

MTR Submits Report on East Rail Line Train Service Disruption

The MTR Corporation today (12 March 2018) submitted the results of its investigation to the Government regarding the train service disruption on the East Rail Line in the morning of 11 January 2018.

The Corporation has carried out a detailed investigation jointly with experts from the signalling equipment supplier to identify the cause of the 11 January train service incident. The investigation confirmed that the failure was due to a hidden software coding error in the Train Control System (TCS) software module related to a specific train regulation command. The adverse effect of the coding error only emerged to impact service after traffic demand had continuously increased over the years. This command was applied right before the incident, and it caused the TCS software module to trigger a situational software memory resources issue and eventually generate an “invalid message”, resulting in the halting of all the workstations and the TCS server.

The system automatically and immediately switched over to a default standby server, but it failed to recover. The system eventually resumed normal operations after the TCS fallback server and its workstations were activated manually by technical staff. After checking equipment conditions, restoring some manually secured points at those essential crossover tracks and confirming all tracks of the East Rail Line were cleared of passengers, train service gradually resumed. The incident caused a suspension of the East Rail Line train service for 122 minutes.

Throughout the incident and recovery, the signalling Automatic Train Protection and Solid State Interlocking systems, which protect the safety of train operations, were operating normally. The experts from the signalling equipment supplier also checked and confirmed that the incident was not related to the signalling replacement works currently being carried out on the East Rail Line. An independent signalling expert consultant employed by the Corporation also reviewed the investigation results and concurred with the cause of the incident and the recommended improvement measures set out below.

To prevent recurrence, the Corporation has taken the following improvement measures:

- A new software patch which rectified the software coding error has been downloaded to TCS system to eliminate the triggering of the “invalid message”;
- Recovery procedures have been further enhanced to ensure more effective recovery process in case of TCS failure;

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- TCS fallback workstations have been isolated to avoid disturbance by any software issues so as to ensure quick manual start-up if necessary;
- Round-the-Clock monitoring of the TCS performance and its software memory resources level is continuously being carried out to enhance responsiveness to any abnormality and recovery need; and
- Frequency of TCS software restarting in non-traffic hours has been increased as an additional preventive measure.

The investigation also concluded the handling of passengers in trains, stations and free shuttle bus stops was safe and orderly throughout the incident and recovery process. During the incident, station and train public announcements, passenger information displays, MTR websites and the MTR Mobile were deployed in a timely manner. An additional of 320 staff members including members of Customer Service Rapid Response Unit and support staff from back offices were deployed to assist passengers at affected stations. There were 131 free shuttle buses running along the affected stations and they served over 16,400 passengers.

For continuous improvement in customer service, the Corporation will further look into enhancing the effectiveness of the despatch of free shuttle buses, queuing plans and facilities at individual stations in consultation with relevant Government Departments as appropriate. As for the passenger information, we will further review how best to provide passenger information with more informative messages. Meanwhile, public education will also be enhanced to advise passengers to follow the guidance of Train Captains in stranded trains and not to descend onto railway tracks without instructions.

The Corporation once again apologises for the inconvenience caused to passengers who were affected by the incident.

(For details, please see the attached investigation results)

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About MTR Corporation

MTR Corporation is regarded as one of the world's leading railway operators for safety, reliability, customer service and cost efficiency. In its home base of Hong Kong, the Corporation operates ten commuter railway lines, a Light Rail network and a high-speed Airport Express link on which about 5.6 million passenger trips are made on a normal week day. Another 5.6 million passenger trips are made on the rail services it operates outside Hong Kong in the Mainland of China, the United Kingdom, Sweden and Australia. In addition, the Corporation is involved in a range of railway construction projects as well as railway consultancy and contracting services around the world. Leveraging on its railway expertise, the Corporation is involved in the development of transit-related residential and commercial property projects, property management, shopping malls leasing and management, advertising media and telecommunication services.

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**Investigation Results on
Train Control System Failure on
East Rail Line on 11 January 2018**

Investigation Results on Train Control System Failure on East Rail Line on 11 January 2018

1. The Incident

- 1.1 On 11 January 2018, at 0912 hours, the controllers in Operations Control Centre (OCC) observed an unstable condition of the server of Train Control System (TCS) which controls the signalling system of East Rail Line (EAL). In response, the system switched over from the Master TCS Server A (TCS-A) to Slave TCS Server B (TCS-B). However, the operation remained unstable. Subsequently, technical team needed to manually restart the servers but unsuccessful.
- 1.2 Having considered that the situation might persist for some time, the OCC made a prudent decision to temporarily suspend the train service of EAL at 0926 hours while the recovery work continued. Some trains which stopped between stations had to be operated in manual mode at low speed to station platforms after station staff went to trackside to do the manual setting of points.
- 1.3 During the incident, several passengers from 2 trains stranded between stations descended onto the track on their own by operating the Interior Emergency Door Release device. Station staff had to conduct a check along the concerned sections of track according to safety procedures and to escort the passengers back to station.
- 1.4 The OCC and recovery team successfully recovered and activated the TCS Fallback Server (TCS-FB), and the signalling system resumed normal operation at 1021 hours. After confirming that all sections of track were cleared of passengers, and the restoration of some manually secured points at those essential crossover tracks, train service gradually resumed at 1128 hours. The incident caused a suspension of EAL service for 122 minutes.

2. Incident Handling and Operational Arrangements

- 2.1 Having considered that the incident would last for more than 8 minutes, the OCC notified Transport Department promptly at 0918 hours (6 minutes after the occurrence). After further confirming that the signalling system could not be recovered within a short period of time and the delay would be over 20 minutes, the OCC declared it a major incident and suspended the train service of EAL at 0926 hours.
- 2.2 Red Alert was also issued. Transport Department, Railways Branch and the media were notified so that Transport Department could coordinate with other public transport operators to strengthen their service to cope with the passenger demand.

- 2.3 At the time of the incident, there were totally 31 trains running on the EAL. All of them maintained full air conditioning and lighting inside the compartment throughout the incident. As information of trains could not be displayed on the TCS, in order to ensure the safety of passengers and train operations, the OCC had to stop all train movements into or out of any station. Subsequently, the OCC had to contact the Train Captains to identify the location of each train. The identification of the location of all the 31 trains was completed at 0950 hours (24 minutes after major incident was declared).
- 2.4 Out of these 31 trains, 14 of them were identified to be stranded between stations. As a result, time was needed for station staff to access the track to secure points at crossover tracks before the stranded trains could be arranged to move safely into station platforms for detrainment. According to contingency plans, it will take not less than 60 minutes to complete securing points manually on EAL in case of relevant failures, taken into account the walking distance between stations. In this incident, a total of 28 points along the EAL were required to be secured by staff from 9 stations. The securing of points was completed at 1031 hours. Upon completion of securing the points of the locations concerned, trains were arranged to move slowly to station platforms for detrainment, which was completed at 1045 hours.
- 2.5 During the incident, 3 passengers respectively from 2 stranded trains descended onto the track on their own by operating the Interior Emergency Door Release device.
- (i) At 0950 hours, 3 passengers on the train stranded at about 500 metres away from Fanling Station descended onto the track from the train on their own. Station staff had to conduct a check along the concerned section of track according to safety procedures and to escort the passengers back to the platform.
 - (ii) At 1033 hours, another 3 passengers on the train stranded between Fo Tan Station and University Station (at about 1300 metres from the latter) also descended onto the track from the train on their own. Station staff had to spend some time again to handle the situation in addition to securing points. The passengers were intercepted and escorted back to the train, and check was conducted along the concerned section of track according to safety procedures.
- 2.6 The signalling system resumed normal at 1021 hours. After checking and testing equipment condition, and confirming that no passengers were stranded on track according to safety procedures, and the restoration of some manually secured points at those essential crossover tracks, train service gradually resumed at 1128 hours. The incident caused a suspension of EAL service for 122 minutes.
- 2.7 A total of 131 MTR Free Shuttle Buses were operated throughout the incident, carrying affected passengers to stations between Kowloon Tong Station and Lo Wu / Lok Ma Chau Stations. Display boards and banners with free shuttle bus information were posted at affected stations to direct passengers to the bus boarding points. The free shuttle buses ran from 0940 hours to

1222 hours, i.e. with extension of service for almost one hour after train service resumption. Over 16,400 passengers were served.

- 2.8 Around 320 additional staff members, including operations staff, support staff from back offices, and Customer Service Rapid Response Unit, etc. were deployed to affected EAL stations to provide assistance to passengers and to assist in crowd management and shuttle bus operation.
- 2.9 Throughout the incident, station staff activated the designated incident mode on ticketing system so as to enable passengers to exit through the gates efficiently without deduction of fare.
- 2.10 Service disruption information, including information about alternative transport as well as free shuttle bus service were disseminated in timely manner to customers through various channels, such as station and train public announcements, passenger information displays, Service Information Panels, website and smartphone apps (MTR Traffic News).
- 2.11 In addition, the Train Captains of the stranded trains constantly provided incident information to passengers through public announcement and advised passengers that the trains were being arranged to move into the stations.
- 2.12 Latest traffic updates were also provided through MTR Traffic News and communicated to the media. When train service gradually resumed at 1128 hours, the information was also disseminated to the public through MTR Traffic News and to the media.
- 2.13 The safety and order of passengers on trains, at stations and shuttle bus stops were maintained throughout the incident and during the recovery process.
- 2.14 The sequence of event is listed in Appendix.

3. Technical Recovery

- 3.1 The existing EAL signalling system ensures train operation safety through the Automatic Train Protection (ATP) system and Solid State Interlocking (SSI) system. The two systems were intact throughout the incident, which protected train operation safety. Trains will be stopped automatically if any abnormality situation was detected. The unstable system involved in this incident is mainly for train service regulation purpose.
- 3.2 Currently, train service regulations on EAL are made by executing train regulation commands on the TCS at the OCC. It was revealed that just before the incident a controller at the OCC had executed a train regulation command, thereafter, the TCS operation became unstable.

3.3 It was identified in subsequent investigation that TCS-A sent out an “invalid message” after the controller had executed the concerned train regulation command, which triggered a situational software issue. It resulted in the halting of all the OCC workstations including the fallback ones at the OCC as well as TCS-A due to surge use of its software memory resource. Figure 1 below shows the TCS servers and workstations configuration during the incident.

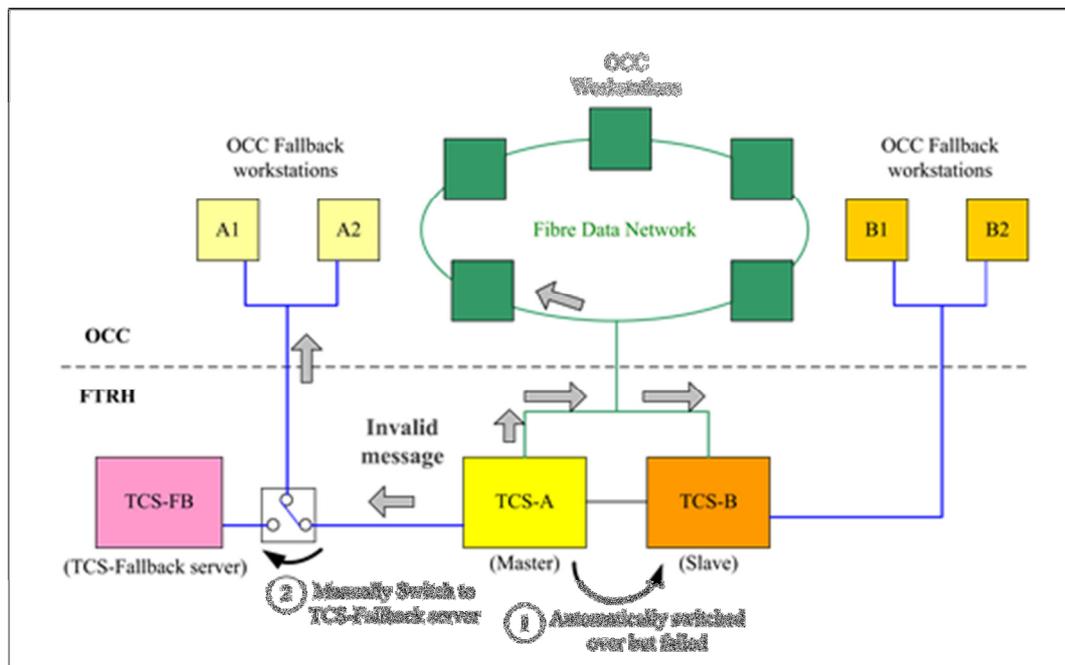


Figure 1: EAL TCS Servers and Workstations configuration

- 3.4 At the beginning of the failure, the system automatically switched over the server from TCS-A to TCS-B, but the system failed to recover with sluggish response because TCS-B was busy performing synchronization of trackside signalling status with the SSI and responding to the workstations rebooting.
- 3.5 The technical team had to manually switch over the server to TCS-FB while carrying out a few attempts to reset TCS-A and TCS-B servers. It took more time than expected because the fallback workstations were also disturbed by the “invalid message”, which needed to be rebooted.
- 3.6 The system eventually resumed normal operation at 1021 hours after the TCS-FB server and fallback workstations had been activated successfully.

4. Technical Root Cause

- 4.1 Right before the failure on 11 January 2018, a controller had executed a specific train regulation command on the TCS. Subsequently, TCS-A sent out an “invalid message”, which triggered situational software issue, resulting in the halting of all the workstations at the OCC as well as TCS-A due to surge use of its software memory resources.
- 4.2 Detailed investigation with experts from the signalling equipment supplier together with the TCS simulator server built to facilitate fault diagnosis and software testing confirmed that the failure was due to a hidden software coding error in the software application module of that specific train regulation command that had been applied right before the incident. It was also confirmed that the concerned command is the only command among all in the TCS software which may trigger the “invalid message” problem when being executed.
- 4.3 Because of such hidden software coding error, the actual execution time of this command would depend and be prolonged with respect to the ever traffic demand changes over the years resulting in more complex timetable, and also the situational software memory resources level. When the execution time reaches a threshold set in the software code, it will trigger the “invalid message” problem. Such execution time prolongation and its threshold limit built in the software was not known to MTR since day one revenue service of TCS system in 2003 noting the traffic demand has been kept on increasing over the years.
- 4.4 Signalling equipment supplier has already developed working method of using alternative command to replace the concerned command. A new TCS software patch has been downloaded to the TCS to remove the concerned command and hence eliminate the chance of triggering “invalid message” again. Moreover, it can also improve the TCS system stability.
- 4.5 Signalling equipment supplier also confirmed that the “invalid message” incident has no direct relationship with the signalling system upgrade work on EAL. It was also confirmed that the incident was not caused by sabotage. The Independent Signalling Expert Consultant employed concurred with the cause of the incident and the improvement measures set out below.

5. Improvement Measures

- 5.1 To prevent recurrence, the following improvement measures have been implemented.
 - (i) New software patch has been downloaded to TCS system to eliminate the chance of triggering the “invalid message”.

- (ii) The recovery procedure has been further enhanced to ensure more effective recovery process in case of TCS failure including this new failure symptom.
- (iii) The TCS fallback workstations have been completely isolated from TCS-A and TCS-B to avoid disturbance by whatever software issues so as to ensure quick manual start-up whenever necessary. Figure 2 below shows the enhanced TCS servers and workstations configuration.
- (iv) Round-the-clock monitoring of the TCS performance and its software memory resources level has been carried out to enhance responsiveness to any abnormality and recovery need.
- (v) The frequency of TCS software restarting in non-traffic hours has been increased as an additional preventive measure.

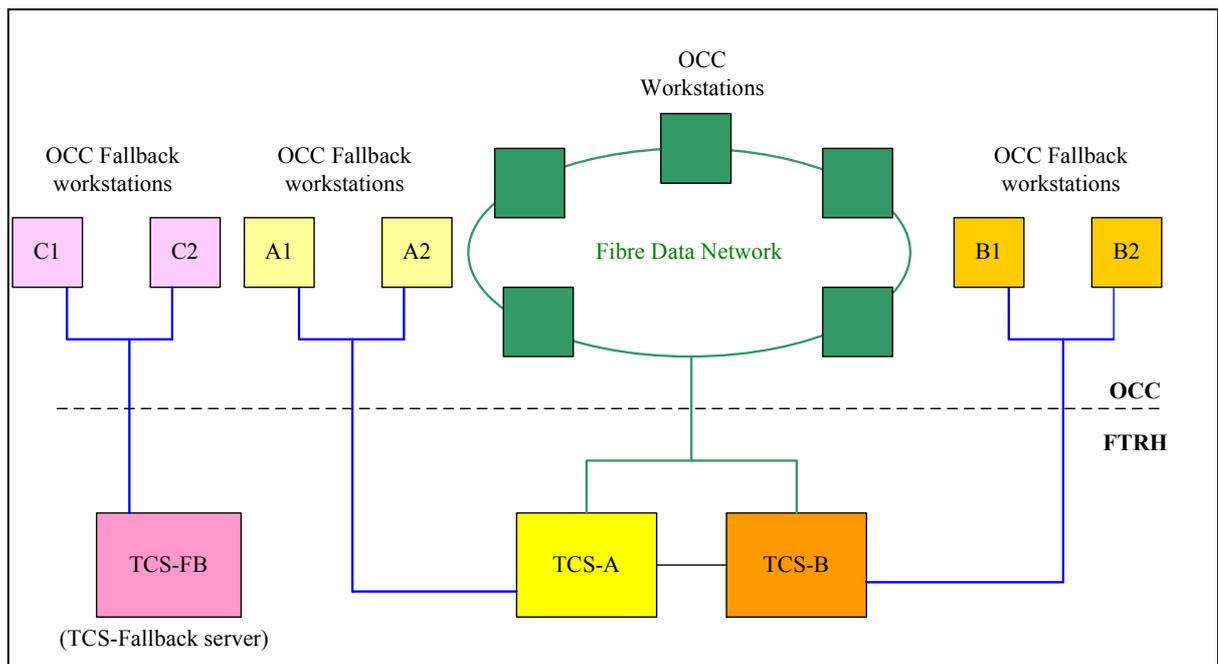


Figure 2: EAL TCS Servers and Workstations enhanced configuration

5.2 For continuous improvement in customer service, the Corporation will further look into enhancing the effectiveness of the despatch of free shuttle buses, queuing plans and facilities at individual stations in consultation with relevant Government Departments as appropriate; and will further review how best to provide passengers with more informative messages during service disruption. Meanwhile, public education will also be enhanced to advise passengers to follow the guidance of Train Captains in stranded trains and not to descend onto railway tracks without instructions.

6. Conclusion

- 6.1 Unstable condition of the server of TCS was experienced at the OCC in the morning of 11 January 2018. The situation persisted despite switchover and rebooting of the servers. Having considered that the situation might persist for some time, the OCC made a prudent decision to temporarily suspend the train service of EAL at 0926 hours.
- 6.2 To ensure the safety of passengers and train operations, time was inevitably needed for identifying the location of each train. Subsequently, manual securing of points at crossover tracks on the whole line and manual train movements at low speed to station platforms for detrainment were required.
- 6.3 During the incident, 3 passengers respectively from 2 stranded trains descended onto the track on their own by operating the Interior Emergency Door Release device.
- 6.4 The signalling system resumed normal at 1021 hours. After checking and testing equipment condition, and confirming that no passengers were stranded on track according to safety procedures, and the restoration of some manually secured points at those essential crossover tracks, train service gradually resumed at 1128 hours.
- 6.5 The incident caused a suspension of EAL service for 122 minutes. MTR Free Shuttle Bus service was provided during the affected period. The safety and order of passengers on trains, at stations and shuttle bus stops were maintained throughout the incident and during the recovery process. The shuttle bus service arrangement and dissemination of passenger information were reviewed for continuous improvement in customer service.
- 6.6 From the detailed investigation conducted jointly with experts from the signalling equipment supplier, it was found that a situational software issue was triggered after a specific train regulation command had been executed in the TCS, resulting in the halting of all the workstations at the OCC and TCS-A due to surge use of its software memory resource. The root cause of generating the “invalid message” was due to a hidden software coding error in the software application module of that specific command.
- 6.7 The improvement measures stated in 5.1 above to prevent recurrence of the incident and enhance the recovery process have been completed. The new software patch with the software coding error rectified has been downloaded to the TCS system to eliminate the chance of generating “invalid message” again. The recovery procedure has also been further enhanced to ensure more effective recovery process in case of TCS failure including this new failure symptom.
- 6.8 The Independent Signalling Expert Consultant employed concurred with the cause of the incident and the identified improvement measures.

Appendix

East Rail Line Incident (11 January 2018)

Sequence of Events

Time	Event
0912	The Controllers in OCC observed an unstable condition of the server of TCS which controls the signalling system of EAL. Technical team attempted to manually restarted the server but unsuccessful.
0913	TCS server switched over from TCS-A to TCS-B automatically.
0917	Execution of TCS application for resuming TCS-B failed.
0924	Switchover of TCS to TCS-FB was carried out.
0926	<p>OCC made a prudent decision to temporarily suspend the train service of EAL while the recovery work continued.</p> <p>14 trains were identified to be stranded between stations. Station staff needed to access the track to secure points before the stranded trains could be arranged to move safely into station platforms for detrainment.</p> <p>OCC disseminated the service disruption information to customers through smartphone apps (MTR Traffic News).</p>
0940	The first shuttle bus departed Kowloon Tong Station for Lok Ma Chau Station.
0950	3 passengers descended onto the track from a stranded train near Fanling Station by operating the Interior Emergency Door Release device. Station staff conducted checking along the concerned section of track according to safety procedures, and escorted the passengers back to the platform.
1021	TCS-FB server was reinstated after several attempts of switchover and rebooting. TCS resumed normal. Checking and testing of

Time	Event
	equipment condition and the restoration of some manually secured points at crossover tracks were arranged.
1033	Another 3 passengers on a stranded train between Fo Tan Station and University Station descended onto the track on their own by operating the Interior Emergency Door Release device. Station staff had to spend some time again to handle the situation before train service could resume safely.
1125	Station staff brought all passengers back to the train and confirmed the track was clear of passengers.
1128	Train service of EAL gradually resumed.