	4.58E+01	3	1.53E+01	,053	,984	,001	,160	,059
	Q7	Linear	,483	3	,161	,219	,883	,006	,657	,090
	Q8	Linear	,950	3	,317	,795	,499	,020	2,384	,217
	Q9	Linear	,612	3	,204	,517	,672	,013	1,550	,153
	Q10	Linear	,600	3	,200	,825	,483	,021	2,474	,224
	Q11	Linear	2,746	3	,915	2,574	,057	,062	7,722	,621
	Q12	Linear	2,346	3	,782	1,051	,373	,026	3,153	,279
	Q13	Linear	1,683	3	,561	,853	,468	,022	2,559	,231
	Q14	Linear	,400	3	,133	,216	,885	,006	,649	,090
	Q15	Linear	,313	3	,104	,081	,970	,002	,243	,064

Tests of Within-Subjects Contrasts

Source	Measure	PREPOST	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
	Q16	Linear	,246	3	8.19E+01	,174	,914	,004	,523	,081
	Q17	Linear	,283	3	9.44E+01	,423	,737	,011	1,269	,132
	Q18	Linear	10,846	3	3,615	2,357	,075	,057	7,070	,578
	Q19	Linear	1,346	3	,449	,824	,483	,021	2,472	,224
	Q20	Linear	,350	3	,117	,247	,863	,006	,740	,096
Error(PREPOST)	Q1	Linear	20,533	116	,177					
	Q2	Linear	8,567	116	7.39E+01					
	Q3	Linear	41,067	116	,354					
	Q4	Linear	28,667	116	,247					
	Q5	Linear	44,883	116	,387					
	Q6	Linear	33,250	116	,287					
	Q7	Linear	85,367	116	,736					
	Q8	Linear	46,233	116	,399					
	Q9	Linear	45,850	116	,395					
	Q10	Linear	28,133	116	,243					
	Q11	Linear	41,250	116	,356					
	Q12	Linear	86,317	116	,744					
	Q13	Linear	76,300	116	,658					
	Q14	Linear	71,533	116	,617					
	Q15	Linear	149,483	116	1,289					
	Q16	Linear	54,550	116	,470					
	Q17	Linear	25,900	116	,223					
	Q18	Linear	177,950	116	1,534					
	Q19	Linear	63,150	116	,544					
	Q20	Linear	54,833	116	,473					

a Computed using alpha = ,05

Table E17. Tests of Between Subject Effects

Tests of Between-Subjects Effects									
Transformed Variable: Average									
Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	Q1	4,183,350	1	4,183,350	11,932,834	,000	,990	11,932,834	1,000
	Q2	4,489,350	1	4,489,350	12,389,324	,000	,991	12,389,324	1,000
	Q3	3,840,000	1	3,840,000	6,931,120	,000	,984	6,931,120	1,000
	Q4	4,250,417	1	4,250,417	8,825,447	,000	,987	8,825,447	1,000
	Q5	3,642,604	1	3,642,604	5,719,045	,000	,980	5,719,045	1,000
	Q6	3,848,004	1	3,848,004	8,227,990	,000	,986	8,227,990	1,000
	Q7	3,496,067	1	3,496,067	3,195,774	,000	,965	3,195,774	1,000
	Q8	3,557,400	1	3,557,400	4,122,462	,000	,973	4,122,462	1,000
	Q9	3,549,704	1	3,549,704	3,572,804	,000	,969	3,572,804	1,000
	Q10	3,872,067	1	3,872,067	9,570,165	,000	,988	9,570,165	1,000
	Q11	3,880,104	1	3,880,104	9,138,926	,000	,987	9,138,926	1,000
	Q12	3,880,104	1	3,880,104	3,147,864	,000	,964	3,147,864	1,000
	Q13	3,435,267	1	3,435,267	3,679,510	,000	,969	3,679,510	1,000
	Q14	3,300,417	1	3,300,417	2,852,819	,000	,961	2,852,819	1,000
	Q15	2,863,504	1	2,863,504	2,509,758	,000	,956	2,509,758	1,000
	Q16	3,912,338	1	3,912,338	3,649,627	,000	,969	3,649,627	1,000
	Q17	4,200,067	1	4,200,067	8,404,964	,000	,986	8,404,964	1,000
	Q18	3,190,104	1	3,190,104	3,004,889	,000	,963	3,004,889	1,000
	Q19	1,054,204	1	1,054,204	872,964	,000	,883	872,964	1,000
	Q20	3,588,267	1	3,588,267	3,532,438	,000	,968	3,532,438	1,000
GROUP	Q1	2,983	3	,994	2,837	,041	,068	8,510	,668
	Q2	1,617	3	,539	1,487	,222	,037	4,462	,385
	Q3	,733	3	,244	,441	,724	,011	1,324	,136
	Q4	2,717	3	,906	1,880	,137	,046	5,641	,476
	Q5	2,012	3	,671	1,053	,372	,027	3,160	,279
	Q6	1,246	3	,415	,888	,450	,022	2,664	,239
	Q7	1,033	3	,344	,315	,815	,008	,945	,109
	Q8	,500	3	,167	,193	,901	,005	,579	,085
	Q9	,546	3	,182	,183	,908	,005	,549	,083
	Q10	2,000	3	,667	1,648	,182	,041	4,943	,423
	Q11	3,146	3	1,049	2,470	,065	,060	7,409	,601
	Q12	,413	3	,138	,112	,953	,003	,335	,070
	Q13	2,433	3	,811	,869	,460	,022	2,606	,235

Transformed Variable: Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
	Q14	1,383	3	,461	,399	,754	,010	1,196	,127
	Q15	,646	3	,215	,189	,904	,005	,566	,084
	Q16	1,812	3	,604	,564	,640	,014	1,691	,163
	Q17	2,967	3	,989	1,979	,121	,049	5,937	,498
	Q18	2,246	3	,749	,705	,551	,018	2,115	,196
	Q19	,212	3	7.08E+01	,059	,981	,002	,176	,060
	Q20	3,900	3	1,300	1,280	,285	,032	3,839	,334
Error	Q1	40,667	116	,351					
	Q2	42,033	116	,362					
	Q3	64,267	116	,554					
	Q4	55,867	116	,482					
	Q5	73,883	116	,637					
	Q6	54,250	116	,468					
	Q7	126,900	116	1,094					
	Q8	100,100	116	,863					
	Q9	115,250	116	,994					
	Q10	46,933	116	,405					
	Q11	49,250	116	,425					
	Q12	142,983	116	1,233					
	Q13	108,300	116	,934					
	Q14	134,200	116	1,157					
	Q15	132,350	116	1,141					
	Q16	124,350	116	1,072					
	Q17	57,967	116	,500					
	Q18	123,150	116	1,062					
	Q19	140,083	116	1,208					
	Q20	117,833	116	1,016					

a Computed using alpha = ,05

Table E18. Estimated Marginal Means

Estimated Marginal Means						
Gruppe * PREPOST						
Measure	Gruppe	PREPOST	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Q1	A	1	4,100	,096	3,909	4,291
		2	4,233	,091	4,053	4,414
	B	1	3,967	,096	3,776	4,158
		2	4,033	,091	3,853	4,214
	C	1	4,200	,096	4,009	4,391
		2	4,267	,091	4,086	4,447
	D	1	4,267	,096	4,076	4,458
		2	4,333	,091	4,153	4,514
	A	1	4,333	,082	4,171	4,496
		2	4,400	,088	4,225	4,575
Q2	B	1	4,233	,082	4,071	4,396
		2	4,333	,088	4,158	4,508
	C	1	4,400	,082	4,238	4,562
		2	4,467	,088	4,292	4,642
	D	1	4,167	,082	4,004	4,329
		2	4,267	,088	4,092	4,442
	A	1	3,900	,144	3,614	4,186
		2	4,267	,097	4,074	4,460
Q3	B	1	3,900	,144	3,614	4,186
		2	4,000	,097	3,807	4,193
	C	1	3,867	,144	3,581	4,152
		2	4,167	,097	3,974	4,360
	D	1	3,867	,144	3,581	4,152
		2	4,033	,097	3,840	4,226
	A	1	4,333	,129	4,077	4,589
		2	4,400	,087	4,228	4,572
Q4	B	1	4,100	,129	3,844	4,356
		2	4,300	,087	4,128	4,472
	C	1	4,067	,129	3,811	4,323
		2	4,333	,087	4,161	4,506
	D	1	3,967	,129	3,711	4,223
		2	4,167	,087	3,994	4,339
Q5	A	1	3,600	,143	3,316	3,884
		2	3,900	,117	3,669	4,131
	B	1	3,767	,143	3,483	4,050
		2	4,033	,117	3,802	4,264
	C	1	3,900	,143	3,616	4,184
		2				

Measure	Gruppe	PREPOST	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Q6	D	2	4,100	,117	3,869	4,331
		1	3,833	,143	3,550	4,117
		2	4,033	,117	3,802	4,264
	A	1	3,800	,126	3,551	4,049
		2	4,033	,096	3,842	4,224
	B	1	3,900	,126	3,651	4,149
		2	4,067	,096	3,876	4,258
	C	1	3,900	,126	3,651	4,149
		2	4,100	,096	3,909	4,291
	D	1	4,033	,126	3,784	4,283
		2	4,200	,096	4,009	4,391
Q7	A	1	3,700	,213	3,278	4,122
		2	4,133	,125	3,886	4,381
	B	1	3,600	,213	3,178	4,022
		2	4,000	,125	3,752	4,248
	C	1	3,633	,213	3,212	4,055
		2	4,000	,125	3,752	4,248
	D	1	3,433	,213	3,012	3,855
		2	4,033	,125	3,786	4,281
Q8	A	1	3,667	,162	3,345	3,988
		2	4,000	,125	3,752	4,248
	B	1	3,700	,162	3,379	4,021
		2	4,067	,125	3,818	4,315
	C	1	3,867	,162	3,545	4,188
		2	3,933	,125	3,685	4,182
	D	1	3,600	,162	3,279	3,921
		2	3,967	,125	3,718	4,215
Q9	A	1	3,700	,182	3,340	4,060
		2	3,867	,115	3,638	4,095
	B	1	3,700	,182	3,340	4,060
		2	3,967	,115	3,738	4,195
	C	1	3,867	,182	3,507	4,226
		2	3,967	,115	3,738	4,195
	D	1	3,667	,182	3,307	4,026
		2	4,033	,115	3,805	4,262
Q10	A	1	4,167	,115	3,939	4,394
		2	4,067	,092	3,885	4,248
	B	1	4,033	,115	3,806	4,261
		2	4,133	,092	3,952	4,315
	C	1	3,933	,115	3,706	4,161
		2	4,033	,092	3,852	4,215
	D	1	3,800	,115	3,573	4,027

Measure	Gruppe	PREPOST	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Q11	A	2	3,967	,092	3,785	4,148
		1	4,200	,128	3,946	4,454
		2	4,067	,098	3,873	4,261
	B	1	4,133	,128	3,880	4,387
		2	4,100	,098	3,906	4,294
	C	1	3,633	,128	3,380	3,887
		2	4,067	,098	3,873	4,261
	D	1	3,933	,128	3,680	4,187
		2	4,033	,098	3,839	4,227
Q12	A	1	4,333	,125	4,085	4,582
		2	3,733	,224	3,290	4,177
	B	1	4,267	,125	4,018	4,515
		2	3,700	,224	3,256	4,144
	C	1	4,200	,125	3,951	4,449
		2	3,767	,224	3,323	4,210
	D	1	4,133	,125	3,885	4,382
		2	4,033	,224	3,590	4,477
Q13	A	1	3,433	,194	3,050	3,817
		2	3,967	,125	3,720	4,214
	B	1	3,733	,194	3,350	4,117
		2	4,033	,125	3,786	4,280
	C	1	3,633	,194	3,250	4,017
		2	3,700	,125	3,453	3,947
	D	1	3,700	,194	3,316	4,084
		2	4,067	,125	3,820	4,314
Q14	A	1	3,500	,188	3,128	3,872
		2	3,933	,154	3,628	4,239
	B	1	3,400	,188	3,028	3,772
		2	3,767	,154	3,461	4,072
	C	1	3,567	,188	3,194	3,939
		2	4,000	,154	3,695	4,305
	D	1	3,633	,188	3,261	4,006
		2	3,867	,154	3,561	4,172
Q15	A	1	3,833	,160	3,517	4,149
		2	3,167	,236	2,700	3,633
	B	1	3,733	,160	3,417	4,049
		2	3,200	,236	2,733	3,667
	C	1	3,600	,160	3,284	3,916
		2	3,133	,236	2,667	3,600
	D	1	3,767	,160	3,451	4,083
		2	3,200	,236	2,733	3,667
Q16	A	1	4,000	,180	3,643	4,357

					95% Confidence Interval		
Measure	Gruppe	PREPOST	Mean	Std. Error	Lower Bound	Upper Bound	
Q17	B	2	4,333	,138	4,061	4,606	
		1	3,933	,180	3,576	4,290	
		2	4,200	,138	3,928	4,472	
	C	1	3,767	,180	3,410	4,124	
		2	4,167	,138	3,894	4,439	
	D	1	3,733	,180	3,376	4,090	
		2	4,167	,138	3,894	4,439	
	A	1	4,233	,116	4,004	4,463	
		2	4,300	,103	4,095	4,505	
		B	1	4,300	,116	4,071	4,529
			2	4,333	,103	4,128	4,538
		C	1	3,967	,116	3,737	4,196
2			4,133	,103	3,928	4,338	
D		1	4,000	,116	3,771	4,229	
		2	4,200	,103	3,995	4,405	
Q18	A	1	4,267	,156	3,958	4,576	
		2	3,333	,249	2,840	3,827	
	B	1	4,167	,156	3,858	4,476	
		2	2,900	,249	2,406	3,394	
	C	1	3,767	,156	3,458	4,076	
		2	3,467	,249	2,973	3,960	
	D	1	3,767	,156	3,458	4,076	
		2	3,500	,249	3,006	3,994	
Q19	A	1	2,367	,183	2,005	2,728	
		2	1,867	,158	1,553	2,180	
	B	1	2,133	,183	1,772	2,495	
		2	2,000	,158	1,686	2,314	
	C	1	2,200	,183	1,838	2,562	
		2	1,933	,158	1,620	2,247	
	D	1	2,200	,183	1,838	2,562	
		2	2,067	,158	1,753	2,380	
Q20	A	1	3,900	,170	3,563	4,237	
		2	4,100	,144	3,815	4,385	
	B	1	3,800	,170	3,463	4,137	
		2	4,100	,144	3,815	4,385	
	C	1	3,467	,170	3,130	3,804	
		2	3,867	,144	3,582	4,151	
	D	1	3,733	,170	3,396	4,070	
		2	3,967	,144	3,682	4,251	

Table E19. Pair Sample Tests

		Paired Samples Test						t	df	Sig. (2-tailed)
		Paired Differences								
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
					Lower	Upper				
Pair 1	Q1A - Q1B	-,08	,588	,054	-,19	,02	-1,552	119	,123	
Pair 2	Q2A - Q2B	-,08	,380	,035	-,15	-,01	-2,403	119	,018	
Pair 3	Q3A - Q3B	-,23	,837	,076	-,38	-,08	-3,052	119	,003	
Pair 4	Q4A - Q4B	-,18	,698	,064	-,31	-,06	-2,878	119	,005	
Pair 5	Q5A - Q5B	-,24	,870	,079	-,40	-,08	-3,044	119	,003	
Pair 6	Q6A - Q6B	-,19	,748	,068	-,33	-,06	-2,807	119	,006	
Pair 7	Q7A - Q7B	-,45	1,201	,110	-,67	-,23	-4,104	119	,000	
Pair 8	Q8A - Q8B	-,28	,891	,081	-,44	-,12	-3,485	119	,001	
Pair 9	Q9A - Q9B	-,23	,884	,081	-,38	-,07	-2,789	119	,006	
Pair 10	Q10A - Q10B	-,07	,695	,063	-,19	,06	-1,051	119	,295	
Pair 11	Q11A - Q11B	-,09	,860	,078	-,25	,06	-1,168	119	,245	
Pair 12	Q12A - Q12B	,43	1,221	,111	,20	,65	3,814	119	,000	
Pair 13	Q13A - Q13B	-,32	1,145	,105	-,52	-,11	-3,030	119	,003	
Pair 14	Q14A - Q14B	-,37	1,100	,100	-,57	-,17	-3,653	119	,000	
Pair 15	Q15A - Q15B	,56	1,587	,145	,27	,85	3,855	119	,000	
Pair 16	Q16A - Q16B	-,36	,960	,088	-,53	-,18	-4,090	119	,000	
Pair 17	Q17A - Q17B	-,12	,663	,061	-,24	,00	-1,927	119	,056	
Pair 18	Q18A - Q18B	,69	1,781	,163	,37	1,01	4,254	119	,000	
Pair 19	Q19A - Q19B	,26	1,041	,095	,07	,45	2,718	119	,008	
Pair 20	Q20A - Q20B	-,28	,963	,088	-,46	-,11	-3,223	119	,002	

Appendix F. Checklist for Observer (Incident Officer-IO)

(1) Arrival Time of IO : _____ hrs(announcement)

- ☐ inform STC of arrival at _____ hrs.
- ☐ inspect the site / damage at _____ hrs.
- ☐ set up ICP at _____ hrs.
- ☐ locate IE at _____ hrs.
- ☐ OHL _____ isolation required ? _____
- ☐ earthing required? _____
- ☐ PTW required? _____
- ☐ establish communication with STC at _____ hrs.
- ☐ establish communication with IE at _____ hrs.
- ☐ agree boundary with STC at _____ hrs.
- ☐ notify with IE the worksite limit at _____ hrs.
- ☐ arrange protection at _____ hrs.
- ☐ appoint IOA at _____ hrs.
- ☐ appoint PCO at _____ hrs.
- ☐ appoint LO at _____ hrs.

(2) Traffic Arrangement

- ☐ request for supplementary bus at _____ hrs.
- ☐ detrainment necessary? at _____ hrs.
- ☐ arrange special working of train
 - Single Line Working by signals at _____ hrs.
 - Single Line Working by Pilotman at _____ hrs.
 - Absolute Block Shuttle Train Working at _____ hrs.
 - Temporary Block Post Working at _____ hrs.
 - Shuttle train service : _____ & _____ & _____
- ☐ call for assisting locomotive at _____ hrs.

(3) Manpower Deployment

- ☐ summon station staff at _____ hrs.
- ☐ IOA ☐ PCO ☐ Bus Service Coordinator

- ☐ LO ☐ other station staff, how many ? _____ from _____

briefing on tasks :

(4) Emergency Service

- ☐ summon Police at _____ hrs.
☐ summon Fire Service at _____ hrs.
☐ summon Ambulance at _____ hrs.

(5) Handover

Yes/No - action plan Yes/No - IE's name & location
 Yes/No - boundary limit Yes/No - engineering train/loco.
 Yes/No - emergency services Yes/No - train service arrangement

Others :

(6) Termination

- Yes/No confirm with IE of completion of work
 Yes/No confirm all workers clear from track at _____ hrs.
 Yes/No confirm all emergency services personnel clear from track
☐ conduct line clear at _____ hrs.
☐ surrender the emergency possession at _____ hrs.

Overall Comments

1. Response

- Areas done well

-
- Areas required for improvement

2. Site Control

- Areas done well

- Areas required for improvement

3. Deployment of Manpower

- Areas done well

- Areas required for improvement

4. Train Service/Train Movement

- Areas done well

-
-
- Areas required for improvement

5. Communication

- Areas done well

-
-
-
- Areas required for improvement

6. Arrangement Leading to Service Resumption

- Areas done well

-
-
-
- Areas required for improvement

7. Other comments

- Areas done well

- Areas required for improvement

Table F1
Assessing Report for West Rail Train Fire Drill

Observations

				West Rail Drill-Train Fire in Tai Lam Tu	East Rail Drill-Train Fire in Beacon Hill Tun	Lesson Learnt	Follow-up Actions		
West Rail Control Centre	Immediate Actions	Communications	List of communication facilities	Observations	Team cohesiveness	Observations	Team cohesiveness	(1) ER IO and IE should adopt "readback message" for safety critical instructions. (2) DSS is effective in incident handling. (3) IO and Ie members shall use standard radio callsigns in communication. (4) IE and IO members should not use mobile phones for communications in incidents. (5) Tunnel ventilation system shall be provided for East Rail Beacon Hill Tunnel. (6) CRM training is nrecommended for East Rail train crew.	(1) East Rail operations implemented "radio readback message campaign" in April 2006. (2) East Rail conducted human factor studies for train crew in June 2006. (3) East Rail Beacon Hill Tunnel is equipped with tunnel ventilation system and commissioning in April 2007. (4) East Rail control system will be equipped with DSS features. (5) Four classes CRM training had been provided for East Rail train crew in February-March 2007. (6) East Rail radio network will be enhanced with better assignment of talkgroups. (7) Subsequent to commissioning of East Rail tunnel ventilation system, a train fire drill had been done in Beacon Hill Tunnel on 18 April 2007. The result is encouraging. CRM training is effective for team building, decision making and communication of train crew.
STC	Declare "Emergency" and deliver verbal instructions for TC,CO, DE,PR. Use hotline telephones to contact Transport Department (TD), Fire Services Department (FSD) and Police Department (PD).	Verbal instructions, radiophones, telephones.	Decision Support System (DSS) delivers checklist-based standard operating instructions according to area of responsibilities (AOR) of users, e.g. AOR defaulted to STC.	Immediate response. DSS provides on checklist according to incident scenarios.	(1) IO and IE members used radio talkgroup "Emergency channel 1" for train crew and "Emergency channel 2" for maintenance crew. (2)Train crew and maintenance used standard callsigns for radio communications.(3) Train crew and maintenance crew adopted readback message on safety critical commands. (4) IO and IE members worked cohesively as a team. (5) Single point of contact between STC, IO and IE.	(1) Immediate response. (2) No DSS in East Rail. STC executed instructions according to hardcopy rule books. (3) There is no tunnel ventilation system in East Rail Beacon Hill Tunnel.	(1) IO and IE members use operation channels for train crew and maintenance channels for maintenance crew. There is no dedicated emergency channels assigned for emergency communications. (2) Train crew used non standard callsigns for radio communications. (3) Maintenance crew often used mobile phones for communications which had no communication records on radio and telephone recorders.(4) IE and IO members did not adopt readback message on safety critical commands which delayed execution of		
TC	Train regulation according to STC's instructions, maintain radio communications with incident train drivers and other trainn drivers by individual calls, group calls, zone calls and all calls.	Radiophones, telephones.	AOR defaulted to TC						
CO	Despatch pager messages, multi FAX and long line announcements to stations and on call engineering officers	Pager messages, long line public address system, telephones, FAX.	AOR defaulted to CO						
DE-FRC	Execute STC's instructions and report incident to maintenance depots and maintenance managers.	Radiophones, telephones.	AOR defaulted to DE						
PE	Execute STC's instructions and arrange electrical emergency isolation/activation of tunnel ventilation system.	Radiophones, telephones.	AOR defaulted to PR						
Station Controller	Execute STC's instruction. Turn on tunnel evacuation lighting, set up incident control point (ICP) and execute manpower backup plan	Verbal instructions, radiophones, telephones.	AOR defaulted to SC						
Incident Officer (IO)	Operations incharge at ICP	Verbal instructions, radiophones, telephones.	Use radiophones and telephones to maintain communications with STC, IE, FSD and police.						
Incident Officer Assistant (IOA)	Operations incharge assistant at ICP	Verbal instructions, radiophones,	Assist IO to communicate with STC, IE, FSD and police.						
Incident Engineer (IE)	On call officer reports to ICP and takeover incident control from IEA	Verbal instructions, radiophones, telephones.	Use radiophones and telephones to maintain communications with IO, STC, DE and PR.						
Incident Engineer Assistant (IEA)	Report to ICP as engineer incharge.	Verbal instructions, radiophones,	Assist IE to communicate with IO, STC, DE and PR.						

Comments on communication

Other comments

Roles and responsibilities

STC- Senior Traffic Controller is the overall shift incharge for train operations in operations control centre (OCC)
CO- Communication Officer is the assistant of STC for broadcasting long line announcements. Under "Emergency" situation, CO is the person distributing information to the concerned parties via multi FAX, pager messages, messages to mobile phones etc.
TC- Traffic Controllers is one the duty traffic controllers to regulate train traffic for a particular zone.
DE- Duty signal and telecommunication engineer on duty in OCC fault reporting centre.
PR-Power Regulator, supervisory control overhead power line and tunnel ventilation system.
SC - Station Controller is the duty shift incharge of station operations of a particular station.
IO - The designated station officer assigned by duty SC to take up the coordination functions in the event of a "Emergency" incident.
IOA- The designated station officer assigned by duty SC to support IO in the event of a declare "Emergency" incident.
SM - Station Manager is the administrator of several stations according to geographical locations. SM is the SIO for major "Emergency" incidents if the level of commend is transferred from IO.
ITD - Incident Train Driver is the train driver sitting in the front cab of on the incident train.
IE-Incident Engineer (IE) - on call incident engineer, he is the commander of engineering functions when "Emergency" is declared by STC
Incident Engineer Assistant (IOA) - duty signal maintenance incharge, he is the first person arrive on incident site for corrective maintenance.
SIE- On call manager. He is the commander of engineering functions for major declare Emergency" incidents if recovery time is greater than two hours. SIE is the commander of "Emergency" incidents if the level of control is transferred from IE.

Notification Arrangements

The STC shall notify the Emergency Transport Coordination Centre(ETCC) of Transport Department within 8 minutes of:-
A railway incident which causes disruption to mainline train service has lasted or is expected to last for 8 minutes or more; or
A railway incident which has caused an extended journey time to a series of two or more trains on any line for 8 minutes or more.

Amber Alert/Red Alert is the alert system established by the Transport Department, Hong Kong.

Amber Alert-An early warning in respect of an incident, which could lead to a serious disruption of service. A serious disruption of service means a reduction in the capacity of any line by 20% during the peak hours or an unplanned station closure due to such events as flooding, police action, etc.

Red Alert-A signal to indicate that a serious disruption has continued or is expected to continue for over 20 minutes, and emergency transport support services from other operators are

Appendix G1. KCRC Annual Report 2006

TRANSPORT OPERATIONS

I am pleased to report that patronage continued to rise and operating costs are being kept under tight control during the year. In 2006 the Corporation took 16.4% of the domestic public transport market, up 0.3% from 2005. Moreover, whilst the franchised public transport market as a whole grew only by some 1.7% in 2006, the Corporation's patronage grew by 3.7%.

East Rail together with the Ma On Shan and Tsim Sha Tsui extensions saw domestic patronage grow by 3.2%, reaching over 700,000 per day in the last months of the year. This strong result reflects the popularity of our services, which serve a long-established catchment and fairly stable population. Ma On Shan Rail usage alone grew to 120,000 per day, representing an increase of 17.5% over 2005.

Since its opening in December 2003, West Rail has become the backbone of the Corporation's transport services in the Transit Service Area, embracing the Tuen Mun, Yuen Long and Tin Shui Wai new towns. West Rail performed well in 2006, showing a healthy growth of patronage

and revenue. Average daily patronage increased by 11.7%, resulting in excess of 200,000 passenger trips per day. In three years of service, West Rail patronage has grown by 100% from the number at opening.

“ Moreover, whilst the franchised public transport market as a whole grew only by some 1.7% in 2006, the Corporation's patronage grew by 3.7%. ”

Average daily patronage over the Transit Service Area increased by some 3.1%, with Light Rail patronage being supplemented by increased patronage on West Rail and KCRC buses. Light Rail and KCRC bus services provide an increasingly popular service for local travel journeys within the new towns and convenient feeder services to West Rail stations for onward longer distance travel between towns or to the urban area. Very heavy peak demand at some locations is being addressed by route improvements intended to maximise the whole design capacity of the available light rail fleet.

AVERAGE DAILY RIDERSHIP

(passenger trips)	2006	2005	% Increase
East Rail domestic service*			
(including Ma On Shan Rail)	677,000	656,200	3.2%
East Rail cross-boundary service* (to Lo Wu)	241,000	235,500	2.3%
Intercity Through Train service	8,970	8,520	5.3%
West Rail service	200,100	179,200	11.7%
Light Rail service	373,800	373,000	0.2%
Bus service (excluding East Rail buses)	82,400	74,600	10.5%
Total average daily passenger trips	1,583,270	1,527,020	3.7%

* Average daily Ma On Shan Rail usage in 2006 was 119,800, which included passengers travelling within Ma On Shan Rail and passengers travelling between Ma On Shan Rail and all other stations including Lo Wu.

Appendix G2. KCRC Annual Report 2006

TRANSPORT

574 MILLION
passenger trips in 2006

3.3 MILLION
Through Train passenger trips
in 2006

677,000 PASSENGERS
a day – East Rail domestic

241,000 PASSENGERS
a day – East Rail cross-boundary

200,100 PASSENGERS
a day on West Rail

373,800 PASSENGERS
a day on Light Rail

82,400 RIDES
on our buses each day

ON TIME
99.82% East Rail

ON TIME
99.94%
Ma On Shan Rail

ON TIME
99.88% West Rail

TRANSPORT

KCRC operates a world-class passenger railway, which has served the people of Hong Kong for 96 years. As with the staff in other divisions, the staff of the Transport Division are meeting new challenges and preparing for the changes that lie ahead.



Appendix G3. KCRC Annual Report 2006

SERVICE PERFORMANCE

	East Rail		Ma On Shan Rail		West Rail	
	2005	2006	2005	2006	2005	2006
Service delivery*	99.84%	99.85%	99.94%	99.95%	99.82%	99.91%
Punctuality*	99.82%	99.82%	99.92%	99.94%	99.76%	99.88%
Availability of ticket vending machines*	99.56%	99.60%	99.83%	99.82%	99.88%	99.93%
Availability of Octopus equipment*	99.93%	99.90%	99.92%	99.91%	99.95%	99.97%
Reliability : million car-km per failure	0.81	0.87	0.87	2.69	1.91	2.70

* 2006 service targets – 99.0%



Quality customer service – a high priority for KCRC

Appendix H. Additional Figures and Movies in CDROM

Additional pictures and movies related to actual training and emergency drill exercises are attached in the enclosed CD-ROM.