Integrated computer based training facility - a new approach to enhancing railway operational training

S.F.Y. Cheung\textsuperscript{a}, P. Anderson\textsuperscript{b}
\textsuperscript{a}Hong Kong Mass Transit Railway Corporation, 8 Wang Hoi Road, 17/F Chevalier Centre, Kowloon Bay, Hong Kong
\textsuperscript{b}Transport Management Group International, 1911 Telford House, 16 Wang Hoi Road, Kowloon Bay, Hong Kong

Abstract

Rapid changes in operational training requirements, coupled with advancements in computer simulation technology, has seen the development of standalone operational training simulators for railways. While effective, recent investigations have shown the need to train railway operating teams more effectively. The first part of this paper outlines methods for developing the training needs for an integrated operational training facility which incorporates; station control, central control and driving cab simulators into one combined unit. The second part of the paper proposes a conceptual system design and concludes with a challenge to industry to improve integration.

1. Introduction

Training of station, central control room and train operations staff has long been recognised as essential to the safe operation of a railway. Traditionally, these training courses have focused on the operational, technical skills and knowledge related to the equipment and systems for which they are responsible. The training for operators typically comprises a combination of tailor-made class room courses, together with on-the-job training, which integrates the skills learned with the real environment.

Over the past 10 to 15 years many railway organisations have invested large sums of money in train driving cab simulators to supplement the conventional training methods\textsuperscript{[1,2]}. While this may have been for reasons of efficiency or
because of rolling stock availability, it is now a well established method of conducting the initial and refresher training for train crews.

These simulators allow new recruits and experienced operators to practise their analysis and decision making skills on a wide range of situations in a controlled environment. This approach is particularly effective in training operators who need to handle emergency situations, which occur infrequently and because of logistics and expense cannot be done using the real equipment.

On the Hong Kong Mass Transit Railway the central and station control room staff are now being trained on computer based training simulators. It is anticipated that the trend to use simulators in all operational areas will continue, particularly as control rooms move from push button control panel technology to computer control.

However, there is a high cost associated with designing this type of training facility, which therefore necessitates careful analysis to ensure that only essential requirements are specified. Part of this analysis is the selection of major incidents and disasters that have occurred in industry as a consequence of deficiencies in communications, teamwork and procedures training. From the list of accidents like the Clapham Junction railway accident, Kings Cross Underground fire, Chernobyl nuclear reactor melt down, the Bhopal toxic chemical discharge and the Challenger Space Shuttle explosion, it was noted that communications and the failure to follow procedures for handling technical defects were major contributing factors in all of these disasters.

As a follow up to the review of the various accident reports, the training methods and facilities currently in use were assessed. It was noted that the focus of training is on the individual competence not team competence, which is most required during incidents. Therefore, a decision was taken to enhance both training methodologies and facilities and to increase the amount of team training given to operators, thereby providing a clearer focus on team competence rather than just individual competence. This paper introduces the concept of the ‘Integrated Operational Training Facility’ (IOTF) as a means of achieving the ‘Team Training’ objective.

2. Training Requirements

As the IOTF is aimed at enhancing team training for railway operators, it is essential to understand how the team work together and their training requirements. It is also important to note that it may not be necessary or practical to use the IOTF for all aspects of their tasks, as some of the team tasks may be more effectively trained by conventional class room and on-the-job training techniques. As such, the IOTF is not required to simulate 100% of the possible situations.
To identify the operational practices of the team, their training requirements and the degree of simulation required for such training, the following steps are recommended:

a) Analyse the Roles and Responsibility of the key job holders namely station operators, train operators and central control room operators. Job descriptions and specifications will provide valuable information on the roles and responsibilities of the operators, however, this information needs to be verified with the job holder and supervisor. The Hierarchical Task Analysis (HTA) technique \cite{HTA} is a useful method for more detailed analysis of the actual task performed by an individual. Figure 1. shows a typical HTA for a Traffic Controller in the central control room.

b) Analyse the rules and procedures that govern their work practice, communication process and decision making processes.

c) Conduct a communication analysis showing the information flows and other interactive behavior during the normal and emergency operational situations. Figure 2 shows the communications channels between two traffic controllers operating on two separate lines during the morning peak hour. Line 1 is operating normally, whereas Line 2 is disrupted.

d) Determine the desired competence and actual competence of the current jobholders, as well as future new recruits.

e) Analyse incident and accident reports to collect information that could be developed into training scenarios.

f) Analyse the capability of existing training equipment and simulators in terms of their ability to be integrated.

g) Assessing the receptiveness of trainers and trainees with respect to the use of technology in training.

h) Ascertain the availability of resources including money and space for the new facility.

Roles, responsibility and task analysis provide a comprehensive list of tasks, knowledge and skill required by the key operators in carrying out their jobs successfully. It also provides information on the relationships between tasks and people. The rules and procedures define the boundary and integration of the various tasks and specify the authority limit of the operators. They also indicate the application of knowledge and skill as well as the flow and line of
Figure 1. Task Analysis

Figure 2. Communications Analysis (Two-line operation with a signal failure on Line 2 during the morning peak).
communications. The rules and procedures also define the ideal operational method and procedures. The communications analysis conducted at the workplace is essential for ascertaining the way the operators communicate in a real situation. In addition, the information is useful in understanding how the operators interact as a team and the way they influence each other in decision making.

The degree of compliance with the rules and procedures by the operators has been shown to vary considerably during incidents because of the behaviour of operators in real-life stressful situations. Hence, their behavioural and communication patterns under normal and emergency situations need to be analysed in both circumstances by observation during normal operations, as well as emergency simulations in the workplace and data from post incident reports. This analysis also provides valuable information on their verbal and non-verbal behaviour, their level of competence and compliance, their workload, as well as their level of stress which are also useful input for designing training for them.

For the purpose of training needs analysis and performance evaluation, it is essential to determine the required competence levels of the various jobs. By finding the gap between the performance level of the jobholders and the predetermined competence levels, the training needs are identified for designing training curriculum and facilities.

Finally, the capability of the existing training equipment and simulators, the trainer’s and trainees ability to use computer-aided training programmes and the availability of resources do have an effect on the final choice of technology and degree of simulation and integration, so they must be considered.

Having analysed the training needs and determined the need to enhance teamwork training between operators, the remainder of the paper will focus on the conceptual system design and functional requirements for an Integrated Operational Training Facility.

3. System Design

a) Existing Systems

The main weaknesses in the current range of simulators available in the market is that they are custom made standalone units, which are built to a diverse range of standards. Hence the compatibility between simulators from different suppliers is low, with no apparent industry standards emerging.

The other problem is that simulators are often specified as part of a
new system, and built by contractors who only see a small part of the overall training facilities, so integration of simulators is further complicated. While the technology is available, the system design is not.

b) Future Direction

At a system level, a certain degree of compatibility can be achieved by the adoption of hardware and software standards for workstations, programing language, authoring tools and networking. While it is recognised that the application software must emulate, as close as possible to the real system, more could be done by railway operators to develop common standards and specifications aimed at improving compatibility between systems.

c) Conceptual Design of an Integrated Operational Training Facility

![Conceptual Design of an Integrated Operational Training Facility](image)

Figure 3. Conceptual Design of an Integrated Operational Training Facility
A functional description of the six main IOTF modules is given below:

1. Train Driving Cab Simulator
2. Station Control Simulator
3. Central Control Simulator
4. Simulator Integration
5. Debriefing Facilities
6. Access to Real-time Information

**Train Driving Cab Simulator**
The Cab Simulator of the future will be required to replicate and model the performance and environment of the driving cab. Features will include modelling of the; automatic train control, interactive speed driver controls, braking reaction (service and emergency), train borne public address, train radio and door controls and other train controls and indications found in the cab.

Through the front windows of the cab the trainee can expect a high resolution video animation of the actual route with the system being capable of storing views of all lines, sidings and depot tracks, at least on railways of less than 100 kilometres in length. The video animation shall be capable of providing views of different operating conditions e.g. crowded platforms, attempted suicide as train enters platform, typhoon conditions etc. Outside the cab, the trainee could expect to be presented with a section of the platform, the headwall and where used platform screen doors. Train regulation indicators, line side signals, count down to departure clocks and CCTV monitors are also essential to improving integrated training.

The train movement simulation shall be synchronized with the audible simulator so that the sound effects are realistic. However, actual movement simulation, like that used in the aircraft industry training simulators, is not envisaged due to the cost of provision.

**Station Control Room Simulators**
In most railways, station control simulators are the least developed. Therefore providing a simulator that can model the many station operational systems and communication facilities is seen as an important future development.

This is because Station Control Rooms are growing in complexity and functionality with the introduction of automation technology and reduced staffing levels. This is particularly true in the case of large
underground railway stations where a station controller needs to be familiar with as many as 15 control and indication systems, from signalling to smoke extract. The station controller has the added burden of crowd control during station evacuation in the case of fire or serious disruption to the train service.

Central Control Room Simulator
The CCR simulator is to a large extent a direct copy of the hardware and software provided in the CCR. To simulate the system it is necessary to build a range of scenarios that require the operator to quickly diagnose and respond appropriately. Decisions and actions such as communications within the control room, other transport operators, station and train operators being paramount in the speedy resolution of an incident.

Integration of Simulators
During normal operations the train and station staff have little direct communications. Therefore, training of operations when a station is in local control mode is important. For example, under certain failure modes a Station Controller can issue a command to a Train Driver to pass a signal at danger, set off in the wrong running direction or detrain passengers in the tunnel, all potential hazards if not managed correctly.

This type of integrated training requires each simulator to be connected together and synchronised i.e. signalling and control simulation from the station control room simulator to the driving cab whereby a trainer can initiate a failure scenario which requires the Central Control Room staff to hand over the control to the station controller and train driver to deal with directly. This would require trainer initiated faults in the signalling system to appear in the same location on all three simulators. Communications systems such as train radio, direct line, PABX and CCTV need to be part of each simulator to conduct this type of exercise.

Debriefing Facilities
An individual Trainer Console is required for each simulator, this is located in close proximity to the actual simulator so that the trainer can supervise the training exercises. This console must also be connected to a remote control panel in the debriefing room so that important replay segments can be initiated from a central point during the debriefing session.

The debriefing console must also have the capability of allowing the team training coordinator the ability to select a team training exercise
from a range of pre-stored scenarios. In addition to the capture of input commands from operators, it is necessary to store the trainees actions and voice communications. Automated assessment facilities for the comparison against quantifiable standards such as time to perform a given function are envisaged as part of the IOTF features. This type of automated analysis will enable trainers to have automated analysis of results which can be quickly fed back to operators to enhance learning.

For team training sessions, in which train drivers, central and station control room staff participate, a large debriefing room with full simulation playback facilities including audio visual taping of the trainees undergoing training will facilitate the process of feeding back the learning points to the whole group.

While it is unlikely that the scenarios will be very long for team training exercises, say 20 minutes, it is expected that the team training will focus on known incidents or potential hazards that could potentially occur causing major disruption or injury to passengers.

Access to Real-time Information
Future simulators will incorporate access to information from the actual systems in use on the railway. This is possible by virtue of local area network technology. By using this facility it is envisaged that trainees will be granted access rights to view what is happening out in the system, thus making it possible to look over the shoulder of an experienced operator and play back the stored real-life incidents. In the station control room it is also possible to project real CCTV images from stations to familiarise trainees with crowded situations.

4. Conclusion

The paper concludes that a higher degree of efficiency is expected of railway operators. Investigations into what could improve efficiency have shown that team training could help day to day operations and reduce human error during incidents. To facilitate team training our investigations have shown that a higher degree of integration is required between railway operational simulators to ensure that team training can be implemented in a cost effective manner.

The paper puts forward an outline methodology of how the training needs should be assessed and the type of findings to be expected. Following on from the assessment, the authors have tried to visualise the facilities that may be constructed to enable this type of training to be implemented.
Aided by technological developments it is envisaged that the next ten to fifteen years will see a new generation of simulators that will largely dispense with conventional class room pencil and paper type exercises. This paper is a signal to industry that new thinking is required in the specification and development of new facilities if business and safety objectives are going to be enhanced.

Compared with the aircraft industry the railway industry has been slow to introduce new computer simulator technology. However, cost reductions in the area of computer-aided multimedia technology now promise affordable solutions that have the potential to allow suppliers to build a wide range of interactive and integrated training facilities for the operator.

The idea of recording on close-circuit television the actions of the trainees has been introduced as a means of capturing both the verbal and non-verbal interactions of the team members. These audio and visual signals are an important addition to the training simulation facility, as it will allow the capture of non verbal behaviour and the observation of how participants handle simulated stressful situations. These signs are important to detect during training because if they are left unidentified they may occur on the job and result in human error.

**BIBLIOGRAPHY**


