Paper presented at the 15th International Symposium of Aviation Psychology. Dayton/OH, April 27-30, 2009.

ADAPTATION OF CRM TRAINING FOR THE RAILWAY INDUSTRY OPERATIONAL SAFETY BENEFITS

Matthew T.S. Tsang
Kowloon Canton Railway Cooperation (KCRC)
Hong Kong, China

Hans-Juergen Hoermann
German Aerospace Center (DLR)
Hamburg, Germany

In aviation, Crew Resource Management (CRM) was developed to address safety issues derived from accident and incident investigations. As CRM has proven its effectiveness by improving teamwork, communication and staff responses to operational hazards, there have been many attempts to expand this concept into other high-risk sectors such as medical, nuclear, or military. Although some work was also conducted to modify CRM for the railway industry, no such experiences yet existed in China or Hong Kong. Having observed the effectiveness of CRM and Line Oriented Training (LOT) in aviation, this paper documents the introduction and initial evaluation of CRM and LOT in Hong Kong in the West Rail (WR) division of the Kowloon-Canton Railway Corporation (KCRC). Results of an initial evaluation study with 120 operative crewmembers provide empirical support for the chosen approach.

Recent world headline disasters such as the September 11 attacks, 2005 London transport bombings, and 2003 Daegu subway arson attacks sent explicit warnings to all nations that mass-transit systems can and do become luscious targets of 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 have a huge influence on its outcome. Since railway and aviation industries share many similar characteristics and vulnerabilities, transferring training strategies for flight crews into the railway industry may be advantageous in developing better training and safety programs for train drivers and traffic controllers. A CRM oriented program for operative train crews could improve performance in managing threats and errors, reducing the consequences of eventual emergencies in the railway sector (Morgan, Olson, Kyte, Roop, 2007; Dedale, 2006).

Human Factors Issues Encountered in the Railway Industry

Railway technology has gone a long way to identify which trains are on the track and controlling their progress and whereabouts by keeping safe but efficient train to train separations, and managing communications between trains and the operations control centre (Wilson, Norris, Clarke & Mills, 2005). However, train operations communications studies showed that the design, implementation and operation of train operations communication 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, 2004). The reliance on control automation during normal operations may mean that when manual control is demanded the crews and drivers task performance have decreased efficiency. After a long period of smooth normal train operations with increased levels of automation, traffic controllers or train drivers could become less efficient in manual control under degraded train operations due to lack of exposure. This was demonstrated by brief survey of railway stakeholders in the UK (Wilson & Norris, 2005), in which 80% of the experts agreed that experience erosion is a potential safety issue.

Lessons learned in railway industries consistently demonstrate failures in organizational and human performance factors as being causal or contributory to accidents, prompting the RSSB (2006-2007) to list major needs and recommendations in safety, many of which can be satisfied by the more interactive and effective styles provided by CRM and LOT training:

- Introduction of structured refresher trainings for train crew;
- Improved co-ordination between train crews, station controllers and traffic controllers for manpower back-up;
- Emphasis on interactive training in Standard Operating Procedures (SOP's);
- Optimisation of training costs by using e-learning, computer-based training (CBT), integrated training facilities (ITF);
- Assess effectiveness of using a decision support system (DSS) to support train crews in coping with emergencies;
- Develop self-learning portals for train crews;
- More efficiency in training time, type-rating tests for train drivers, station controllers and traffic controller train crews due to job rotation.

Superseding the conventional training courses, CRM and LOT type of training in the railway industry could provide a more interactive and more effective environment for learning.

Methods

Drivers, station and traffic controllers from the West Rail (WR) division of the Kowloon-Canton Railway Corporation (KCRC) 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 other safety related concepts in a series of workshops, experiential learning, role plays, video exercises, case studies, discussion groups, team building exercises and social and leisure activities (Tsang, 2007). ITF is a centralized training facility that links the main control system simulator, the train control and signaling system simulator and the cab simulator in a networked, integrated team-training environment. It was used in LOT programs to simulate emergency and abnormal operation scenarios to test and train the ability of teams to efficiently handle such situations. Feedback was provided by computer, video and voice records, as well as CRM/LOT trainer debriefings. An attitude survey was administered to provide pre- and post-training scores, to track changes in safety related attitudes attributable to the training. In addition, a non-CRM trained control group was available, which provided performance data during an emergency drill as compared to the CRM trained group (Tsang, 2007).

Personal Attributes of the Trainees

The trainee population consists of 120 participants: 80 train drivers, which is 80% of West Rail working population (KCRC, 2005); 20 station controllers (60% of WR population), 20 traffic controllers (60% of WR population). The male to female ratio is 1:0.15, which is representative of the overall employee population. Trainees were divided into four groups of 30 members based upon age, education background and years of experience in the railway industry. Participants who satisfied any of the 3 factors listed in table 1 were accepted into the respective group, prioritizing from group A to D. Therefore, if a participant fitted multiple categories they were accepted into the higher ranked group.

Table 1. *Criteria for sorting participants into groups.*

Group qualification criteria	Age (years)	*or*	Highest Education Qualification	*or*	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

CRM Training Program

Five designated CRM-trainers first underwent a CRM class instructor course before they facilitated 4 sessions of three-day CRM programs for the operating train crews. The CRM program used for the KCRC covered the following methods and activities: (see Tsang, 2007 for further details).

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

The training was further supported by automated facilities including integrated training facilities (ITF), computer based training (CBT) and a decision support system (DSS).

Results

Evaluation of Changes in Safety Attitudes

Before and after CRM training, train crews were asked to fill out an attitude survey on safety climate consisting of 20 questions focusing on safety awareness and safety practices in the organization to gain indications on whether there have been changes in safety attitudes. T-Tests for paired samples were used to compare each item pre and post for all 120 subjects and multivariate Analysis of Variance (MANOVA) with one between subject factor (Group) and one within subject factor (pre and post CRM) was conducted. The subjects showed generally stronger team working attitudes after training. There is a strong within subject effect for the attitude items ($F = 11.28$, $p < .001$). All changes were in the desired safety related direction. There was only a small between subject (group) effect ($F = 1.42$, $p < .05$) and no interaction of both. The attitude questionnaire showed positive changes of safety attitudes of the trained subjects after training. After the CRM training crews displayed an increase in safety oriented attitudes probably because of the new concept of CRM was stimulating new ideas in their way of thinking. This indicated that CRM was able to introduce the safety critical concepts and ways of thinking that crews should adopt in their day to day roles.

Performance Observations from Drills

Another test of training effectiveness was conducted during an emergency drill (fire inside tunnel drill) at East Rail Beacon Hill Tunnel (2.75 km in length) and West Rail Tai Lam Tunnel (5.5 km in length) in conjunction with the Hong Kong police, fire and hospital services by comparison of a CRM-untrained control group and a CRM-trained group. An observer panel scored behaviours of the two groups. It was reported to display better incident handling capabilities, stronger teamwork and communication skills throughout the exercise. They were also 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. Overall, the train crew who attended CRM training worked more cohesively as a team, maintained stronger situation awareness and adopted "readback message" as double confirmation before execution of safety critical commands as compared to the CRM-untrained control group. The use of accident scenarios to evaluate CRM training effects had been used similarly before for air traffic controllers (Andersen & Bove, 2000).

Post Training Feedback

Feedback was obtained with a specific course feedback questionnaire regarding the relevance, interest, standards of teaching, exercises, videos and course exercises from all 120 train crews who participated in the course. Feedback was generally positive, and participants showed the desire for a longer course to help consolidate concepts. Overall, the CRM courses were well-accepted by the course participants and management. Based on these post course survey results, increased management attention had emerged at corporate level to provide more teambuilding workshops, more consultancy studies on human factors aspects such as fatigue awareness and safety awareness training for all levels of KCRC staff in 2007.

Workplace Performance

Tangible evidences of success were observed from train services achievements in 2005 and 2006 (KCRC, 2006, 2007a). 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 method involved a six months workplace performance summary report feedback from the General Manager of West Rail Operations Department (KCRC 2006, 2007a, 2007b). The items in this survey included:

- Immediate results: Computer records from ITF interactive responses
- Performance results: Ride checks and workplace performance audits
- Overall performance results of West Rail (accident rate)
- Complaint and Commendation letters from the customers
- CRM and computer-based training (CBT) computer records;
- Train "Black box" data and ride checks by train crew inspectors to monitor train drivers performance.

A Real Challenge

On 14 February 2007, a train fire occurred inside West Rail Tai Lam tunnel. Due to effective teamwork in incident handling, 800 passengers evacuated from the incident train to the nearest station from the tunnel within 20 minutes with no injuries reported. Train services had recovered 221 minutes after the outbreak. Most of the train crew in this incident were participants of the prior CRM training. The train crew team received commendations from the CEO of the Hong Kong Special Administrative Region government.

Post CRM Training Observations.

Some points of interests have also been noted in this research that may hold relevance for further studies. Firstly, train crews 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 (Tsang, 2007). Therefore, it is probably of benefit to 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. Observations and reports also revealed 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, making them ideal candidates at the Incident Control Point (ICP) to observe and report to internal and external parties of any incidents. Train crew with a better education background and qualifications (see table 1) displayed better cognitive skills to deal with the human machine interface. This may be due to their prior familiarity with computerized 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 other KCRC railway lines such that they are able to draw upon the experiences and knowledge from West Rail. The VAT can now be accessed through KCRC intranet, serving as an effective tool to refresh and aid crew in regularly refreshing learnt concepts after the training.

Discussion and Conclusions

The KCRC CRM programme was designed to introduce models of effective CRM behaviours. Such positive CRM models allowed the crews to engage in role-playing exercises during which such behaviours were practiced, and provided feedback to the crews with respect to their performance. As a result of the training and team building exercises, there is now increased synergy between crew members and most can work better and more effectively as a team. Radio communication quality had increased amongst West Rail members compared to other CRM-untrained KCRC divisions. Trainees' concepts of team coordination have been reinforced as reflected in the post training questionnaire and also on-the-job performance involving communication and coordination between train drivers, station controllers and traffic, better incident handling and the ability to reduce operational impacts due to equipment failure.

Therefore, this development and implementation of the CRM program in KCRC represents a significant example of team performance research being translated into practice in 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, and the existing CBT, VAT, DSS and ITF facilities were all found to be valuable to achieving training objectives. Equally important, integrated training based on CRM and LOT will help to narrow if not bridge the gap between the performance of experienced and inexperienced, as well as highly educated versus fairly educated employees.

From the organizational point of view, the implementation of CRM has put the focus on expecting better performance. There is an explicit tendency of working towards a higher level of safety and risk awareness in KCRC work culture, as well a higher standard of occupational safety and health at the workplace. The adaptation of CRM concepts signify a new era in the KCRC training philosophy, and it is expected that more scenario-based training under the platform of CRM will soon be evolving and emerging. Positive results and commendations of teams trained by CRM resulted in increased commitment from senior management to such applications with the commitment of increasing the safety level and confidence in service reliability to the stakeholders.

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 realization to various incidents and the efficiency of team work as a whole. Although the adoption of CRM training in KCRC is still in its infancy, it is too early at this stage to draw a definitive conclusion of how successful it will be in the long run. However, with results demonstrated so far across a variety of measured and real life performance indicators, the training had help to satisfy the safety centric needs demanded in modern railways and hopefully improving human performance when emergency situations do arise.

References

Andersen, V. & Bove, T. (2000). A feasibility study of the use of incidents and accidents reports to evaluation effects of team resource management in air traffic control, *Safety Science, 35*, 87-94.

Dedale Asia Pacific (2006). *National rail resource management project: Review of best practice implementation issues and task analysis.* Interim Report. Dedale: Albert/VIC, March 2006.

KCRC (2006). *KCRC West Rail Performance Report 2005*. KCRC: Hong Kong.

KCRC (2007a). *KCRC West Rail Performance Report 2006*. KCRC: Hong Kong.

KCRC (2007b) *KCRC Annual Report 2006* (pp 23-30). KCRC: Hong Kong.

Morgan, C.A., Olson, L.E., Kyte, T.B. & Roop S.S. (2007). *Railroad crew resource management (CRM): Pilot rail CRM training development and implementation.* Final report. US DOT, Federal Railway Administration. DOT/FRA/ORD-07/03.

RSSB (2006). *Understanding human factors – a guide for the railway industry.* CD ROM – Rail Safety and Standards Board: UK.

RSSB (2007). *Annual safety performance report.* Rail Safety and Standards Board: UK.

Tsang, M.T.S. (2007). *Rail human factor training: Adaptation of Crew Resource Training in KCRC to enhance modern railway safety*. Master thesis. Massey University: Auckland/NZ.

Wilson, J. & Norris, B. (2005). Rail human factor: Past, present and future, *Applied Ergonomics, 36*, 649-660.

Wilson, J., Norris, B., Clarke, T. & Mills, A. (2005): *Rail Human Factors Supporting the Integrated Railway*, Ashgate, USA, 3-19, 41-50, 309, 319-331, 93-405.

Wright, M. Turner, D., Antonelli, A. & Bendig, M. (2004). The impact of experience erosion on safety *Final Report for RSSB* 20-T153-GSBI-55-TRT, RSSB UK.