Development of the Integrated Training Systems for the KCRC West Rail

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Abstract

The Kowloon Canton Railway Corporation (KCRC) of Hong Kong is now building Phase I of the new West Rail (WR) network. Staff training will be crucial to the success of WR operations and maintenance as well as the safe transportation of passengers. KCRC has endorsed a plan to implement an Integrated Training Systems (ITS) for West Rail. The ITS includes a state-of-the-art integrated training facility (ITF) for the integration of cab simulator, train control and signalling system simulator and main control system simulator, and a comprehensive Computer Based Training (CBT) courseware production and delivery system. This paper presents an overview of the WR integrated training system and the technologies envisioned to be adopted in this project. It also discusses the benefits and expected outcomes from the ITF and CBT systems as well as the plans for further development and applications.

1 Introduction

The early railway system simulators including driving cab simulator have been in use for many years. 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 main objective was to train new recruits using simulator to avoid the risk of damaging the real system and in many instances, also for the sake of their personal safety.

Simulators produced in the 70’s or 80’s were not powerful enough to accommodate the highly complicated and dynamic models of the real systems due to the limitation of the “engines” in the simulators. For instance, the cab simulator produced rather simplified viewing objects in the simulation
environment and the trackside graphics produced were also relatively primitive without the necessary fine details for training purpose. The flexibility and the ability to upgrade the systems were also limited, difficult and hence expensive. One more shortfall of these simulators were the very limited integration capability with external equipment.

Computer based training started to be employed by large corporations some ten years ago. This “new” training technique was made practical after the cost of powerful computers came down, while their power has grown exponentially every year. The wide acceptability of using computers in training were also attributed to the benefits of self-pace learning concept and the advantage of all time available on-line help approach in training.

2 Current Technology

Computer technology development in the recent years has dramatically changed the way people learn, the way they work and even the way they live and think. It has likewise fundamentally altered the way organisations are structured, the purpose of management and the manner in which companies relate to their customers. Technology has totally transformed the system in how employees are educated to carry out their work prompting organisations to give them more technology based tools and resources to keep abreast of the ever changing knowledge base.

Today’s technology integrates video, audio and data information through digitisation and compression techniques using the Internet, Intranet, Extranet and off-line media in a cost-effective and universally available approach. This can provide a very powerful learning environment for the development and use of both simulator and computer based training[1].

3 KCRC and West Rail

The Kowloon-Canton Railway Corporation in Hong Kong provides a means of transportation for people commuting between the New Territories and urban Kowloon, as well as passenger and freight services to and from mainland China. The heavy railway (East Rail) being operated by KCRC began service as a single-track operation in 1910; and by 1983, it had been upgraded into a fully electrified, double-tracked service. It now runs on a 34-km track, with 13 stations from Hung Hom to Lo Wu. In addition, KCRC also operates the Light Rail (LR) system that provides a modern and efficient mass transportation service among the fast growing new towns in north-western New Territories. Phase one of the LR system was opened in September 1988 consisting of 23.35 Km of double tracks and 41 stops. The system has expanded by 38% since then, adding to its network extensions of about 8.5km and 10 more stops.

In December 1996, the Hong Kong Government announced that the West Rail Phase I proposed by KCRC be adopted and that KCRC should proceed with the planning and hence construction of the 30.3km West Rail to achieve the scheduled opening date by 2003. KCRC has completed various technical studies
during 1997 and 1998 and began the land resumption programme as well as construction in late 1998. The total cost of the project is estimated to be HK$64 billion. West Rail will be financed by a mix of Government equity, commercial borrowing and KCRC’s internal source of funds.

West Rail Phase I will be a mass rapid transit system providing a safe and efficient means of passenger transport. Figure 1 gives a route map of WR together with an overview of the railway networks in Hong Kong.

![Route Map of West Rail and Overview of railway networks in Hong Kong](image)

Figure 1: Route Map of West Rail and Overview of railway networks in Hong Kong

### 4 Training for West Rail

As a new railway to be built and operated, it is envisaged that the basic grade of the operating and maintenance staff will be new to the industry and very likely with little associated work experience, whilst those at the supervisory and managerial levels will have already spent some years working in the railway environment. The West Rail systems and subsystems as well as the operating and maintenance regime will, however, be new to them.

Staff training will be crucial to the success of the West Rail operation. Every staff member will have to be highly competent in performing their jobs independently and collectively as a team under both normal and abnormal modes of operation.

Operations and maintenance staff will be recruited and trained when West Rail is still in the testing and commissioning stage. This will limit the
availability of trains, tracks, equipment and apparatus for on-the-job hands-on training. Furthermore, the number of staff to be trained will be substantial over a relatively short time window before revenue operation commences.

Subsequently, after the opening of West Rail for revenue services, staff will be required to undergo refresher and/or upgrade training at regular intervals. In addition, changes made to equipment and operating procedures as well as skills practice on analysis and decision making must be accommodated on a wide range of simulated failures and emergency scenarios. This training cannot always be carried out using operational equipment which would cause interruption to the actual operations. Three major training systems that will be operated by WR operation staff are Main Control System Simulator, Train Control and Signalling Simulator and Driving Cab Simulator.

Main Control System (MCS) is to control all the infrastructure facilities of the railway network, such as traction power, tunnel ventilation, lifts and escalators. The MCS simulator provided under the same contract will consist of one trainer and three trainee positions containing all simulation software and hardware necessary to completely emulate all the interfacing systems (i.e. centrally controlled ventilation and traction power supply system and locally controlled station equipment like Station ECS, fire detection system, PA, PIDS, etc.) required to facilitate the training of MCS controllers;

Train Control and Signalling (TC&S) System provides all the important functions such as train protection, train control, train supervision and train regulation. The associated training simulator provided under this contract will also comprise a trainer and three trainee simulation facilities that can emulate train movements as well as the operations of the track-side equipment. It will replicate, as much as possible, the real train control system for the training of the traffic controllers.

A driving cab is a compartment in the cab car with full facility and equipment necessary to drive the train in all available operating modes. The Driving Cab Simulator consists of two full sized mock-up cabs and a computer based simulation system which models the performance and environment of the real driving cab in order to simulate the complete driving environment for training the trainee operators (drivers). The cab simulator system to be procured for WR allows the training of a maximum of two trainee operators at any one time.

With the use of these three standalone task based training simulators, the relevant controllers / operators would be trained so as to ensure they are equipped with the necessary skills and knowledge to operate the individual sophisticated systems. However, one key aspect that is highly important for smooth and efficient operation of WR is yet to be fully covered by these three standalone simulation facilities, i.e. teamwork - particularly in handling major incidents. This brings up the concept of the implementation of an integrated training facility whereby these simulators are suitably integrated to provide team training exercises on selected major incident scenarios\textsuperscript{[2]}. 
5 Integrated Training Facility

Integrated Training Facility (ITF) is a centralised training facility which connects the main control system simulator (MCS), the train control and signalling system simulator (TC&S) and the cab simulator (Cab Sim) to form a networked, integrated team training environment. The system shall be configured in such a way that these functional simulators can continue to work in a standalone mode if so selected for individual task training. Figure 2 below gives a high level data flow diagram among the simulators for the ITF system.

![Data Flow Diagram for the ITF System](image)

Under the team training mode, training scenarios will be developed and loaded from the ITF to the three simulators in order to perform team training for the train drivers, the main control system operators (station controller and MCS controller) and the train control and signalling system operators (traffic controller).

These team training scenarios will focus on the development of the communication and teamwork skills of these different operating personnel groups to handle incident and emergency operations in Station Control as well as Central Control aspects.

The ITF will consist of a trainer console through which scenarios can be activated and trainee performance monitored. The ITF includes a master computer for overall control and execution of training scenarios and events as
well as to control the data communication flows among the functional simulators.

The individual simulator will be connected via a Local Area Network (LAN) with 100Mbps data transmission rate. Determination of transmission speed and bandwidth mainly depends on the transmission data type, data exchange volume and the required response time in the real-time environment. In order to achieve a high level of fidelity in the ITF system, the ITF network is expected to transmit thousand bytes of data messages and control commands in real time.

The data exchange requirements between ITF and the three simulators are briefly described in the following paragraphs.

For MCS simulator, the following information is anticipated to be required:
(a) the command signal to start a tunnel ventilation mode and the data to indicate the geographical zone of a stopped train in the tunnel;
(b) the command signal to allow the MCS to adjust the speed of fans when a train approaches and departs from each platform;
(c) the status of major Tunnel Ventilation Sub-systems;
(d) overhead line or catenary section status; and
(e) common station fire alarms.

For TC&S and Cab Simulators, the following information needs to be passed from the ITF system:
(a) the initialisation data identifying the start, end and incident positions and the routing of the exercise;
(b) the initialisation data required to configure the TC&S simulator for commencement of exercise including number of trains, selection of time tables and other necessary parameters;
(c) the initialisation data identifying the tunnel crossover doors status and travel direction;
(d) the initialisation data identifying the initial target speed and maximum allowable speed; and
(e) the data identifying initial distance to target point.

The real-time data that are required to be exchanged between the TC&S and Cab Simulators include:
(a) the data identifying the train location;
(b) the data identifying the maximum allowable, target and actual train driving speeds;
(c) the data identifying the mode of train operation;
(d) the data indicating the train faults and equipment health status;
(e) the data identifying the train doors enables status and which side;
(f) the data identifying derailment detection status;
(g) the data identifying train hold and train docking status; and
(h) the data identifying distance to target point.

TCP/IP is specified as the lower levels communication protocol for message transfer among the various subsystems. For the higher levels, protocol conforming to industrial standards, such as MODBUS and MMS, are anticipated to be used. The conceptual system configuration of the ITF is shown in Figure 3.
With the ITF set up, the trainees operators / controllers are trained on co-ordinated decision making and synchronised action prioritising which are vitally important to the speedy and safe recovery of an incident especially when dealing with potentially life threatening situations.

It is envisaged that ITF will provide a distinct advantage over the traditional training whereby clear and effective communications during this integrated team training ensures the team understands the various actions to be taken independently by each position, which then work towards a common objective of safe and effective recovery of incidents.

6 Computer-Based Training

As part of the WR training curriculum, computer-based training (CBT) is determined to be adopted as a cost effective training tool. CBT provides structured and self-paced training using highly interactive, multimedia based technologies. The CBT courseware will include training on all the key systems and sub-systems within West Rail.

The CBT system comprises the multimedia authoring and management software tools, courseware and a comprehensive delivery interface with computer-managed instruction capability that will be delivered over an independent network. The CBT hardware includes the CBT system server, the
CBT development workstations and the CBT delivery workstations. Figure 4 below illustrates the high level system configuration of the CBT system.

The CBT authoring software and media / asset development and management software will be off-the-shelf packages using the full capability of multimedia learning technologies incorporating voice / audio, video, graphics with 2-D and 3-D animation and creative text combinations in a user friendly design utilising effective and appropriate mix of the media. The system will also utilise off-the-shelf hardware technology to ensure that CBT development and delivery is cost-effective and to take advantage of the power and ease of use of the latest PC technology.

The CBT courses will be designed using the Instructional Systems Design approach incorporating distinct phases for analysing requirements and tasks, designing learning objectives and performance measures to ensure task mastery, script and storyboard development to precisely reflect overall course and individual screen design, branching and interactive learning techniques and an entertaining and easy to use courseware delivery interface.

The computer-managed instruction sub-system will manage trainee data and training data including performance testing and recording, curriculum management, training assignments and management, while the sub-system will provide standard and customised reports.
7 Future Plans

Only ten major well defined scenarios are specified in the pilot implementation of West Rail Integrated Training Facility system. Both our operational and design personnel are in the process of gathering experience in using this advanced training tool to facilitate team training. More scenarios are expected to be introduced after ITF has put into operation and fine-tuning of the ten scenarios is anticipated to take place when operational experience is obtained after the opening of the railway.

In addition, Decision Support System (DSS) will be introduced to the operation of WR, using ITF to test out the correct implementation of DSS as well as to familiarise the controllers with the use of DSS is another area of further applications.

Regarding CBT developments, design extensions being explored include system expansion to enable CBT delivery over the KCRC corporate intranet and the possibility of utilising an Internet Service Provider to provide web-based training over the Internet. Both extensions aim to optimise the use of CBT using the existing infrastructure in the most cost effective way.

8 Conclusion

Integrated Training Facility (ITF) is a sophisticated training tool which integrates three standalone task based training simulators to provide team training exercises for WR. The concept of using this kind of advanced integrated training tool in railway industry is relatively new and the development of this innovative training system is very challenging. On the other hand, Computer Based Training (CBT) have been deployed for different applications across many types of businesses. However, developing CBT in parallel with the design and development of the various new systems to be installed for WR poses another challenge to both the training system design engineers as well as the training development manager.

Finally, West Rail is at the forefront of KCRC’s corporate vision and its mission is to provide a safe, reliable, profitable and integrated railway network. Training plays an important role in the safe and reliable operation of railway system in ensuring only experienced, competent and well trained staff work on the railway. Integrated Training Facility and Computer Based Training are envisaged to meet the training target requirements in a quality manner and form an vital part in the overall comprehensive WR training system for the future operation and maintenance of this advanced railway system of the 21st century.

References