

FACILITATION AND PROMOTION OF I&T FOR ENHANCEMENT OF RAILWAY SAFETY – HONG KONG EXPERIENCE

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1. BACKGROUND

The Electrical and Mechanical Services Department (EMSD) has two functional arms, Regulatory Services and Trading Services. The Regulatory Services of EMSD ensures E&M safe operations and public safety comply with ordinances relating to electricity, energy saving and efficiency, gas, lifts and escalators, and railway operation through law enforcement and public education. The Trading Services of EMSD manages building service systems for more than 8,000 government venues throughout Hong Kong, providing professional, one-stop comprehensive and cost-effective E&M project management, procurement, operation and maintenance engineering services.

EMSD is the railway safety regulator in Hong Kong which regulates safety of railways, tramways and peak trams through law enforcement and continuous public education. The major functions of EMSD regarding railway safety are ensuring the adoption of appropriate safety measures to assure safe operations of its railway systems; assessing and vetting new railway projects and major modifications of existing railway facilities; assessing and following up with operators on improvement measures in respect of railway safety; and investigating safety-related railway incidents and recommending improvement measures to prevent recurrence of the incidents. Apart from these traditional regulatory functions, EMSD also actively played the role of innovation facilitator in recent years to facilitate and promote the wider adoption of Innovation & Technology (I&T) to enhance railway safety.

In 2018, EMSD formulated a 5-year Strategy Plan which aims to lay down a cornerstone for nourishing various developments in I&T and provide digitised E&M engineering solutions to maximise public value with the interests of the community. Besides, according to the Pro-innovation Government Procurement Policy implemented in April 2019, EMSD acts as the Government's Innovation Facilitator to assist various government departments in identifying new technologies and products related to E&M solutions. Under this procurement policy, the tender assessment board will not only consider the tender price to make decision, but also consider the involvement of innovative ideas and adoption of I&T technology. EMSD also assists the departments to connect with





stakeholders in the I&T sector, including local small and medium enterprises and startups, to establish collaborative relationships.

For the sake of railway safety, EMSD continuously explores and studies different types of I&T solutions and strives to implement appropriate I&T solutions for trials in the real railway environment which aims to assist the railway operators in managing their railway assets more effectively and efficiently, understanding the asset condition more comprehensively, and strengthening the control of the human factor related issues which are less controllable to minimise the occurrence of railway incidents in future, and provide a world-class railway service to the public.

2. OBJECTIVE

This paper aims to share the Hong Kong experience in promoting and facilitating I&T applications in enhancing railway safety through close collaboration among the railway safety regulator, railway operators and the trade, and to showcase some examples of I&T applications that have been successfully implemented or being explored via pilot projects for enhancing railway safety in Hong Kong.

3. WAYS TO FACILITATE AND PROMOTE I&T APPLICATIONS

3.1 E&M InnoPortal

In order to improve the quality of public services, various government departments are eager to tackle different kinds of issues in daily operations with reliable, effective, efficient and automatic I&T solutions. As the Government's Innovation Facilitator, EMSD launched an online technological demand matching platform, the E&M InnoPortal, in March 2018. The E&M InnoPortal maintains a list of technology development "wishes" from various government departments, public bodies and the E&M trade. I&T solution providers, such as start-ups, universities and research institutions, can provide their I&T solution proposals to the I&T wishes with a view to commercialising the research and development results.

E&M InnoPortal is not just a platform for matching I&T wishes and solutions. On completion of trials, solution providers receive objective advice and impartial performance reports from EMSD that are uploaded to the E&M InnoPortal, so that other stakeholders may also refer to the data when considering the adoption of solutions, thereby helping further promote wider application of the solutions.

This initiative has received strong support from various sectors, with more than 410 I&T wishes, 960 I&T solutions and 150 I&T trials being conducted by the end of August 2022. Up to 2022, 34 railway safety-related wishes requesting for the use of new technologies to enhance railway safety have been put on the platform for matching with technical





solutions from universities and start-ups, and 11 of them were successfully matched and implemented through pilot projects.

3.2 Strategic Partnerships with I&T Solution Providers

To facilitate collaboration and enhance efficiency in I&T development, EMSD established strategic partnerships in Hong Kong and the Great Bay Area (GBA) through memoranda of co-operation (MOC). A total of 18 organisations including local universities, local research institutions and Guangdong province's academic institutions have signed the MOC since 2018. These eighteen strategic partners represent a significant share of start-ups and top-notch solution experts from research and academic institutions and provide solid technical support to EMSD in I&T development. The strategic partners are invited to upload their I&T solutions onto the E&M InnoPortal, and apply their innovative ideas and research achievements to real-life cases so as to commercialise their academic development results and implementation of I&T. Combining diverse I&T knowledge among these strategic partners with EMSD's railway regulatory experience, railway safety-related wishes in the E&M InnoPortal were accomplished through successful implementation of the I&T solutions to enhance safety and reliability of the railway systems in Hong Kong for the benefit of the general public.



Figure 1 - Signing Ceremony of Memorandum of Co-operation

3.3 TechConnect Fund

Apart from the technology development demand matching mechanism provided through the E&M InnoPortal, funding support is another important factor driving the success of digitalisation and I&T development to deliver public services. The Innovation and Technology Bureau (ITB) rolled out a funding scheme, TechConnect (block vote), in mid-2017 to assist government departments to improve the quality of public services through technology adoption. EMSD participates in this scheme to help the successfully matched proposals obtain the required funding to implement pilot projects, allowing I&T solution providers to demonstrate and prove the feasibility of their innovative ideas with minimal financial constraints. User departments could experience and enjoy the benefits of adopting these I&T solutions and decide whether to further adopt these technologies based on the pilot project results. Up to 2022, funding of 6 pilot projects related to railway safety listed below have been approved:





- i. Adoption of 3D point cloud technology for AI analysis of railway infrastructure condition
- ii. AI-based accident prevention system for escalator
- iii. Tramway track small / foreign object detection system
- iv. Tram speed alert system
- v. AI data analytics on historical incident data and trends
- vi. AI data analytics on concession applications for delayed maintenance activities to enhance railway safety

3.4 Regulator-Operator Partnership Approach

As a railway regulator, EMSD shared the same vision with the railway operators of providing safe, reliable and high-quality railway services to the community. Applying I&T solutions to railway environment to tackle the challenges facing in the rapidly changing society requires the railway operators' support. To align the strategic direction with railway operators for promoting wider adoption of I&T in railway operations, EMSD holds regular I&T forums and communication workshops with the senior management of railway operators to exchange views on the latest development and experience in I&T applications, share the remarkable achievements of the pilot I&T projects and discuss the ways to tackle the current railway safety issues through wider adoption of I&T. This partnership approach facilitates close collaboration with railway operators, strengthens the I&T culture in the railway industry, and inspires more innovative ideas applied in the railway environment to enhance railway safety and service reliability.

3.5 Foster I&T Cultural Development

Cultivating talents is the key to the long-term development of I&T culture. EMSD proactively organises I&T seminars, international conferences, technical visits and I&T competitions to nurture talents and creativity of the next generation and young engineers. For example, EMSD collaborated with Guangdong Provincial Association for Science and Technology and the trade to organize the "Global AI Challenge for Building E&M Facilities" in October 2021 to encourage wider application of I&T and promote international innovation and technology ideas through knowledge exchange and cooperation. This is a global event, comprising technical conference and worldwide competitions, highlighting artificial intelligence (AI) development and applications in the building services industry. Moreover, EMSD participated in international organisations, e.g. Core Group member of IRSC, to share and exchange the good practises of I&T adoption in managing railway safety with overseas railway regulators and operators to enrich the I&T knowledge and experience in railway operations and uplift the railway safety standard of the industry. In addition, EMSD encouraged their engineers to participate in various international competitions, such as the International Exhibition of Inventions of Geneva (IEIG), to showcase the achievements of those successfully implemented I&T solutions to promote knowledge sharing and to recognise individual





and collective efforts in I&T development. In 2022, EMSD achieved encouraging results at IEIG with the following awards that are relating to railway safety:

- i. Gold medal: Smart Driver Assistant for Automated People Mover for prevention of human fatigue and errors during manual driving of a train.
- ii. Silver medal: Semantic AI for Predictive Maintenance of Railway Track Systems for analysing massive maintenance/incident data and derive health indices for indicating the healthiness of railway track system.

4. EXAMPLES OF I&T APPLICATIONS

EMSD has all along been proactive in applying new technologies to enhance service quality and ensuring that electrical, mechanical and energy technologies are harnessed in a safe, reliable, economical and environmentally friendly manner to improve quality of life. With the continuous efforts of the above-mentioned ways of facilitation and promotion over the years, the following I&T projects were put on trial or fully implemented by EMSD/railway operators to enhance railway safety and strengthen railway regulatory work to safeguard public safety.

4.1 Smart Maintenance

4.1.1 Real-time Dynamic Track Performance Monitoring System (DTGMS)

The lesson learnt from the derailment incident in the East Rail Line in Hong Kong on 17th September 2019 is the importance of monitoring a critical parameter of the permanent way system, i.e. track gauge. Before the deployment of DTGMS, track gauge measurement was performed by maintenance staff manually and by measurement vehicles during the maintenance window of which the time was limited. With the support of DTGMS, the track gauge measurement can be performed at any time during the service hours as the system was installed on the bogie frame of selected passenger train(s) in various operating railway lines. The gauge measurement is performed by 2 laser sensors and the signal processor, and such measurement data are recorded with time stamps and precise GPS locations, which can be further matched to track chainages accurately. Exceedance of gauge measurements against maintenance requirements can be categorised by classes and alerts will automatically be generated to the maintenance team which can plan further corrective maintenance actions for specific locations based on severity of categorisation of the received information. Measurement data can also be visualised on a dashboard for trend analysis.







Figure 2 - Laser Sensors of DTGMS installed on the bogie frame



Figure 3 - Dashboard of the measurement data

4.1.2 Semantic AI for Predictive Maintenance of Railway Track System

The current railway system in Hong Kong has been put in service for more than 40 years, thus asset replacement, large-scale retrofitting, maintenance and repair works are required to enhance operational safety and service reliability of the railways. It is necessary for EMSD to explore the feasibility of adopting new technologies to analyse railway incidents and other related maintenance data, such as fault data, maintenance records and asset condition data of MTRCL's permanent way system, to facilitate further insights on predicting the occurrence probability of rail incident at specific areas in the track system. The project applies AI techniques to analyse the past permanent way incidents and associated maintenance data to derive health indices for indicating the healthiness of the permanent way system and facilitating predictive maintenance. The system is being developed to facilitate proactive regulatory monitoring by EMSD as well as carrying out predictive maintenance by railway operator to enhance the overall system safety and reliability of the railways.







Figure 4 - System Architecture

4.1.3 Adoption of 3D Point Cloud Technology for AI Analytics of Railway Infrastructure Condition

In view of the efficiency and effectiveness of manual patrolling for railway infrastructure, 3D point cloud technology with AI analytics for checking the conditions of railway infrastructure will facilitate staff deployment and optimize the maintenance strategy for enhancing the safety of railway operations. The 3D scanner is planned to be installed on a train to check the conditions of railway infrastructure (e.g. railway tunnels) including concrete spalling, crack, water seepage, etc. The 3D point cloud model of the designated infrastructure section and the objects in the infrastructure section will be generated regularly, and then AI analytics will be used to automatically compare and evaluate the infrastructure conditions. The 3D point cloud model with AI analytics aims to enable automated checking of railway infrastructures thus shortening inspection time and saving manpower. Efficiency and effectiveness of inspection will be significantly improved.



Figure 5 - 3D scanner installed on the train







Figure 6 - Sample trackside 3D image

4.2 Smart Operation

4.2.1 Smart Driver Assistant for Automated People Mover (APM)

Smart Driver Assistant is a device using AI and video analytics technologies for the drivers of APM running between terminals in the Hong Kong International Airport. It is a portable device and easy to use in the APM. It is designed to real-time detecting improper driving behaviours (e.g. fatigue, yawning or inattention) of the driver, and providing alerts to the driver and APM controller when dangerous situations (e.g. speeding, red signalling light or objects on track) are detected during manual driving. Besides, the recorded videos were encrypted and saved on the device for easy future retrieval for reference. It can be played back in pairs with track conditions and driver images as well as provision of records for incident investigation. The device can prevent occurrence of accidents during manual driving by giving early audio alerts to the concerned driver on potential safety risks and achieve operational reliability by minimizing downtime of the APM system. The system had been launched after it was put on trial in July 2021.







Figure 7 - Smart Driver Assistant Device



Figure 8 - Detection of Driving Behaviours

Similar design concepts are being applied to the light rail system in Hong Kong, in which the light rail operation relies on manual driving by the train driver, to assist drivers to minimise human factor related issues that may lead to incident during driving by giving early audio messages and seat vibration warning to alert the driver when situation having potential safety risks is detected.



Figure 9 - Driver Fitness Monitoring System





4.2.2 Smart Railway Track Intrusion Detection System

Smart Railway Track Intrusion Detection System uses AI and video analytics technologies for real-time detection of intrusion objects infringing into railway track areas. Instant SMS messages will be sent out from the on-site detection device to operations control centre to take follow-up actions promptly. It will also provide snapshot images of the intrusion objects and live video streaming clips of the incident site. The system was commissioned at Tai Wai Station (East Rail Line) and Che Kung Temple Station (Tuen Ma Line) in December 2021. It has been used for monitoring any objects incidentally fallen to the railway track areas due to the demolition works of a building near the track area.



4.2.3 Tramway Track Small / Foreign Object Detection System

To prevent tramway derailment incident after tram wheels hitting a small / foreign object on tram track in daytime, night-time and bad weather, a technical study of on-board realtime object detection and alert system commenced in September 2021. The system works in real-time to identify any objects in front of a tram which is a potential hazard to tram operation, then generates an alarm to alert the tram driver to stop the tram before hitting the objects. The system will make use of Light Detection and Ranging (LiDAR) technology to detect if there is an object in rail groove ahead of a tram that may pose a potential safety hazard to tram operation. Alerts will be generated to tram driver for actions if high risk object is detected. As a result, the operational safety of tramway is enhanced.











Figure 111 - LiDAR installed on the tramway



Figure 122 - Detection of small object on the track

4.2.4 Tram Speed Alert System

The Tram Speed Alert System is designed to permit real-time monitoring of the tram speed on road with different speed limit settings and generate real-time alert to tram driver. The technical study of this on-board real-time alert system for the assistance on speed control of the tramcar commenced in September 2021. The system makes use of Global Navigation Satellite System (GNSS) for enabling a tram to compare against the speed limits along the tram lane in database. Alert will be generated to tram driver requesting for slowing down the tram when its speed exceeds the pre-set speed limit thereby enhancing the operational safety of tramway.





Zone	Zone area corners (Geolocation)	Zone area speed limit (km/h)
Α	A1, A2	20
В	B1, B2	10
С	C1, C2	20
D	D1, D2	10

Figure 13 - Speed limits in different zone preset in the system

4.3 Management of Passenger Behaviour

4.3.1 LiDAR Detection System

Misbehaviour by passengers, such as running on escalator etc., may lead to escalator incidents in MTR stations due to loss of balance when carrying bulky objects or baby pram, etc.

In July 2020, EMSD implemented a pilot project to install LiDAR detection system in a railway station (Choi Hung Station) with a view to reducing escalator incidents with the collaboration with the railway operator. This project aims to reduce escalator accident caused by passengers using escalator improperly. When the system detects passengers carrying bulky items, bicycles, or prams, etc. who are about to use escalators after passing the entrance gates, it will issue specific broadcast messages and project images on the floor near the entrance gates to remind them to use lifts nearby rather than escalator. Instant SMS message will also be sent to station controllers who can provide assistance to passengers in need in a timely manner, especially those carrying prohibited items, such as excessive long ladder, LPG cylinders, metallic balloon, etc. The performance evaluation of the system at Choi Hung Station was completed in July 2022 with positive results in raising passenger safety awareness of using escalator.







Figure 14 - Specific alerts generated to the targeted passengers

Figure 135 - LiDAR sensor

4.3.2 LiDAR Crowd Control System

A number of railway lines were not equipped with platform screen doors at station platforms. There are incidents in the past related to passenger behaviour on the platform, such as passenger jumped down from platform to the railway track. There is a need to explore I&T solutions for assisting the railway operators to take appropriate actions against improper passenger behaviour at platform.

EMSD introduced the "AI-based Platform Crowd Control System" which utilizes LiDAR sensors to provide a live 3D image and AI program through analysing passengers' behaviour on platform to detect platform over-crowding situations, passengers trespassing the track area or standing beyond platform edge yellow line. The system will trigger announcement and inform station staff immediately to take timely action to ensure safety of passengers.



Figure 146 - Object detection at the platform





5. CONCLUSION

With expanding railway network and patronage, and ageing railway assets in Hong Kong, maintaining a safe operation of railways will become more challenging. As a railway safety regulator with the support of I&T policy, EMSD is committed to expedite the I&T transformation to sustain improvement in railway safety and regulatory enforcement in railway safety.

Through adopting a regulator-operator partnership approach, EMSD collaborated with railway operators in regular I&T forums, technology sharing sessions and communication workshop to exchange information and share experience in development and promotion of I&T applications. EMSD also leads by example to implement pilot projects to demonstrate a series of I&T solutions to the railway operators for their further implementation and continuous development. The above-mentioned examples of I&T applications symbolise the beginning of the I&T transformation. Looking ahead, EMSD will continue to work towards a smart regulator by enhancing the effectiveness and efficiency of regulatory work process by digitization and automation, and continuously facilitating and promoting cohered partnerships with different stakeholders, including railway operators, the trades, research institutes and universities in I&T collaboration, to enrich the I&T development and application in railway safety to safeguard the public safety.

Keywords: Innovation and Technology; Partnership; Facilitation; Promotion; Railway Safety

