PR108/18
19 December 2018

**MTR Adopts Enhancement Measures after Service Disruption on Tsuen Wan Line, Island Line, Kwun Tong Line and Tseung Kwan O Line**

The MTR Corporation today (19 December 2018) submitted to the Government the results of its investigation into the service disruption which occurred on the Tsuen Wan Line (TWL), Island Line (ISL), Kwun Tong Line (KTL) and Tseung Kwan O Line (TKL) on 16 October 2018.

The Corporation takes the service disruption very seriously. An Executive Review Panel co-chaired by the Operations Director Mr Adi Lau and Engineering Director Dr Peter Ewen was set up to look into the incident, in consultation with three external experts who provided professional advice during the investigation.

Cause of the Incident

The signalling systems of the four lines concerned were provided by Alstom (for most parts of KTL and the entire TWL and ISL) and Siemens (for the remaining part of KTL and the entire TKL) with their respective equipment designed to the same SACEM signalling system functional standards. The Alstom and Siemens systems are linked through sector computers at Kwun Tong and Lam Tin stations. There are 33 sector computers along the four lines which are interconnected to allow trains to cross lines in order to optimize train service to cater for operational needs, and these computers are always synchronized through their software counters to ensure the correct delivery of train control commands. The sector computers of the Alstom and Siemens systems have been put into service in different years since 1996. Their software counters are synchronized to the higher counter figure among the lines and require re-initialization when they reach the ceiling figure. It was found during the investigation that the counter re-initialization arrangement for the Alstom and Siemens systems is different due to their different design. The former will automatically re-initialize some time prior to reaching its ceiling figure, while the latter need to be manually re-initialized.

The Panel concluded that the root cause was the different software counter re-initialization arrangements of the two connected systems when the re-initialization was activated at the incident time on 16 October 2018. Since the four lines are connected, the inconsistent re-initialization situation led to repeated re-synchronization causing instability in sector computers. The software counter re-initialization algorithm, the differences in the counter re-initialization arrangements between the Alstom and Siemens systems and the possible impact on the train service were not known to the operators and maintainers, nor were they explicitly described in the Operation and Maintenance Manuals. The Panel also concluded there was no correlation between the incident and the signalling replacement project and its testing.

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Handling of the Incident

The MTR principle for incident recovery is to firstly ensure safety throughout the process, and to continue to provide train service as far as possible in an orderly manner while minimizing delays. The Panel concluded that this principle was consistently applied during the incident. While safe train services were maintained at a reduced speed under proper over-speed protection, signalling maintenance staff used their best efforts to isolate and reboot the 33 sector computers located at different MTR stations through a logical deduction process in order to recover the systems.

The Panel noted that the Corporation had notified the Transport Department ("TD") of the incident and issued alerts in accordance with the requirements set out in the existing "Action Checklist on Emergency Public Transport Service for MTR Service Breakdown" published by TD. Train service information was disseminated in a timely manner to the public via the MTR mobile app "Traffic News", MTR website, announcements at MTR stations and on trains, passenger information displays at MTR stations and through the media. The cooperation of the passengers and assistance of the Police had enabled the Corporation to maintain order at MTR stations. Over 400 additional staff members were deployed to assist passengers on the day.

After having carefully considered the option of providing shuttle bus service during the incident, the Corporation considered such option as impractical for a number of reasons. Firstly, given the limited carrying capacity of buses and the scale of the disruption across four lines, it would lead to very long queues and unacceptable waiting time. Secondly, since there are currently no planned or pre-agreed bus routes with parties concerned including TD to cater for disruption in multiple lines, in the absence of such plans, relevant drills and exercises previously conducted and properly planned supporting arrangements such as locations for bus laybys and queuing points, it is impossible to operate unplanned shuttle bus service in a safe, effective and orderly manner. If shuttle bus service was provided without proper planning, passengers may waver between taking the train or the bus, which would lead to conflicting passenger movements that would have exacerbated the congestion at MTR stations and on the streets. The Panel opined that the decision of not providing shuttle bus service during the incident was not an unreasonable one in view of the established procedures and circumstances.

Improvement Measures

Following the incident, the Corporation installed manual switches to allow effective disconnection/connection of the interconnections between the relevant lines whenever necessary. Regular checking of the software counter operation of all relevant lines has been implemented to ensure the counter value is normal. The signalling systems of other rail lines were also checked and they have been either re-initialized or do not have any similar inconsistent re-initialization issue.

Key recommendations made by the Panel for continuous improvement include:

- To conduct a review and implement a maintenance programme to manually re-initialize all of the software counters in the railway systems, particularly the signalling systems, before they reach the triggering or ceiling figure;

- To establish a dedicated team with experts from the academia and the industries to enhance software integration and performance for future newly built and modification of critical railway systems;
- To take into account the challenges including additional platform dwell time during service disruption when providing information on train services, including the time for the first train and train service headway;
- To invite passengers to participate in more drills and exercises to better understand passenger interaction during service disruption; and
- To conduct a review with TD by mid-2019 to examine the feasibility of deploying shuttle buses to major MTR stations along affected sections or stations where there are few or no alternative transport when there is a prolonged service delay or limited train service on the entire line.

The Corporation once again apologises for the inconvenience caused to passengers during the incident.

Please refer to the annex for the results of the investigation.

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**Annex**

# Executive Review Panel Report on the Signalling Failure on the Tsuen Wan, Island, Kwun Tong and Tseung Kwan O Lines on 16 October 2018

## 1. Introduction

1.1 On 16 October, at 05:28 hours, the Operations Control Centre (OCC) received reports that trains running on the Tsuen Wan (TWL), Island (ISL) and Kwun Tong (KTL) lines were receiving unstable train control commands from the signalling system and that they had to be operated in Restricted Manual (RM) mode in accordance with the safety procedures. At 10:02 hours, signalling failure was also reported on the Tseung Kwan O Line (TKL).

1.2 After isolation of the interconnections between the signalling systems of the four incident lines, all the sector computers were re-booted to complete a full re-initialization process. Normal signalling control on the ISL, KTL and TWL was successfully resumed at 09:20 hours, 11:10 hours and 11:30 hours respectively. Normal off-peak train services for the ISL, KTL and TWL were restored at 11:10 hours, 11:30 hours and 11:45 hours respectively to cope with train service regulation amongst lines. Normal train service resumed on the TKL at 11:24 hours.

## 2. The Executive Review Panel

2.1 On 22 October 2018, the Corporation set up an Executive Review Panel to establish the facts and circumstances surrounding the incident and its immediate aftermath by identifying the root cause(s) leading to the incident and reviewing the timeliness and effectiveness of the incident response and recovery process. The Panel was also tasked to assess and advise on the timeliness and adequacy of the information provided to the public and the arrangement of the train service and to identify areas for improvement.

2.2 The Panel was chaired jointly by Adi Lau, Operations Director and Peter Ewen, Engineering Director. Membership consisted of senior MTR personnel in the fields of Operations and Engineering as well as three external experts, namely Michael Hamlyn and Bruce MacDougall Fellow of the Institution of Railway Signal Engineers and Professor S.L. Ho of the Department of Electrical Engineering, HK Polytechnic University.

## 3. Handling of the Incident

3.1 The Incident

3.1.1 On 16 October, at 05:00 hours, engineering trains began returning to the depot using the existing signalling system after finishing tests on the new signalling system. At 05:28 hours, some 30 minutes before the start of passenger service, the incident was reported when trains running on the TWL, ISL and KTL began receiving unstable train control commands from the signalling system. To maintain safe operations, all trains had to be operated in RM mode with a set maximum speed of 22kph. The OCC immediately arranged for maintenance staff to investigate the fault. As the problem had not been resolved by the start of passenger service, an Amber Alert was issued at 06:00 hours, while the Signalling Indication and Control Panel (SICP) was rebooted. However, the reboot was not successful and as it was then anticipated that the fault would continue for 20 minutes or more, a Red Alert was issued at 06:20 hours. Information of an extra travelling time of 40 minutes was disseminated at the same time.

3.1.2 At 10:02 hours, trains running on the TKL were affected by a similar signalling failure and also had to be operated in RM mode, resulting in an extra travelling time of 25 minutes. A Red Alert for the TKL was issued at 10:14 hours.

3.1.3 A limited train service was maintained on the incident lines. Normal signalling control on the ISL, KTL and TWL was resumed at 09:20 hours, 11:10 hours and 11:30 hours respectively. Normal off-peak train services for the ISL, KTL and TWL were restored at 11:10 hours, 11:30 hours and 11:45 hours respectively to cope with train service regulation amongst lines. Normal train service resumed on the TKL at 11:24 hours.

3.2 Notification

3.2.1 According to the Action Checklist on Emergency Public Transport Service for MTR Service Breakdown (Action Checklist) issued by Transport Department (TD), MTR is required to inform the TD Emergency Transport Coordination Centre (ETCC) within 8 minutes of any service disruption that has occurred for 8 minutes or is expected to last for 8 minutes or more.

3.2.2 On the incident day, the OCC first knew of a problem at 05:28 hours. At 05:46 hours, maintenance staff reported to the OCC that the SICP had to be rebooted as is the normal procedure to recover the signalling system. Once the OCC learnt that the SICP needed to be rebooted, they started the notification process anticipating that the fault would extend into traffic hours causing delays to train service. The OCC notified the ETCC at 05:52 hours, 6 minutes after learning that passenger service would be affected, i.e. within the requirement of 8 minutes as stated in the Action Checklist. Immediately after informing the ETCC, the OCC informed the media. Passengers were also informed through MTR mobile apps “Traffic News”.

3.2.3 At 06:00 hours, the Amber Alert was issued on the basis that train service would be affected during the initial period of traffic hours before the completion of the SICP reboot.

3.2.4 Rebooting the SICP did not resolve the problem and so at 06:17 hours it was decided to reboot the sector computers in stations. As this reboot was expected to be a lengthy process and the delay would continue for 20 minutes or more, the OCC issued a Red Alert at 06:20 hours.

3.2.5 The Panel considered that the notification to TD was made in accordance with and within the requirements of the Action Checklist and both the Amber Alert and Red Alert were properly issued. However, with the experience gained in this incident, the Panel considered that the communication on incidents during non-traffic hours that might seriously affect the first train service could be introduced.

## 3.3 Train Service Arrangements

3.3.1 The MTR principle when recovering an incident is first to ensure safety throughout the process; then to continue train service as much as possible in an orderly manner while at the same time minimizing delays. During the incident, all trains operating in RM mode were operated under a caution speed of not greater than 22kph under over-speed protection, with all train movements having to be authorized by the Traffic Controller in accordance with procedures. The Panel concluded that this principle was consistently applied in managing the train service safely throughout the incident.

3.3.2 Train service was initially planned at a headway of 8 minutes and later adjusted to 12 to 15 minutes when it was realized that the time taken for communication between the OCC and train captains in accordance with the safety procedures stipulated for manual mode train working, was longer than anticipated. Passengers were also informed of a longer waiting time for trains of at least 30 minutes and an extra travelling time of 40 minutes.

3.3.3 However, there was a discrepancy between the announced headway and the actual headway achieved. The discrepancy was primarily caused by prolonged dwell times at station platforms due to the need to allow more time for passengers alighting and boarding the train at crowded platforms. In addition, numerous passengers inside trains operated Passenger Alarm Devices, and it took time for staff to enter congested trains to reset them. On the other hand, as the incident happened before the start of traffic, and trains had to run under manual mode with train speed not greater than 22kph over long distances from depots to the originating stations to start service, passengers experienced the longest waiting times for the first trains.

## 3.4 Station Management

3.4.1 Integrated crowd management measures were implemented at stations along the TWL, ISL, KTL and TKL during the incident. More than 400 staff including those from cross-line backup, the Customer Services Rapid Response Unit (CSRRU) and office staff under the Customer Service Support Team (CSST) were deployed at various stations to provide assistance to passengers. Despite the large number of passengers waiting at stations especially the interchange stations, the Panel agreed that, all stations were maintained in an orderly manner with the assistance of the Police and additional staff and through effective public announcements and integrated crowd management measures as well as the good co-operation of passengers.

3.5 Alternative Transport Arrangements

3.5.1 From the outbreak of the incident, MTR notified passengers of the situation through different channels including the MTR website, MTR mobile app, media, public announcements in stations, etc. and advised them to use alternative transport. The Red Alert was also declared in a timely manner so that TD could coordinate with other public transport operators to enhance services for affected passengers.

3.5.2 The existing Action Checklist specifies the shuttle bus routes to be provided when the train service for specific sections of TWL, ISL, KTL or TKL is suspended and also the principle of provision. The principle of the shuttle bus service is to carry affected passengers to the nearest MTR station where train service is still available so they can access the operating section of the rail network. Such routes are pre-planned and agreed with parties concerned including TD to ensure that all operational aspects including temporary bus stops and queuing points are acceptable from a traffic management perspective.

3.5.3 The provision of a shuttle bus service during this incident was considered but it was decided that it would be impractical for a number of reasons. Firstly, there was no planned and agreed bus route under the failure scenario of the incident in the Action Checklist. For all planned routes, the impact on road traffic is thoroughly assessed and the bus stopping points are pre-determined to minimize congestion. The routes and bus stops are not only agreed by TD but also well communicated with the Police. MTR station and CSRRU staff are well trained on all the scenarios of the planned shuttle bus routes and are familiarized with the working through drills and exercises. Without this planning, coordination, training, drills and exercises, it was considered impractical to operate unplanned shuttle bus services covering over 40 stations on the incident day in a safe, effective and orderly manner. Secondly, in the face of the scale of the disruption, and given the limited number of shuttle buses available during peak hours and the limited carrying capacity of buses, running shuttle buses would lead to very long queues at the street level and unacceptable waiting times. Moreover, passengers would have likely wavered between taking the limited train service or the shuttle bus, leading to unnecessary and conflicting passenger movement that would have exacerbated the congestion at stations and in nearby streets. The MTR therefore decided to focus its attention on maintaining the train service and managing passengers boarding and alighting.

3.5.4 The Panel opined that it was not an unreasonable decision not to provide a shuttle bus service during the incident in view of the established procedures and taking into account all the circumstances of the case. However, with the experience gained in this incident, the Panel considered that it would be worth reviewing with TD to explore the practicability and effectiveness of running shuttle bus service for strategic stations during similar incidents.

3.6 Service Recovery

3.6.1 Immediately after the incident occurred, maintenance staff were dispatched to carry out investigations and emergency recovery. The rebooting of 33 sector computers with the deployment of professional staff to 33 sites across all four incident lines and the time taken in executing the coordinated rebooting based on a prudent logical deduction process presented unprecedented challenges. After the interconnections between the relevant lines were isolated and all sector computers were effectively rebooted, the signalling systems of the four incident lines gradually resumed.

> ***"Unaware of the software counter re-initialization issue, MTR were faced with a multiple line event of unprecedented scale with no easily identifiable cause or source"***
>
> ***"the only approach is one of logical elimination whilst breaking the problem down into manageable pieces, a difficult process to manage at any time but especially so under such pressure to restore services"***
>
> ***"the decision to attempt a whole line coordinated restart was inspired, but presented a daunting logistical challenge"***
>
> ***Michael Hamlyn***
> ***Overseas External Signalling Expert***

3.6.2 Normal signalling control on the ISL, KTL and TWL was successfully resumed at 09:20 hours, 11:10 hours and 11:30 hours respectively. Normal off-peak train services for the ISL, KTL and TWL were restored at 11:10 hours, 11:30 hours and 11:45 hours respectively. Normal train service resumed on the TKL at 11:24 hours.

3.6.3 The prolonged recovery time was also contributed by the unprecedentedly large number of affected sector computers installed at 33 stations across the four incident lines which hampered the mobilisation of signalling maintenance staff to each of the locations for recovery. There were more than 50 numbers of signalling maintenance staff deployed to various stations, carrying out the required recovery actions in a coordinated manner. However, with the experience gained in this incident, the Panel considered worth reviewing the existing manpower backup support arrangement in the recovery procedures for speeding up the overall recovery process.

## 4. Passenger Information

4.1 Service disruption and train service information updates (including both headway and expected additional waiting time) were disseminated to passengers and the general public in a timely manner through various channels including the MTR website and MTR mobile apps “Traffic News”, announcements at stations and on trains, and through passenger information displays in stations. Incident information and service updates were also proactively provided to the media.

4.2 Passenger information of extra waiting time and extra travelling time allowed passengers to plan their journeys and consider whether to continue using the MTR for travel during the incident. As a result of management of passenger expectations together with the implementation of crowd management measures and assistance from the Police, passengers in stations were generally calm and all stations maintained good order despite very large numbers of waiting passengers.

4.3 However, feedback from passengers revealed that they experienced a longer waiting time in reality than that being communicated. This was mainly because the planned train service headway could not be achieved for reasons discussed in paragraph 3.3.3. Passengers also said they were not aware of alternative transport information provided during the incident. The Panel therefore considered that more realistic train headway information and more education on access to information about alternative transport and the use of the MTR mobile apps (Citymapper Link) would have helped passengers better decide on the action they wished to take during the service disruption.

## 5. Cause of the Incident

5.1 Signal System Overview and the Root Cause

5.1.1 All the four incident lines use the SACEM signalling system with the equipment on the TWL, ISL and most of KTL (from Whampoa (WHA) to Kwun Tong (KWT) stations) designed and supplied by Alstom and that for TKL and the rest of KTL (from Lam Tin (LAT) to Tiu Keng Leng (TIK) stations) by Siemens. Whilst the equipment provided by the two suppliers differs in detail, it is designed to the same SACEM functional system standards to allow uninterrupted through train working across the four lines.

5.1.2 The Alstom system is equipped with 25 sector computers and has been in use since 1996 (including two sector computers for ISL extension and KTL extension that were put into service in 2014 and 2016 respectively). The Siemens system covered 8 sector computers and has been in use since 2001 and 2002 respectively. The sector computers are located in the Signal Equipment Room (SER) at stations and serve to deliver train control commands to all trains in each respective sector. The sector computers for each line are interconnected by Inter-sector Links to manage trains running between sectors. There are also interconnections between lines to allow trains to cross between lines to optimize train service when there is an operational need. The two suppliers' sector computers are linked between KWT (Alstom) and LAT (Siemens), i.e. along the KTL (refer to Figure 1 in the appendix).

5.1.3 Data transmission between sector computers is always synchronized through an internal software counter in each sector computer. If any individual sector computer is individually rebooted, its counter will be re-initialized and will immediately synchronize to the higher counter figure for the whole synchronized network. Therefore, when the Siemens sector computers were commissioned and put into service in 2001/2002, the relevant counters were synchronized to those of the Alstom sector computers which were installed in 1996. If the counter reaches its ceiling figure, the associated sector computer will halt and need to be re-initialized. However the counter re-initialization arrangements for the two suppliers' sector computers are different. The Alstom sector computers will be re-initialized automatically once their counters reach an in-built re-initialization triggering point approximately 5 hours before reaching the ceiling figure. However, this internal software function was not made known to the operators and maintainers. The Siemens sector computers do not have an automatic re-initialization function and therefore need to be manually re-initialized through rebooting in SER by maintenance staff.

5.1.4 At around 05:26 hours on the incident day, the Alstom software counters reached the triggering point for automatic re-initialization while the Siemens sector computers continued counting up, creating an inconsistent re-initialization situation between the two interconnected sector computers at KWT (Alstom) and LAT (Siemens). This resulted in repeated execution of re-initialization followed by re-synchronization with the higher counter figure from LAT, in the KWT sector computer in an endless loop causing corresponding instability in all 25 Alstom sector computers in the system.

5.1.5 When all the Siemens software counters reached the ceiling figure at around 10:22 hours, some 5 hours after the Alstom sector computers had passed their automatic re-initialization triggering point, the 8 Siemens sector computers halted as designed. Moreover, trains on the TKL had already encountered trainborne signalling failure earlier at 10:02 hours due to the around 20 minutes counter look ahead validity requirements.

5.1.6 After the interconnections between the signalling systems of the relevant lines and the Alstom and Siemens sector computers between KWT and LAT were isolated, all sector computers were effectively rebooted to complete the entire re-initialization process and the signalling system for the four incident lines resumed normal.

5.1.7 Simulations during non-traffic hours reproduced the same fault when the sector computers of both the Alstom and Siemens systems were loaded to operate with the same set of software counter figures as those at the material time of the incident.

5.1.8 The software counter re-initialization algorithm and the differences in the counter re-initialization arrangements between the Alstom and Siemens systems and the possible impact on the train service were not known to the operators and maintainers nor were they explicitly described in the Operation and Maintenance Manuals. Although in Siemens documentation the requirement for resetting all sector computers after 20 years of operation was stated, the information was inadequate and unclear for the operators and maintainers to be aware of any need of further pursuing this specific system behaviour of the interconnected Alstom and Siemens systems. As a result, the counters of all four incident lines have never been effectively re-initialized wholly since their installation and they all reached the ceiling figure on the incident day, causing the incident.

5.1.9 Based on the signalling system data records on the incident day, the subsequent signalling system testing and simulations conducted, in-depth analysis by the two signalling system suppliers and external experts, the Panel concluded that the root cause of the incident was the inconsistent software counter re-initialization arrangements of the signalling equipment provided by the two different suppliers. As all the incident lines were interconnected, the synchronization between sector computers led to propagation of a resulting instability to Alstom-equipped areas, i.e. the ISL, TWL, and most of KTL. A lack of provision for counter re-initialization wholly for all lines then affected Siemens-equipped areas, i.e. the TKL and the rest of KTL.

> ***"The immediate cause of the incident that initially affected the ISL, TWL and most of the KTL was an incompatibility between the software counter re-initialization provisions in SACEM sector computers from two different suppliers."***
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> ***"The underlying cause was that MTR were unaware of the software counter re-initialization incompatibility between Alstom and Siemens sub-systems because there was no documentation that described the automatic re-initialization function of the Alstom equipment."***
>
> ***"The immediate cause of the extension of the incident to the rest of the KTL and to the TKL was that no manual re-initialization of the entire interconnected SACEM system had been carried out."***
>
> ***"The underlying cause was that MTR had not fully appreciated the implications for whole system behavior of the interaction of software counters between adjacent sector computers."***
>
> ***Michael Hamlyn***
>
> ***Overseas External Signalling Expert***

5.1.10 Based on the signalling data records, the incident occurred only after the signal replacement project testing work on the TWL had been completed and the signalling system had been switched back to the existing SACEM system around 50 minutes before the incident and trains had operated normally for some time. Therefore the Panel concluded that there was no co-relation between the incident and the signal replacement project and its testing.

> ***"Since it has been proved that the instability is caused by the discrepancy in the 're-initialization' of the Software Counter of the Alstom System and the Siemens System and coupled with the fact that the SACEM system has been operating from 5:06 am until the Software Counter reached 7FFF2F9C at 5:26 am on 16th October 2018, one could rule out the possibility of the new signaling system disturbing the SACEM legacy system on 16 October 2018."***
>
> ***Professor S.L. Ho***
>
> ***External Expert***
>
> ***Note: 7FFF2F9C is a hexadecimal number equivalent to 2,147,430,000 in decimal number, that means around 22 years and 8 months.***

5.1.11 During recovery of the incident, the Security Operation Centre (SOC) checked that there were no suspicious activities that triggered any security alerts on the Corporate Data Network (CDN) safeguard between 00:00 hours and 09:20 hours on 16 October 2018. A detailed review of security event logs confirmed that there were no security issues or suspicious connections between the CDN and the Internet on the incident day. Therefore the Panel concluded that the incident was not a result of computer virus or sabotage.

5.2 Preventive and Improvement Measures

5.2.1 As a short-term measure, the interconnection of the sector computers of the TWL, ISL and KTL has been temporarily segregated, while the interlink between the sector computers at KWT and LAT, and between KTL and TKL continue to be interconnected due to system operational needs. With the conclusion of the root cause and recommended by the Panel, manual switches have been installed to allow effective disconnection/connection of the interconnections between the three lines, and the relevant recovery procedures have been developed for future application. The Panel considered that the sector computers could be re-connected.

5.2.2 As recommended by the Panel, regular checking of software counter operation for all SACEM equipped lines has been implemented to ensure the counter value is normal. For even better risk control and mitigation, all the sector computers of the Airport Express and Tung Chung Line were effectively re-initialized manually on 25 November 2018. The signalling systems of other lines have also been checked and clarifications have been made with the relevant suppliers. There are software counters in some other lines that also require re-initialization that can be done manually or automatically depending on the signalling system design of the particular line. However, these systems are not at any risk of an uncoordinated software counter re-initialization problem as occurred in this incident.

## 6. Conclusions

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

a) Train service was maintained at a reduced capacity and in a safe manner during the incident.

b) The notification to TD was made in accordance with the requirements of the existing Action Checklist and both the Amber Alert and Red Alert were properly issued.

c) The decision of not running shuttle buses was not unreasonable in view of the established procedures and when all the circumstances of the incident were taken into account.

d) Passenger Information was disseminated in a proactive and timely manner through various channels, although there was a discrepancy between the announced headway and the actual headway achieved.

e) The root cause of the incident was the inconsistent software counter re-initialization arrangements of the two types of signalling equipment supplied by Alstom and Siemens. As all the incident lines were interconnected, the synchronization between sector computers led to propagation of a resulting instability to the ISL, TWL and most of KTL. A lack of provision for counter re-initialization then affected the TKL and the rest of KTL.

f) There was no co-relation between the incident and the signal replacement project and testing. Nor was the incident a result of computer virus or sabotage.

## 7. Recommendations

7.1 The Panel has made recommendations with the experience gained in this incident in the following areas in order to avoid recurrence of the incident and to enhance the contingency arrangements in case of similar incident:

7.2 Recommendations for enhancing information disseminations and contingency arrangements:

a) For continuous improvement, communication with TD should be enhanced during non-traffic hours on incidents that might seriously affect the first train service.

b) OCC should take into account the challenges of manual mode train working at low speed (≤ 22kph) and the additional platform dwell time under the limited train service scenario along a whole line when providing information about the first trains and planning the train service headway during train service disruption.

c) The contingency plans and passenger information should be reviewed for enhancement during a line-wide service disruption scenario based on the experience of this unprecedented incident.

d) A review should be conducted with TD by mid-2019 to examine the feasibility of also deploying shuttle buses for major railway stations along affected sections and for stations where there is little or no alternative transport, including the running of express shuttle bus route to other railway line in service, when there is prolonged delay of service or during the situation of a line-wide limited train service, with priority given to lines involving more remote areas such as Tseung Kwan O, Tung Chung, East Rail and West Rail lines. Interim measures of shuttle bus deployment should be developed before completion of the review.

e) Passengers should be invited to participate in more physical drills and exercises so that MTR can better understand passenger interaction during service disruption and further enhance passenger information dissemination.

7.3 Recommendations for avoiding recurrence of the incident:

a) The numbers, locations and backup provision for critical units should be optimized and such requirements should be included in Signalling System Design Standards for future new signalling systems in order to guard against common mode failures that could simultaneously affect equipment in different locations, and to minimize impact on the train services and maximize recovery efficiency in case of system failure.

b) With the resumption of the interconnections between the TWL, ISL and KTL, regular drills should be conducted on the procedures developed for recovery of the incident and the manpower backup support deployment plan should be reviewed to facilitate prompt recovery.

c) Regular checking of software counter figures for all relevant lines should be conducted, and a maintenance programme should be implemented for manual re-initialization of all the software counters in the signalling systems of relevant lines before the software counters reach the relevant triggering or ceiling figure.

d) A review of all operating railway software based systems should be conducted to determine whether or not there are other similar system counters with re-initialization issues, and follow up as appropriate.

e) A dedicated team with advisors from academia and related industries should be established as and when required to enhance the introduction and subsequent modifications of new software based systems are well controlled, and to establish an assurance mechanism to enhance software performance and integration for service critical systems.

- End of Report -

Appendix

Figure 1 - Configuration and Interconnection of Sector Computers