Legislative Council Panel on Transport
Subcommittee on Matters Relating to Railways

Progress on Upgrading Signalling System for Railway Lines

Purpose

In March 2015, the MTR Corporation Limited ("MTRCL") awarded a contract of $3.3 billion to replace the signalling systems of seven MTR lines (Tsuen Wan Line, Island Line, Kwun Tong Line, Tseung Kwan O Line, Disneyland Resort Line, Tung Chung Line and Airport Express). The signalling system of East Rail Line is also being upgraded as part of the works under the Shatin to Central Link ("SCL"). This paper aims to brief the Subcommittee on progress of signalling replacement of railway lines.

Signalling Replacement

Background

2. Signalling system is the heart of railway operation. It comprises different components including central computer, computers at different levels, train-borne computers, back-up computers as well as equipment installed at trackside and equipment rooms along railway lines, etc. The signalling system controls train operation and adopts a "fail-safe" design. Once irregularities are detected, such design will bring the trains to an automatic halt, thus ensuring trains are kept at a safe distance apart. The Tsing Yi Operations Control Centre ("OCC") captures the operation status of the signalling system via data transmitted through the monitoring and communications system.

3. The MTRCL has been monitoring the capacity of railway lines under the existing signalling system. To increase capacity and further enhance the overall reliability and efficiency of railway services, the MTRCL earlier decided to replace the signalling systems of seven MTR lines (Tsuen Wan Line, Island Line, Kwun Tong Line, Tseung Kwan O Line, Disneyland Resort Line, Tung Chung Line and Airport Express). Works of the replacement projects will be completed in phases starting from end of 2018. The MTRCL is also replacing the signalling system of the East Rail Line to tie in with the operations of SCL. For details, please refer to paper of the Subcommittee on Progress update of the construction

of the SCL (as at 30 September 2017). The timeframe of completion of signalling replacement is at Annex 1.

Features of the New Signalling System

4. Signalling system controls the safe operations of trains. Railway lines are divided into blocks and only one train is allowed in each block at a time to ensure trains are kept at a safe distance apart. The existing signalling system adopts the fixed block or "distance-to-go" concepts[1]; while the new system uses the "Communications Based Train Control" technology[2] which adopts the moving block concept. The MTRCL can hence increase train frequency and capacity while ensuring the safety distance between trains (see Annex 2).

5. Besides, the new signalling system has a smaller number of overall parts and components which would reduce the chances of faults. To further enhance the reliability of train service, the new signalling system is designed with strengthened back-up devices. Even if a component malfunctions, back-up devices will ensure the signalling system continue to function properly.

Minimising the Impact on Train Service during Signalling Replacement

6. As a railway signalling system involves tens of thousands of electronic components. Internationally, no railway system is completely fault-free. Any large-scale system upgrade would entail the risks that the system may become unstable during the process with higher risks of service disruption. Such risks are common to any system change.

7. Overseas experiences indicate that some railways try to avoid such risks by partially or fully suspending railway services when their

[1] With the fixed block concept, track circuits are set up at intervals along railway lines to detect the locations of trains. If there is a train in a certain block, the signalling system will send commands to the following train not to enter that block. Distance-to-go uses the distance that a train is allowed to travel as the basis to calculate the distance of which a train needs to slow down before it reaches the next block.

[2] The new signalling system uses wireless communication with signals from trains replacing signals from fixed locations on tracks to transmit information such as location and speed of train to the central computer. The computer then works out the safety distance required between trains and transmits the information back to the train.

signalling systems undergo major upgrades until the completion of works. However, the public transport services (including railway) in these places are not as well developed as in Hong Kong and the number of passengers affected by service suspension is relatively smaller. As Hong Kong's public transport system is well-developed, partial or full suspension of train service for enhancement of signalling system is not practicable. Therefore, the MTRCL has to maintain its service level during upgrades of its signalling systems to avoid causing inconvenience to passengers. It is crucial to complete a smooth upgrade of the signalling system while minimising the risks of impacting on railway service. Such task is challenging.

8. Replacement of signalling system involves the installation of a large number of new equipment such as optical fibres, cables, equipment at trackside and stations, followed by extensive tests to be rolled out in a progressive manner to achieve safe and smooth operations before the new system comes into service. Tests include switching from the existing signalling system to the new system on test-tracks at depots and on main lines. To minimise impact on train services, on-site tests on main lines are conducted during non-traffic hours overnight and there are only about two hours available each night for the tests. The Electrical and Mechanical Services Department ("EMSD") will inspect the tests on-site and the new system could only come into operations after obtaining the approval by EMSD.

9. The MTRCL has conducted a comprehensive risk assessment of the replacement of the signalling systems. To reduce the potential risks during the works, having taken into account various factors including patronage of each railway line, signalling equipment and impact on passengers and stakeholders, the MTRCL has formulated the schedule for signalling replacement for the seven MTR lines in a prudent manner. Works or preparations have commenced on the Tsuen Wan Line, Island Line and Kwun Tong Line with details in paragraphs 10 to 13 below. Preliminary works for Tseung Kwan O Line would commence in 2019 with the enhancement expected to be completed in 2021. As the Tung Chung Line and the Airport Express share part of their tracks and the Disneyland Resort Line is connected to the Tung Chung Line, the MTRCL would consider replacing the signalling systems of these three lines together. Based on the current rough estimate, preliminary works for these three lines would commence in 2021/22 with the works expected to be completed in 2026.

Tsuen Wan Line

10. The Tsuen Wan Line is the busiest railway line in urban area and its train frequency is at the maximum capacity of its signalling system. The signalling system of the Tsuen Wan Line is the first to be replaced and works have achieved an overall completion of over 70%. Major signalling equipments have been installed at stations, trackside and on half of the Tsuen Wan Line's train fleet. Since end of 2016, on-site tests have been conducted in phases on the main line during non-traffic hours. Tests include switching from the existing signalling system to the new system, coordination among trains, new trackside equipment and the OCC, accuracy of trains' stopping locations, coordination between train doors' opening and closing and platform screen doors, as well as on-train public announcement. The MTRCL will switch the signalling system back to the existing one before the first train commences service the next day, to continue to provide normal train service during the day.

11. Tests are conducted in a prudent manner – first in a small area such as involving one or two signalling equipments or crossings, then extended to a larger area such as within a station or between two stations. Tests are now extended to multiple trains running simultaneously on half or over half of the length of Tsuen Wan Line and full test is expected to commence in early 2018 at the earliest. Since the commencement of static and dynamic tests on the Tsuen Wan Line, 400 tests have been conducted on tracks at depots while signal transmitters and system switching have undergone over 1 000 tests respectively. Training for MTR staff including staff at OCC, train captains and maintenance staff will commence soon to help them familiarise themselves with the new signalling system. The replacement of the signalling system of the Tsuen Wan Line is expected to be completed by the end of 2018.

Island Line

12. The Island Line is another relatively busy railway line in the urban area. Its signalling system is similar to that of the Tsuen Wan Line. For instance, both lines use the same train model. Experience gained from replacing the signalling system of the Tsuen Wan Line can be applied to reduce the risks of the works on the Island Line and speed up the process. Currently, installation work on the Island Line is about 30% complete including optical fibres laid at tunnels, new signalling equipment installed at trackside and preparations underway for installing new equipment at stations. The MTRCL plans to commence on-site tests

on the main line in 2018. The replacement of the Island Line's signalling system is expected to be completed in 2019.

Kwun Tong Line

13. The signalling system of the Kwun Tong Line is unique and complex because, for instance, a section is connected with the Eastern Harbour Crossing and the Tseung Kwan O Line. To minimise the potential risks of the replacement of the Kwun Tong Line's signalling system, the MTRCL therefore plans to start the relevant works only after gaining experience in the replacement works on the Tsuen Wan Line and Island Line. Preparations for signalling replacement such as site inspections are underway on the Kwun Tong Line while equipment rooms at stations are being re-designed to accommodate the new signalling equipment. Replacement of the Kwun Tong Line's signalling system is expected to be completed in 2020.

14. A signalling fault occurred on the Kwun Tong Line on 5 August 2017, resulting in service disruption. Investigation conducted by a panel set up by the MTRCL showed that the incident was caused by water ingress through a junction box near the Ngau Tau Kok Station which led to corrosion of a copper datalink. Transmission of data was affected as a result, and the intermittent signalling fault in the Kwun Tong station interlocking area had triggered the fail-safe protocol, causing all trains in the affected area to stop.

15. The panel report (see Annex 3 for details) concluded that the signalling system of the Kwun Tong Line functions effectively with no fundamental issue. The incident was caused by an individual copper datalink. The MTRCL had originally planned to replace the concerned copper datalink with a fibre optic system by 2020 as part of the Kwun Tong Line's signalling replacement. To reduce the risk of recurrence of similar signalling faults, the panel suggested an early replacement of such long-distance copper datalink system. The replacement was completed in October 2017.

Contingency Plans during Works

16. Hiccups and faults may occur during the testing of the new signalling system as it involves a switchover to and from the existing system. The MTRCL will strictly adhere to its principle of "safety first" when there is any problem in the switchover and normal train service will

only resume after the problem has been rectified. As a result, train service in the next morning may be affected. The MTRCL has formulated corresponding contingency measures on the basis of the existing contingency mechanism for railway service delays (salient points of existing contingency plans are at Annex 4). The MTRCL has arranged technical personnel and shuttle buses to be on standby and manpower to provide assistance to passengers when necessary. In the event of a railway service delay, the MTRCL will, where the situation warrants, activate suitable measures including deploying more staff to the affected stations to assist passengers and implement crowd control measures. Should train service be suspended due to incidents, the MTRCL will provide shuttle bus services to take passengers to nearby unaffected MTR stations to continue with their journey. Contingency plans formulated by the MTRCL for railway service disruptions are subject to the agreement of the Transport Department ("TD"). In case of service disruptions, the MTRCL will disseminate the latest train service information to passengers through different channels including announcements at stations and on trains, LCD information display systems at stations, MTR website and the MTR Mobile App so that passengers would allow more time for travelling.

Conclusion

17. The MTRCL's aim is to not affect train service during the replacement of signalling system. The MTRCL has formulated contingency plans to handle potential risks. Upon the full completion of the upgrade of signalling systems in 2026, the overall capacity of the Tsuen Wan Line, Island Line, Kwun Tong Line, Tseung Kwan O Line, Disneyland Resort Line, Tung Chung Line and Airport Express can be increased by about 10%. MTR staff will continue to carry out regular repair and maintenance works during the replacement of signalling systems to ensure the railway system is in good condition to provide safe, reliable and convenient railway services to passengers.

MTR Corporation Limited
November 2017

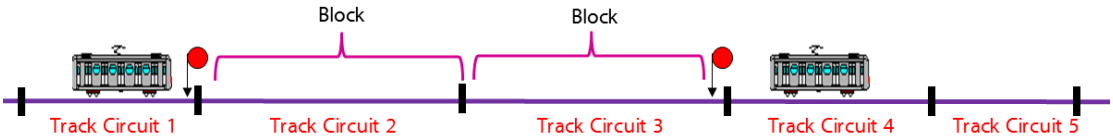
Annex 1

Timeframe of Expected Completion of New Signalling Systems

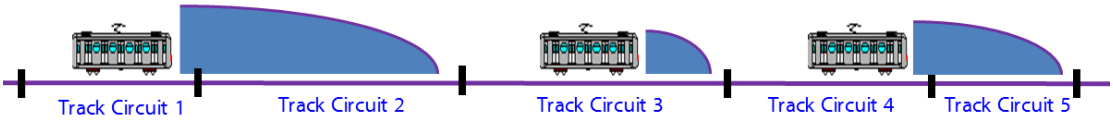
Railway Line	Expected Completion
Tsuen Wan Line	End of 2018
East Rail Line	2019
Island Line	2019
Kwun Tong Line	2020
Tseung Kwan O Line	2021
Tung Chung Line, Disneyland Resort Line and Airport Express	2026

Annex 2

Development of Signalling System



Fixed Block



Distance-to-go

Moving Block

Executive Review Panel Report on Signal Control Failure at Kwun Tong Station Area on 5 August 2017

1. Overview

1.1 The MTR principle of recovering an incident is, first to ensure safety throughout the process, then to continue train service as much as possible, and at the same time minimise delays. This principle was consistently applied in the recovery of the signaling incident on the Kwun Tong Line (KTL) on 5 August 2017.

1.2 On that day at 1102 hrs., signal control of Kwun Tong station (KWT) interlocking area was lost. All points in the area could not be controlled or secured at both Operations Control Centre (OCC) and station level. Manual securing of points and manual train movement at low speed were required inside the area.

1.3 Signalling system incidents can be complex, and the incident on that day was unusually difficult because it was caused by an intermittent cable fault. The fault created changing symptoms through time and made fast diagnosis almost impossible. Although temporary recovery actions of the train service were completed at 1159 hrs and a steady service was achieved by 1432 hrs, the recovery team pressed on with a process of elimination testing and eventually found the fault and resumed the full signaling system capability by 2134 hrs.

1.4 Throughout the incident, train service was always maintained for the rest of KTL between Whampoa station (WHA) and Choi Hung station (CHH). Train service between CHH and Tiu Keng Leng station (TIK) took some time to be built up after the securing of points. By around 1432 hrs., train service headway on the KTL had been resumed to a steady state with headway between 4 minutes to 5 minutes. This service generally met the passenger flow demand on that day.

1.5 KTL signaling system has been maintained to a good standard. The line has experienced a stable and even slightly improving trend of signaling incident rate, even though the equipment is scheduled to be replaced in 2020.

1.6 Nevertheless, lessons learnt from this incident will help MTR improve its performance further.

2. The Executive Review Panel

2.1 On 7 August 2017, the Corporation set up an Executive Review Panel with the following terms of reference:

(a) To establish the facts and circumstances surrounding the incident and its immediate aftermath;

(b) To identify the root cause(s) and other contributory factors leading to the incident;

(c) To review the timeliness and effectiveness of the incident response and recovery processes including the initial actions taken at site and the adequacy of the relevant procedures, to identify areas for improvement;

(d) To assess the timeliness and adequacy of the information provided to the public in relation to the incident and the arrangement of train service and shuttle bus services, to identify areas for enhancement; and

(e) To review the signalling system of KTL if it is still fit-for-purpose to meet the needs of current operations in terms of functionality and failure trend.

2.2 The findings of the Review Panel are summarised as follows:

3. Train Service

3.1 The MTR principle of recovering an incident is, first to ensure safety throughout the process, then to continue train service as much as possible, and at the same time minimise delays. This principle was consistently applied in managing the train service on the incident day.

3.2 After the initial efforts of securing points on track and releasing trains which were stranded between stations, through-line service on KTL was enabled at around 1159 hrs.

3.3 During the incident 135 additional staff were deployed to the affected KTL stations (mainly CHH, Ngau Tau Kok, KWT and Yau Tong stations) to help customers.

3.4 While train service was always maintained between WHA and CHH, train service between CHH and TIK needed time to be built up after the securing of points, through the use of a safety procedure called "pilotman working"[1]. By 1432 hrs., a stable train service on the KTL had been achieved with headway at around 4 minutes to 5 minutes. The achieved train service frequency has generally met the demand on that Saturday, and it was observed that the vast majority of passengers on platforms along KTL managed to board the first or the second trains. Stations and platforms were orderly throughout the incident.

3.5 In the first hour of the incident, time was needed to secure a number of points on the track, in order to ensure safe operations of train service between CHH and TIK. As a result, only a few train passes, including moving the 3 stranded trains, were possible in the two directions of travel between CHH and TIK.

In the second hour, the train service between CHH and TIK was slightly improved as limited train passes were run in the two directions between CHH and TIK.

In the third hour, headways of 6 minutes (10 train passes) and 7.5 minutes (8 train passes) were achieved in the two directions between CHH and TIK respectively.

From 1400 hrs. onwards, train service started stabilising with an average headway at around 5 minutes. By 1432 hrs. (3½ hours after the start of the incident), a steady service with headway at 4 minutes to 5 minutes was achieved.

3.6 The longest train journey delay during the incident was 83 minutes which happened during the first 2 hours of the incident. Some passengers in the first 2 hours of the incident had to wait quite some time for a train because the service was still building up and the trains did not arrive at the various stations evenly over the first 2 hours. The Panel considers the situation inevitable at the start of a "signal control area failure" incident. It

[1] Pilotman Working is a safety procedure for multiple trains under manual operations in sequence.

is impossible to provide a normal service in such circumstances even among the best railways in the world.

> ***"One must realize the signaling system is highly complex and the engineers were under immense pressure during the recovery period and in fairness, they had already done a reasonable job of providing a slightly degraded service from around 2:30 pm onwards and this is indeed as best as any international railway operators can achieve."***
>
> - ***By External Consultant Professor S.L. Ho***

4. Handling of Stranded Trains

4.1 At the start of the incident, there were 2 trains stranded between stations, namely train T01 which had just left Lam Tin station (LAT) and T09 which was approaching Ngau Tau Kok station (NTK).

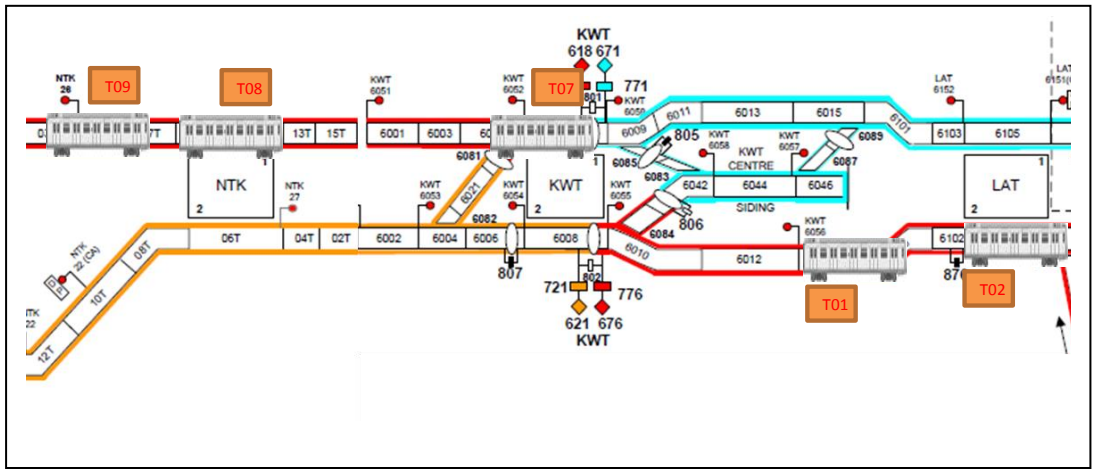


Diagram 4.1: Locations of Affected Trains
(NTK = Ngau Tau Kok station, KWT = Kwun Tong station, LAT = Lam Tin station)

4.2 By following safety procedure, NTK platform was cleared of any train after 23 minutes and T09 was moved to the platform and passengers could get off the train.

4.3 While T01 was stranded, the following train T02 was held at LAT platform automatically by the signalling system for LAT area control. After stopping for 5 minutes, T01 was manually driven to KWT platform to release the passengers. As the forward path was cleared, T02 was automatically driven by the signaling system to the next signal KWT6056 at which it became stranded. It took another 48 minutes before T02 can be moved to KWT platform following safety procedures.

4.4 It is normal practice to leave trains under automatic signaling control as far as possible because this is the best way to minimize train-running delays. With hind-sight, although this is not in the standard procedure, train T02 could have been manually held at LAT and it would not have been stranded between two stations.

4.5 ***The Panel considers that there is room for improving the procedure in releasing stranded trains and preventing additional trains from becoming stranded in incidents.***

4.6 ***The Panel also recommends that the revised procedure be included in traffic control staff's normal and refresher training. Drills and exercises should be carried out to ensure competency of all relevant staff in applying the procedure.***

4.7 There was a question on whether T02 passengers could have been detrained onto track. The Panel considered that train-to-track detrainment would have exposed the passengers to walking hazards and it was safer to keep passengers on the train, where they still had full air conditioning and lighting. Furthermore, train-to-track detrainment would have added another hour of delay to the incident based upon previous experience because it would have required passengers to walk on the track to a station and the follow-up process to ensure the track clear of the detrained passengers. It was correct not to conduct train-to-track detrainment.

5. Passenger Information

5.1 Service disruption and headway information updates were disseminated in a timely manner to customers and passengers in stations and on trains through multiple channels, including station and train public announcements, passenger information displays, Service Information Panels, website and smartphone apps (MTR Traffic News). Incident information and service updates were also proactively provided to media so as to disseminate the information to public.

5.2 In the first hour of the incident, however, the messages of "10 to 15 minutes additional journey time" and "service at 15 minute intervals" did not accurately reflect the changing condition of the service as train arrival frequency was not regular or stable at the time. The 15 minute headway was gradually achieved only in the second hour. In the beginning of an incident of this type, the service can be very limited and service patterns can vary a lot. It is therefore important that more accurate service information is conveyed to passengers for them to better understand the changing situation.

5.3 By 1432 hrs., train service had become steady and was generally meeting the demand of passenger volume. In other words, the vast majority of passengers could get onto the first or the second trains. Passengers were informed that the headway had been restored to 5 minutes, and they could have been told that temporary recovery actions had been completed, a steady service had been achieved and the service was generally meeting demand. In accordance with established protocol, a message of resumption was given at 2135 hrs. when the system was restored to be able to operate at the established timetable. As a result, the public perceived that the KTL service was disrupted for over 10 hours even though the service had been steady since 1432 hrs.

5.4 ***The Panel considers that there is room for improving passenger communication and information to cater for atypical situation of long recovery and with temporary recovery actions completed and to enable customers to understand the changing train service pattern better,***

including the limited service in the initial stage of such an incident.

6. Technical Root Cause

6.1 The root cause of the incident was an intermittent open circuit in one of the two concurrent data transmission link cables. The two link cables provide redundancy in the signaling interlocking so that signaling control will work normally as long as one cable is working. However, the intermittent open circuit did not stop data transmission in that cable completely, but rather it caused intermittent loss or corruption of data. The resulting data corruption caused the KWT area interlocking system to automatically shut down according to the fail-safe design principle.

6.2 Each of the two data links consists of a twisted pair of copper cables that run along track-side in insulated sheaths. KWT signalling interlocking is the only interlocking in the MTR network that is still using copper cables as long distance data link between equipment rooms. All the rest use fibre optics. Although new systems will use fibre optics, copper cable is a well-established technology for data transmission. The KWT copper cables were originally planned to be removed when the KTL signalling system is replaced in 2020.

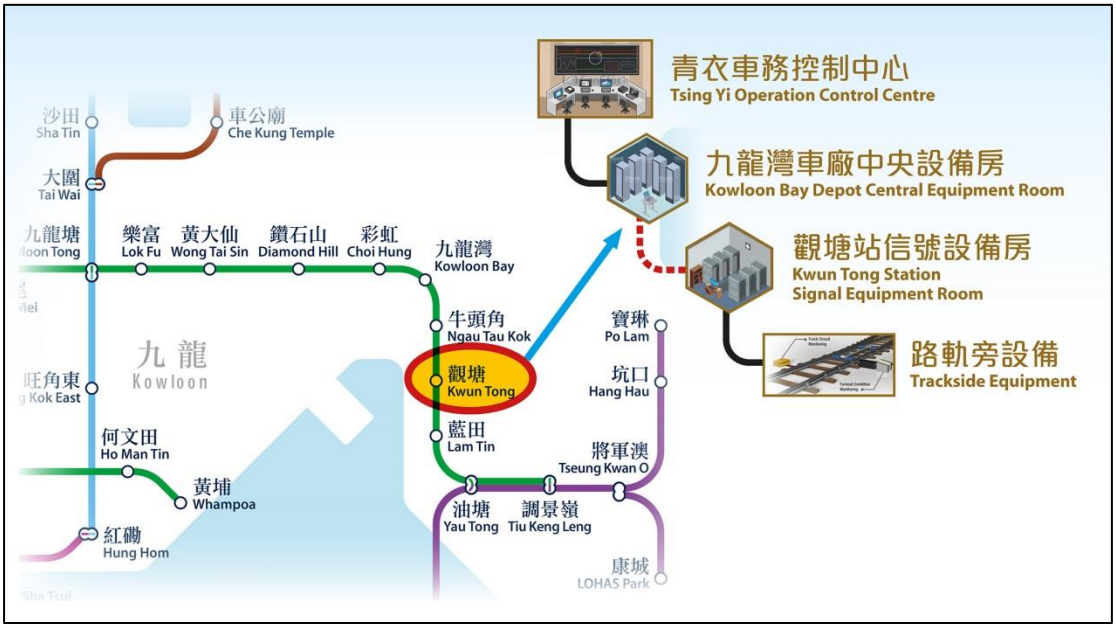


Diagram 6.1: Data transmission

6.3 The intermittent fault was due to water ingress and corrosion inside one junction box of the copper cables. The corrosion of electrical contacts coupled with train movement vibrations caused intermittent short duration open-circuits, resulting in intermittent loss or corruption of data. As the inter-locking system detected inconsistent data set, it executed the fail-safe protocol and shut down all the 3 Multiple-Processor Modules (each module is like a computer), causing all trains in the affected interlocking area to stop. Such an intermittent cable fault had never happened in the KTL interlocking system in the past.

6.4 The junction boxes were supplied with the original cables and had sufficient water proofing for track-side / outdoor environment. It appeared that in one box the water-proof seals had not been able to completely prevent water ingress, perhaps during the recent typhoons and heavy rainfall. The water ingress then led to corrosion of electrical contacts inside the boxes.

6.5 The intermittent cable fault was unusually difficult to be identified quickly. The fault produced inconsistent, changing and even conflicting symptoms which made fast diagnosis difficult in an emergency recovery, and could only be detected by using appropriate specialist equipment to study the data signal being transmitted.

6.6 Although after the enhanced maintenance recommended in the next section of this report, the copper cables would continue to be fit for use until 2020, the Panel considers that fibre optics based data transmission link can further enhance the signalling system's fault tolerance and has failure modes that are more easily detected. Work has been completed in the last few weeks to prove that the copper data links can be converted into a fibre optic system.

6.7 ***The Panel recommends to convert the KWT signal interlocking data-links into a fibre optic system before end of October 2017.***

> ***"MTR have correctly determined that the asset which failed was a Data Link Junction Box which is located along the track."***
>
> ***"As the data transmissions were interrupted intermittently rather than permanently the system was unable to tolerate the intermittent signal by switching channels and, in accordance with fail-safe design principles, the Solid State Interlocking shut down which caused all trains in the Kwun Tong area to be halted automatically."***
>
> ***"WSP agree that conversion to fibre-optic will eliminate the failure mode that caused the KTL data transmission link failure on 5/8/17."***
>
> \- ***By External Consultant WSP***

7. Effectiveness of Technical Recovery

7.1 The MTR principle of recovering an incident is, first to ensure safety throughout the process, then to continue train service as much as possible, and at the same time minimise delays. Even though the priority to keep trains running will likely prolong the total recovery time, this principle keeps passengers moving and reduces the burden on the other transport modes and on road traffic, when compared with shutting down a section of a line. Based on this principle, train service was not suspended while the technical team attempted recovery of the signalling system. The Panel considers that this principle was consistently applied in the technical recovery of the incident.

7.2 The initial loss of signal control in KWT area was the result of the fail-safe shutdown of the KWT interlocking system. 27 technical staff were deployed to respond to the incident. The interlocking system was first successfully restarted after half an hour but signal control could not be regained. In order to identify the root

cause, the technical team had to go through a systematic process of elimination by checking and testing of all relevant equipment in Central Equipment Room (CER) at Kowloon Bay Depot (KBD) and the Signalling Equipment Room (SER) at KWT.

7.3 After the completion of the temporary recovery actions at 1159 hrs. and steady train service achieved at 1432 hrs., additional checks and tests were only allowed to be conducted in limited time slots, in order not to affect the steady train service. This was consistent with the principle to keep trains running as a priority and was an important reason for the prolonged recovery time after 1432 hrs. Further tests and recovery actions after 1432 hrs. were only allowed to be done very slowly and very carefully to prevent the steady service from being disturbed.

7.4 The intermittent cable fault produced inconsistent, changing and even conflicting symptoms, which made root cause identification unusually difficult. In fact such faults could only be correctly identified by using appropriate specialist equipment to study the data signal being transmitted. Such a study takes time and is not normally done during emergency recovery. So the technical team does not normally carry or use such specialist equipment in emergency recovery. Therefore the intermittent fault could not be identified quickly and could only be identified through a process of elimination testing of each equipment.

> ***"It is a common practice to use the principle of elimination to rule out the cause of failure but it is rather unfortunate that the root cause was identified towards the end of the elimination exercise."***
>
> \- ***By External Consultant Professor S.L. Ho***

7.5 Once the root cause was identified and isolated, KWT area signal control was fully regained at 2134 hrs.

7.6 Many railways would not have continued recovery actions after the completion of temporary recovery actions at 1159 hrs. and the achievement of steady train service at 1432 hrs. In this case, the recovery team continued to work on the signaling system until the established train running timetable was restored. In fact,

on a normal Saturday afternoon, passenger volume can be well catered for even with one or two minutes increase in headway. The Panel appreciates such efforts and considers that the time taken for the work was consistent with the principle to first ensure safety and then to keep trains running as a priority.

7.7 The Panel is of the view that, had the appropriate specialist equipment been deployed, the intermittent cable fault would have been identified probably earlier during the incident (but not before 1432 hrs.). However, using such specialist equipment will take time and may prolong the recovery process unnecessarily if the actual root cause is not a data cable fault.

7.8 Therefore, ***the Panel recommends to investigate the feasibility of using appropriate specialist equipment or special methods for future fault diagnosis of such data cables, in situations that do not delay emergency recovery. Further drills should also be organised to enhance the ability to detect such intermittent cable faults.***

8. Asset Maintenance and Prevention of Failures

8.1 The data-link system was designed to detect fault (breakage) automatically, rather than relying on detection by manual inspection. The data-link cables and their junction boxes had never failed in the past. There is also a parallel redundancy for the cables. In other words, if one data cable breaks, the signalling system continues to work normally because there is another (concurrent) data cable that will continue to transmit the data.

8.2 However this incident showed that there is a new failure mode for the copper cables (that is, intermittent fault rather than complete cable breakage) that the system cannot detect. The Panel therefore considers it necessary to conduct regular manual maintenance of such data cables. A thorough check has now been completed on the current conditions of all similar main track-side copper data transmission cables and their junction boxes for long distance data transmission between equipment rooms.

"MTR revised their maintenance regime for Data Link Junction Boxes in 2002 following system modifications made upon the opening of TKL. The Junction Boxes were deemed to be "maintenance free" on the basis of redundancy and open circuit detection provision through system design.

WSP note that this approach to maintenance (sometimes termed as "risk based maintenance") can be appropriate if the risk of system failure is low, all failure modes are self-revealing and failures can be tolerated.

In light of this new failure mode (intermittent open circuit failure), the preventive maintenance regime should be revised."

\- ***By External Consultant WSP***

8.3 The Panel also believes that the best practice is to conduct a risk assessment of the data cables and review / audit the maintenance effectiveness of similar equipment, and plan regular maintenance according to their risks to train service. Regular maintenance should include checking the integrity of data transmission using specialist equipment and the general condition of the equipment. Benchmarking on how other railways maintain different data transmission cables would also help formulate the best maintenance practice.

8.4 Therefore, ***the Panel recommends that a risk assessment be conducted on the data cables and regular maintenance be planned according to their risks to train service. Regular maintenance should include checking the integrity of data transmission using appropriate specialist equipment, to ensure smooth transmission.***

8.5 After the interlocking data transmission links have been replaced by a fibre optic system, the risk will be significantly reduced.

9. Asset Conditions of KTL Signalling System

9.1 The KTL signalling system continues to meet the functional needs of train service operations. For the sub-systems that will be replaced with a new signalling system, the incident rate (incident number per million car-km) has remained stable since 2008.

9.2 Nevertheless, design for the new KTL signalling system has already begun and the existing system is on schedule to be replaced by around 2020. The data-cable problem revealed in this incident will be eliminated soon by replacing the data transmission links with a fibre optic system. Lessons learnt from this incident will also be taken into account in the design of the new signalling system.

> ***"Lessons learned from this failure can also be applied to future signalling upgrade projects as even the latest generation of signalling systems still have some components trackside which utilise junction boxes and these are not entirely maintenance-free***."
>
> - ***By External Consultant WSP***

9.3 As for signalling system replacement, there are several issues that also need to be considered.

First is the complexity of the existing system. KTL signalling is more complex than in other lines because it is made up of several signalling systems and sub-systems supplied by different suppliers. In order to reduce risk to day-to-day train service, it was considered better to build up knowledge and experience over time on how the new signalling system will interact with the existing systems, before KTL signalling could be replaced.

Second is that signalling replacement only involves the train control and train detection parts of the system, some track-related systems such as points will remain. So signalling system replacement will not eliminate incidents caused by points and still require points to be secured during a control failure incident.

Third is the potential service risk during the replacement. In order to replace the signalling system, other associated equipment, such as trains and some station equipment, need to be modified. The programme of these modifications will have to be synchronised with the signalling replacement work, otherwise significant service disruptions could result.

9.4 Asset replacement decision is not a simple decision that can be taken lightly.

9.5 Nevertheless, ***the Panel recommends that the design of the new KTL signalling system should take into account the lessons learnt from this incident. A review should also be undertaken to determine whether the conditions of existing assets require any immediate improvement such as upgrades and partial replacement before the full system replacement around 2020.***

10. Conclusions

10.1 The Review Panel has reviewed the facts and factors relevant to the root cause and recovery of the incident and concluded that:

(a) The incident was managed in a safe manner and according to established procedures.

(b) The MTR principle of recovering an incident is, first to ensure safety throughout the process, then to continue train service as much as possible, and at the same time minimise delays. This principle was consistently applied in the recovery of this incident both in train service management and in technical recovery. On the incident day, temporary recovery actions were completed at 1159 hrs. and train service became steady by 1432 hrs. (i.e. 3½ hours after the

incident outbreak) and since that time, was generally meeting the demand of passenger volume.

(c) The incident was caused by intermittent open-circuits of the copper data link in KWT signal control interlocking area. Such copper cable as long distance data link is unique among the MTR network for signal interlocking.

(d) Although with enhanced maintenance, the copper data link can continue to be used, the Corporation has proactively decided to replace the copper data link with a fibre optic system before end of October 2017.

(e) There was no sign of increasing systematic equipment failure due to ageing or obsolescence of the KTL signalling system, and this incident was considered an isolated case.

11. Recommendations

11.1 The Panel has made recommendations in the following areas in order to reduce the probability of recurrence and to improve the overall customer service and shorten the technical recovery of similar incidents in the future:

Short Term

(a) Priority should be given to releasing trains stranded between stations and preventing additional trains from becoming stranded. Practical procedures / guidelines should be provided for traffic control staff to put this into practice.

(b) The procedure / guidelines should be included in traffic control staff's normal and refresher training. Drills and exercises should be carried out to ensure competency of all relevant staff in applying the procedure.

(c) According to established procedures, train frequencies and extra train journey time are communicated to passengers and resumption of full service is announced only after full time table operations have been achieved. However, this arrangement may not be appropriate for atypical situations

of long recovery and with temporary recovery actions completed. Passenger communication and information should be enhanced for atypical situations to enable customers to understand the changing train service pattern better, including the limited service in the initial stage of such an incident.

(d) The KWT signal interlocking data links should be converted into a fibre optic system before end of October 2017.

Medium to Long Term

(a) Feasibility should be studied on the use of appropriate specialist equipment or special methods for future fault diagnosis of similar data cables, in situations that do not delay emergency recovery. Further drills should also be organised to enhance the ability to detect intermittent cable faults.

(b) A risk assessment should be conducted on the data cables and regular maintenance be planned according to their risks to train service. Regular maintenance should include checking the integrity of data transmission using appropriate specialist equipment, to ensure smooth transmission.

(c) The design of the new KTL signalling system should take into account the lessons learnt from this incident. A review should also be undertaken to determine whether the conditions of existing assets require any immediate improvement such as upgrades and partial replacement before the full system replacement around 2020.

- End of Report -

Annex 4

MTRCL's contingency plans for railway service disruptions

Purpose

The MTRCL has drawn up contingency plans for various service disruption scenarios specific with regard to the needs of individual stations. MTR staff responsible for contingency duties are familiar with these plans. Information that is of use to passengers is available at stations and on the MTR website. This note gives an account of MTRCL's contingency plans for railway service disruptions.

Handling of railway service disruptions

2. When a serious incident happens and is expected to lead to a prolonged suspension of railway services for 20 minutes or more, MTRCL will issue a "Red Alert" message to inform Government departments including TD, other public transport operators and media organisations of the incident. Upon notification by MTRCL, other public transport operators will provide appropriate support services as best as they can under the coordination of TD. MTRCL will suitably adjust its railway service to minimise the impact and arrange free MTR shuttle buses to carry passengers from the affected stations to convenient locations such as the nearest MTR station with railway service still in operation.

Alert system

3. "Red Alert" is defined as a signal which denotes that serious railway service disruption will continue or is expected to continue for 20 minutes or more, and emergency transport support services from other public transport operators are required. Upon receiving the Alert, public transport operators will urgently mobilise their resources to provide appropriate supporting services as quickly as possible.

4. Prior to the issuance of a Red Alert message, MTRCL may issue an "Amber Alert" message. "Amber Alert" is defined as an early warning in respect of an incident which may lead to a serious disruption of service. After receiving this Alert, other public transport operators will alert their emergency unit, get prepared for possible emergency actions which may be required at a short notice and keep close contact with MTRCL.

5. MTRCL is also required to notify TD within 8 minutes on any service disruption incident which has lasted for 8 minutes or is expected to last for 8 minutes or more. Train service disruption incidents refer to incidents that lead to a suspension or delay of service at a railway station or a Light Rail stop, or on a section of a railway line.

6. Besides, according to the Mass Transit Railway Regulations (Cap. 556A), MTRCL shall report to EMSD any incident that occurs at any part of the entire railway premises which has a direct bearing on the safe operation of the railway.

Dissemination of information during incident

7. Regarding dissemination of information to passengers, MTRCL has formulated measures to ensure effective communication with passengers during service disruption, with a view to assisting them to make appropriate alternative travel arrangements. These measures include:

(a) broadcasting details of the service at stations and on trains;

(b) providing information on alternative public transport services such as franchised bus routes, bus stop locations and free MTR shuttle bus boarding/alighting points on large information displays installed at stations;

(c) displaying signs from concourse ceilings and at street level to mark routes to free MTR shuttle bus boarding/alighting points when free shuttle bus service is ready;

(d) during service disruption, using LCD display systems installed at visible locations near entry gates at stations to provide train service information and other important notices;

(e) posting railway service disruption message and information on free MTR shuttle bus services on the MTR website and MTR Mobile App "Traffic News", and users of "Traffic News" will be redirected to the Citymapper app to look for alternative transportation information to reach their destinations during severe delays or disruptions; and

(f) distributing "Rail Service Suspension – Passenger Guide" to passengers.

Operation of train and free MTR shuttle bus during serious railway service disruptions

8. In the event of a serious service disruption, MTRCL will endeavour to minimise the area being affected and provide train service to the farthest extent by:

(a) reversing trains at designated track sections to maintain train service in unaffected sections;

(b) diverting trains through supplementary track sections to bypass the affected section;

(c) diverting trains across lines through designated track sections to reduce the impact of service disruption; and

(d) diverting trains through spare track sections to reduce the impact of service disruption (for example, when the cross-harbour section of Tseung Kwan O Line is suspended, depending on which section is affected, cross-harbour train service can be maintained via the Service Connection Tunnel of Kwun Tong Line to provide linkage between Lam Tin Station and Quarry Bay Station).

9. MTRCL has formulated free shuttle bus deployment plans for railway incidents and agreements have been entered into with bus operators for the provision of such services during railway incidents to carry affected passengers to the nearest MTR station still under normal operation to continue with their journeys.

<u>Operation of free MTR shuttle buses</u>

10. Free MTR shuttle bus service is a supplementary measure to assist passengers to travel to convenient locations. Given the limited carrying capacity of shuttle buses, it is not intended to be a substitute for normal train service. It brings passengers to the nearest station outside the affected section of a railway line where service is disrupted to enable them to continue with their journeys. Shuttle buses would also stop at stations in the affected section to provide services to passengers.

Activation of free MTR shuttle bus services

11. The number of free MTR shuttle buses and the level of shuttle bus service to be deployed during a railway incident will depend on which section of the railway line is involved and the seriousness of the situation. Generally speaking, according to the agreement between MTRCL and the Public Omnibus Operators Association (POOA)[1], when free MTR shuttle bus service is needed, the POOA will arrange about 10 buses to provide service within 30 to 45 minutes after receiving MTRCL's notification; an additional 40 buses, if required, will be deployed within 1 to 1.5 hour; and about 100 buses in total after 2 to 2.5 hours. The actual number of buses to be deployed will depend on the extent of the impact on train service and road traffic condition. Depending on the actual situation, MTRCL may operate additional shuttle buses or modify the operating details of shuttle bus services to suit the need of the affected passengers.

12. Information on the estimated arrival time, locations of and routes to boarding and alighting points of free MTR shuttle buses is included in MTRCL's "Rail Service Suspension – Passenger Guide" which is tailor-made for each station for distribution at the station. The Guide is also available on the MTR website. (http://www.mtr.com.hk/en/customer/needs_index.html)

13. Since the carrying capacity of shuttle buses is far below that of the railway, these buses can only serve as a support service to assist affected passengers to continue with their journeys. It is not possible for shuttle buses to serve as full replacement for railway service. Therefore, lines queuing for such bus service are expected and most of the passengers may have to switch to other unaffected MTR lines or take alternative public transport to travel to their destinations.

Manpower deployment

14. In response to a service disruption incident, MTR staff would be on duty at each MTR station to carry out crowd management duties, make public announcements, issue station notices and help passengers on fare matters according to the established procedures in times of incidents. The number of station staff will be increased as necessary.

[1] POOA is the confederation of non-franchised public bus operators in Hong Kong. Currently, more than 200 non-franchised operators are members of the POOA and altogether they have a fleet of about 4 000 buses which accounts for about 60% of the total number of non-franchised buses operating in Hong Kong.

15. MTRCL has also established a dedicated Customer Service Rapid Response Unit ("CSRRU") with around 90 members to provide additional support focusing on customer service on top of the staff stationed at individual stations. MTRCL will, from time to time, review the number of team members of the CSRRU as necessary.

16. Upon calling out the free MTR shuttle bus services during serious service disruption, the OCC of MTRCL will mobilise the CSRRU to affected stations to provide extra support on:

- setting up facilities for the implementation of free MTR shuttle bus services;
- maintaining order at affected stations and free MTR shuttle bus boarding/alighting points;
- making timely reports to the OCC during incidents to facilitate more effective coordination with relevant Government departments such as the Police for better crowd management;
- handling enquiries and advising passengers on alternative routes and transport choices; and
- providing guidance and assistance to passengers.

17. Upon notification of deployment, CSRRU team members will proceed to the affected stations by the best available means of transport, including taxi. The first team would likely arrive within 20 minutes in most cases according to past experience. CSRRU team members are easily identifiable in their pink vests.

Regular review and updating

18. MTRCL will continue to regularly review and update its contingency plans for railway service disruption in consultation with relevant Government departments, in the light of operational experience gained in each incident.