Legislative Council Transport Panel
Sub-Committee on Matters Relating to Railways
14 April 2020

Derailment Incident at Hung Hom Station on East Rail Line on 17 September 2019 and Incident happened near Lai King Station on Tsuen Wan Line on 6 October 2019

This paper reports on two incidents happened respectively in September and October 2019:

a) the derailment incident happened near Hung Hom Station (HUH) on East Rail Line (EAL) on 17 September 2019; and
b) the incident happened near Lai King Station (LAK) on Tsuen Wan Line (TWL) where a train had hit the concrete buffer beside the railway track on 6 October 2019.

The MTR Corporation Limited (MTRCL) apologised for the affected passengers in the two incidents. The Corporation will learn the lessons and make the best attempt to avoid the recurrence of similar incidents.

Part I: Derailment incident happened near HUH on EAL on 17 September 2019

2. The Government and the MTRCL are very concerned about the derailment incident that occurred near HUH on the EAL on 17 September 2019. Immediately after the incident, the MTRCL promptly set up an investigation panel[1] (the Panel) comprising local and overseas

[1] MTRCL appointed then Operations Director Mr Adi Lau and Engineering Director Dr Peter Ewen to jointly chair the Panel, and invited three local and overseas experts to provide expert advice. They are Mr Ravi Ravitharan, Director of the Institute of Railway Technology, Monash University; Mr Owen Evans, Senior Vehicle Dynamicist, Resonate Group Limited; and Professor SL Ho, Associate Vice President (Academic Support), The Hong Kong Polytechnic University. The Panel comprises also nine senior representatives of the Operations and Engineering divisions of MTRCL.

experts and senior representatives of the MTRCL to investigate into and identify the root causes of the incident and to propose recommendations for improvement. The Panel completed the investigation and submitted a report to the Electrical and Mechanical Services Department (EMSD). EMSD also completed its independent investigation. The respective reports of the MTRCL and EMSD were released on 3 March 2020 (at **Annex 1** and **Annex 2**).

The incident

3. On 17 September 2019 at 8:29 a.m., a train in passenger service from Mong Kok East Station (MKK) approaching HUH platform 1 derailed at the turnout P5116 north of the station. Three cars (the 4th, 5th and 6th cars) derailed and the train was divided between the 4th and 5th car. At 8:32 a.m., train service of EAL between HUH and MKK was suspended. All passengers in the train (about 500) were detrained in a safe and orderly manner to HUH platform by about 9:43 a.m.. In the incident, eight passengers were reported injured and received first aid and medical treatments, among whom two were admitted to hospital.

4. After the safe evacuation of the passengers, the MTRCL immediately arranged on site investigation and subsequent emergency recovery works. Two crane vehicles were deployed to lift the derailed train cars and re-position them on the tracks, which was a time-consuming and challenging process. Upon the notification from the MTRCL, EMSD has immediately sent colleagues on site to conduct investigation, and monitored the whole recovery and testing work of the MTRCL.

5. As a result of the incident, train service between HUH and MKK was suspended on the day of the incident and the frequency of EAL and West Rail Line (WRL) were adjusted. The MTRCL arranged free shuttle buses to run between Tai Wai and Diamond Hill stations to help divert passengers. The train service between HUH and MKK was resumed at 6:05 a.m. on 18 September 2019 using HUH platform 4 alone. On 20 September 2019, both EAL platforms (i.e. platforms 1 & 4) of HUH resumed service.

6. The sequence of events is set out in **Annex 3** and the contingency arrangements during the incident are provided at **Annex 4**.

The cause of the incident

7. After a rigorous and in-depth investigation, the Panel concluded that the derailment was caused by a dynamic track gauge[2] widening beyond a critical level at turnout P5116. The investigation found that, in the early hours of 4 August 2019, the EAL Track Maintenance Team replaced two worn out timber sleepers with new synthetic sleepers to correct an earlier identified track gauge widening. Due to the special combination of rail alignment at a sharp curve, high traffic intensity and the difference in stiffness between the new synthetic sleepers and neighbouring sleepers in this particular location, this arrangement resulted in an unexpected consequence in that the two synthetic sleepers created a localised hard spot in the rail support system. This hard spot resulted in most of the sideways loading from the trains passing through this curved section being exerted onto the rail fastening of the two newly replaced synthetic sleepers, which accelerated the fastening's deterioration. Three of the fixing screws failed as a result, which allowed one of the rails to move sideways, leading to an increase in the gap between the two rails, i.e. "dynamic track gauge widening beyond a critical level" and causing the train wheels to hit the check rail, thus in turn led to the derailment.

8. The management of railway assets and track maintenance of the MTRCL are on par with international standards. However, the Panel concluded that the EAL Track Maintenance Team had a knowledge gap of the effect of the special combination of circumstances at turnout P5116 for making an informed judgement on the scope, timeliness and effectiveness of the remedial measures required to correct the dynamic track gauge widening. Nevertheless, similar problems with the use of synthetic sleepers[3] had not been encountered since the MTRCL introduced them ten years ago.

9. The Panel also concluded that follow-up measures of the Maintenance Team to inspect and rectify the track gauge in the Hung Hom area, and to prepare reports, had not always been conducted strictly in accordance with the MTRCL procedures. Although the Maintenance Team had carried out regular patrolling and preventative maintenance, the

[2] Track gauge is the distance between the inner side surfaces of a pair of rails. The dynamic track gauge is the distance of the rail when running trains are exerting force on the rail. Excessive gauge widening might cause a train to derail.

[3] MTRCL introduced the synthetic sleepers since 2009 to gradually replace the timber sleepers. Synthetic sleepers have longer lifecycle than timber sleepers and are able to improve the overall track reliability.

Panel considered the team should have relied more heavily on measurement data, rather than their experience, to observe the trend of track gauge widening.

10. No evidence has been found to suggest that the condition or performance of the rolling stock and/or the signaling system contributed to the derailment. Nor was there any evidence to suggest any external influence in the derailment.

Remedial measures and improvement actions taken by the MTRCL

11. Following the incident, enhanced measures were put in place at turnout P5116, including arranging cab ride monitoring by a supervisory grade staff twice a day; daily on-site day time inspection; and imposing speed restriction of 30 km/h. In addition, all the concerned sleepers at turnout P5116 were replaced.

12. The MTRCL has carefully implemented the following recommendations made by the Panel:

a) developed measures to address the variation in lateral stiffness when using synthetic sleepers in replacing timber sleepers to avoid prolonged stress concentration on individual coach screws **(completed)**;

b) accelerated the planned replacement of 2 627 EAL timber sleepers to give extra performance resilience to track integrity **(completed)**;

c) refined maintenance action thresholds using a "step" approach and enhanced monitoring of compliance of track gauge and escalation through reinforced governance **(completed)**;

d) enhanced change management of introducing new track technology, including site testing, staff competence enhancement to bridge any knowledge gap based on the lessons learnt **(completed)**; and

e) exploring and implementing new technology and data analytics to monitor track gauge and track integrity in traffic hours as well as its trend analysis for maintenance

and criteria to trigger necessary escalation to senior management for attention **(The new equipment was delivered in February this year and is undergoing trial).**

13. According to the Service Performance Arrangement (SPA) under the Fare Adjustment Mechanism, for any train service disruption and suspensions lasting for 31 minutes and above, which is caused by equipment failure or human factor, the MTRCL will put aside certain amount of money for fare concession to passengers in the next year. Under the SPA, the MTRCL will set aside $25 million for this incident (paragraph 5 above).

Investigation findings and follow-up of the EMSD

14. The independent investigation of the EMSD revealed that the immediate cause of the train derailment was track gauge widening. The track gauge widening was due to the deteriorated condition of the sleepers which supported and fixed the rails in the incident location. The deterioration had reduced the strength of sleepers such that they were unable to effectively retain the rails in the correct position. The track gauge under dynamic loading of trains would be even wider, and this excessive gauge widening caused the train to derail.

15. The root cause of the incident was related to the repetitive non-compliance of the MTRCL's internal maintenance procedures. The EMSD and the overseas railway safety experts engaged to assist in the investigation have thoroughly reviewed the maintenance procedures of the MTRCL, and confirmed that there are established requirements for the regular measurement and maintenance of tracks. That said, according to the investigation findings, the track gauge widening were repetitively identified in regular measurements at the incident location but the MTRCL did not strictly follow the established maintenance procedures to rectify the problem. The managerial staff responsible for supervising track maintenance did not follow the internal procedures to prepare quarterly reports for reporting the maintenance shortfalls to the senior management. The investigation also revealed that the internal management control and internal audit procedures of the MTRCL had failed to identify the relevant maintenance failures. The management of the MTRCL did not know the above situations.

16. The investigation of the EMSD confirmed that the incident did not involve train equipment failure, signalling system failure, external objects or cyber-attack. The broken rails and rail cracks at the incident location were caused by the derailed train wheels hitting the rails, but were not the cause of the incident.

17. After the incident, the MTRCL has been carrying out maintenance of tracks in strict accordance with the established maintenance procedures. The EMSD also requested the MTRCL to install monitoring devices to facilitate monitoring of rail conditions. The EMSD instructed the MTRCL and confirmed that they had reviewed the condition of sleepers along the whole EAL and completed replacement of sleepers of dissatisfactory condition. The MTRCL also proposed improvement measures for enhancing track maintenance to prevent the recurrence of similar incident. The EMSD had reviewed the investigation report submitted by the MTRCL and accepted their investigation findings on the cause of incident and improvement measures.

Long-term improvement measures

18. The Government is very concerned of the incident, which revealed the systemic issue with the MTRCL's management of maintenance work. Improvement measures must be taken to ensure the proper maintenance of railway system. In the interest of safety, the Secretary for Transport and Housing has, pursuant to section 28[4] of the Mass Transit Railway Ordinance (Cap. 556), given a notice in writing to the MTRCL, requesting the MTRCL to take relevant steps, including the installation of real-time monitoring system on passenger trains to enhance track monitoring and the submission of a report on the measures taken to improve the management of track maintenance, with a view to preventing recurrence of similar incident. The EMSD continues to closely monitor the progress and effectiveness of the MTRCL in implementing the relevant measures.

19. In addition, the Secretary for Transport and Housing raised at the MTRCL Board meeting that the incident has reflected deficiency in the overall corporate governance. The MTRCL needs to seriously and comprehensively review the shortfalls of their maintenance management

[4] If the MTRCL fails without reasonable excuse to comply with a notice given under section 28 of the Mass Transit Railway Ordinance (Cap. 556), the MTRCL commits an offence and is liable to a fine of $100,000 and to a further fine of $10,000 for each day during which the failure to comply with this notice has continued without reasonable excuse.

system to ensure railway safety. The MTRCL Board will follow up on the matter.

Part II: Incident happened near LAK on TWL where a train hit the concrete buffer beside the railway track on 6 October 2019

The incident

20. The incident near LAK on TWL on 6 October 2019 happened in the context of public order events (POEs), where vandalism of multiple station facilities had caused the closure of various stations in the network[5]. Initially on that day, only limited services[6] were maintained between Central station to Kwai Hing station (KWH) on TWL. After 4 p.m., Yau Ma Tei Station[7] and Lai Chi Kok station[8] were vandalised consecutively. To maintain the train service for passengers, the Corporation had run a special short loop service between KWH, LAK and Mei Foo (MEF) stations since 4:50 p.m. after risk assessment. TD was reported on the service arrangements under the existing mechanism.

21. At around 5:43 p.m., a train carrying around 300 passengers from LAK ran towards MEF via a special routing and stopped after hitting the concrete buffer at the end of the railway track. Station staff immediately came to the incident spot and assisted passengers to get back to LAK via the track.

22. At the same time, given the POEs in various stations along TWL, and certain station facilities were vandalised, for the safety of passengers, staff and operations, the MTRCL suspended the limited service of TWL. The MTRCL timely informed the public of the train service arrangement via the media, MTR website, MTR Mobile, etc.

23. As mentioned above, the incident happened during the POE period. Many stations in the network were closed due to vandalism. Train services continued to be adjusted within a short period of time. The

[5] Various MTR stations were vandalised on 4 October 2019, the whole MTR network could not resume service for the whole day on 5 October. MTRCL could only reopen 45 stations on 6 October and the rest of 48 stations were closed, including Admiralty, Tsim Sha Tsui, Jordon, Mong Kok, Prince Edward, Sham Shui Po, Cheung Sha Wan, Kwai Fong, Tai Wo Hau and Tsuen Wan stations along TWL.

[6] Starting from service on 6 October 2019, train of TWL only stopped at Central, Yau Ma Tei, Lai Chi Kok, Mei Foo, Lai King and Kwai Hing stations.

[7] In order to ensure the safety of passengers and staff, Yau Ma Tei station was closed at 4:03p.m. due to vandalism.

[8] In order to ensure the safety of passengers and staff, Lai Chi Kok station was closed at 4:44p.m. due to vandalism.

special short loop service provided by the MTRCL was unusual. The train departing from LAK required to pass through a special route, to go to the Platform 1 of MEF for detrainment and train reversing and the abovementioned incident happened.

Follow-up actions

24. After the incident, the two concerned train captains have been suspended from their driving duties. The MTRCL has strengthened the guidelines of the special train service arrangement, and the arrangements for manual train movement. We understand that the Police has completed criminal investigation and sought legal advice, and decided to lay charges on the two train captains concerned in accordance with section 29 of the MTR Ordinance (Cap. 556).

Conclusion

25. The MTRCL is gravely concerned about the two incidents. The MTRCL will put in place appropriate improvement measures as early as possible, so as to prevent the recurrence of similar incident. Once again, the MTRCL apologises to the passengers affected.

Transport and Housing Bureau
Electrical and Mechanical Services Department
Transport Department
MTR Corporation Limited
April 2020

Annex 1

MTRCL's Investigation Report

新聞稿

Press Release

PR018/20
3 March 2020

MTR Implements Improvement Measures as Investigation Panel Concludes Dynamic Track Gauge Widening Caused East Rail Line Derailment Incident

The MTR Corporation today (3 March 2020) made public the results of its investigation into the East Rail Line ("EAL") derailment incident which occurred on 17 September 2019. It was concluded that the incident was caused by dynamic track gauge widening at a turnout near Hung Hom Station ("HUH").

Safety is of the utmost importance to MTR operations and the Corporation takes the incident very seriously. An Investigation Panel ("the Panel") comprising MTR staff from relevant disciplines and advised by external experts from the United Kingdom, Australia and Hong Kong was set up to identify the cause of the incident and recommend improvement measures. The Panel submitted a report to the Electrical and Mechanical Services Department ("EMSD") on 14 February 2020, and the EMSD has just completed its review. The Corporation also cooperated with an independent investigation by the EMSD over the incident.

The Incident

At 8:29am on 17 September 2019, an EAL train in passenger service was approaching Platform 1 of HUH when it derailed at turnout P5116, north of the station, at around 39 km/h. Three cars (4, 5 and 6) of the 12-car train derailed and cars 4 and 5 were separated. Eight passengers were reported injured in the incident on 17 September 2019 and two of them were hospitalised for two days. EAL service between Hung Hom and Mong Kok East stations was suspended on that day for site investigation and re-railing of the affected cars, and service resumed the following morning.

Cause of the Incident

The Panel concluded that the derailment was caused by the dynamic track gauge widening beyond a critical level at turnout P5116. The investigation found that, in the early hours of 4 August 2019, the EAL Track Maintenance Team replaced two worn out timber sleepers with new synthetic sleepers to correct the track gauge. Due to the special combination of rail alignment at a sharp curve, high traffic intensity and the difference in stiffness between the new synthetic sleepers and neighbouring sleepers in this particular location, this arrangement had an unintended consequence in that the two synthetic sleepers created a localised hard spot in the rail support system. This hard spot resulted in most of the sideways loading from the trains passing through this curved section being exerted onto the rail fastening of the two newly replaced synthetic sleepers, which accelerated the fastening's deterioration. Three of the fixing screws failed as a result, which allowed one of the rails to move sideways, leading to an increase in the gap between the two rails or "dynamic track gauge widening beyond a critical level" and train wheels hitting the check rail. This in turn led to the derailment.

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The Panel concluded that the rolling stock and signalling system worked normally and did not contribute to the derailment. There was no external obstruction identified. The broken rails found at the incident site were the result of the damage caused by the derailment.

Railway Asset Management and Track Maintenance

The management of railway assets and track maintenance of the MTR are in line with international standards. However, the Panel concluded that the EAL Track Maintenance Team had a knowledge gap of the effect of the special combination of circumstances at turnout P5116 for making an informed decision on the scope, timeliness and effectiveness of the remedial measures required to correct the dynamic track gauge. Similar problems with the use of synthetic sleepers had not been encountered in the ten years since their introduction in MTR.

The Panel concluded that follow up measures to inspect and rectify the track gauge in the Hung Hom area, and to prepare reports, had not always been conducted strictly in accordance with MTR procedure. Although the Maintenance Team had carried out regular patrolling and preventative maintenance, the Panel considered the team should have relied more heavily on measurement data, rather than their experience, to observe the trend of track gauge widening.

"On behalf of the Corporation, I sincerely apologise again to the passengers affected by the incident. We have learnt lessons from this incident and will spare no effort in putting in place the improvement measures recommended by the Panel to enhance our track maintenance," said Mr Adi Lau, Managing Director – Operations and Mainland Business of MTR Corporation and Co-chairperson of the Investigation Panel.

Improvement Measures

The Corporation has implemented improvement measures recommended by the Panel, and they are as follows:

- Developed measures to address changes in track stiffness after sleeper replacement;
- Replaced 2,627 EAL timber sleepers to give extra track reliability;
- Adopted a "step" approach for track maintenance works to enhance monitoring of track gauge and timely escalation;
- Enhanced change management and staff competence for relevant maintenance works when track technology new to MTR is introduced;
- Explore and implement new technology and data analytics to monitor track gauge and track integrity in traffic hours, its trend analysis for maintenance and criteria to trigger necessary escalation to senior management for attention (Installation of the new equipment commenced in February 2020).

The detailed findings of the investigation are set out in the annex.

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About MTR Corporation

Every day, MTR connects people and communities. As a recognised world-class operator of sustainable rail transport services, we are a leader in safety, reliability, customer service and efficiency.

MTR has extensive end-to-end railway expertise with more than 40 years of railway projects experience from design to planning and construction through to commissioning, maintenance and operations. Going beyond railway delivery and operation, MTR also creates and manages dynamic communities around its network through seamless integration of rail, commercial and property development.

With more than 40,000 dedicated staff*, MTR carries over 13 million passenger journeys worldwide every weekday in Hong Kong, the United Kingdom, Sweden, Australia and the Mainland of China. MTR strives to grow and connect communities for a better future.

For more information about MTR Corporation, please visit www.mtr.com.hk.

*includes our subsidiaries and associates in Hong Kong and worldwide

Annex

Executive Summary

At 08:29 hours on 17 September 2019, a train in passenger service on the East Rail Line (EAL) approaching Hung Hom Station (HUH) platform 1 derailed at turnout P5116 north of the station. Three cars (the 4th, 5th and 6th cars) of the 12-car incident train number L094 [hereafter "Train 1"] derailed and the train was divided between the 4th and 5th cars.

An Investigation Panel (the Panel) was established to investigate and identify the cause of the incident. It concluded that dynamic track gauge widening at HUH turnout P5116 caused the derailment.

Shortly before the incident, dynamic track gauge widening at HUH turnout P5116 reached a level which led to the wheels of a preceding train number L086 [hereafter "Train 5"] damaging the check rail of turnout P5116. Subsequently, the incident Train 1 derailed at turnout P5116 at a speed of around 39km/h and travelled on the unintended route at turnout P5114.

The EAL Track Maintenance Team had been addressing track gauge widening at turnout P5116 through a series of inspections, verifications and maintenance interventions since July 2018, when the dynamic gauge threshold was first exceeded. On 3^4 August 2019, 2 out of 5 deteriorating timber sleepers of an array of 17 sleepers were replaced with 2 new synthetic sleepers at the approach of the check rail of turnout P5116.

This intervention on 3^4 August 2019 was intended to correct the track gauge at the incident location. However, this intervention, which the Maintenance Team considered according to their experience would be sufficient, created a localized uneven lateral stiffness between the 2 new sleepers and the preceding 15 sleepers. This resulted in unexpected excessive lateral force being applied to the rail under train operation which subsequently broke the coach-screws that secured the rail to the new sleepers.

Despite the intention of the Maintenance Team to rectify the gauge widening at the incident turnout P5116, the Panel considered such interventions were not sufficient. The replacement of the 2 timber sleepers created uneven lateral track stiffness at the turnout P5116 which has an atypical combination of sharp curve track geometry and high traffic intensity.

The Panel concluded that the Maintenance Team clearly had a knowledge gap of the effect of this atypical combination of circumstances to make an informed judgement on the scope, timeliness and effectiveness of remedial measures required to correct the dynamic track gauge. Similar problems had not been encountered with the use of synthetic sleepers in the 10 years since their introduction in MTR.

The Panel concluded that follow up measures to inspect and rectify the track gauge, and to prepare reports, had not always been conducted strictly in accordance with the MTR procedure since the dynamic gauge threshold was first exceeded in July 2018. The Panel considered the Maintenance Team should have relied more heavily on measurement data, rather than their experience, to observe the trend of track gauge widening, despite the fact that they had carried out the regular patrolling and preventative maintenance throughout the period.

Senior management was not aware of this situation as it was not escalated, nor was it revealed by internal management processes, such as routine management reports and audits. The Panel opined that the monitoring of compliance of track gauge should be enhanced and escalated through reinforced internal governance.

No evidence has been found to suggest that the condition or performance of the rolling stock and/or the signaling system contributed to the derailment, nor was there any evidence of external influence in the derailment. The Panel concluded that the broken rails identified at the incident site were the result of damage caused by the derailment.

The following recommendations have been made by the Panel:

a) Develop measures to address the variation in lateral stiffness when using synthetic sleepers in replacing timber sleepers to avoid prolonged stress concentration on individual coach screws. (Completed);

b) Accelerate the planned replacement of 2,627 East Rail Line timber sleepers to give extra performance resilience to track integrity. (To be completed by mid-February 2020);

c) Refine maintenance action thresholds using a “step” approach and enhance monitoring of compliance of track gauge and escalation through reinforced governance (“lines of defence”). (Completed);

d) Enhance change management of introducing track technology that is new to MTR, including site testing and staff competence enhancement to bridge any knowledge gap based on the lessons learnt. (Completed);

e) Explore and implement new technology and data analytics to monitor track gauge and track integrity in traffic hours, its trend analysis for maintenance and criteria to trigger necessary escalation to senior management for attention. (Equipment to be delivered in February 2020 for trial).

1. Introduction

1.1 At 08:29 hours on 17 September 2019, a train in passenger service on East Rail Line (EAL) approaching Hung Hom Station (HUH) platform 1 derailed at turnout P5116 north of the station at a speed of around 39km/h. Three cars (the 4th, 5th and 6th cars) of the 12-car incident train number L094 (hereafter "Train 1") derailed and the train was divided between the 4th and 5th car as shown in Annex 1.

2. The Investigation Panel

2.1 The Corporation was greatly concerned about the incident and therefore set up an Investigation Panel to investigate and identify the cause of the incident, and to make recommendations to prevent the recurrence of any similar incident.

2.2 The Panel was chaired jointly by Adi Lau, Operations Director at the time the Panel was formed, and Peter Ewen, Engineering Director. Membership consisted of senior MTR personnel in the fields of Operations and Engineering as well as external experts, namely Ravi Ravitharan, Director of the Institute of Railway Technology (IRT), Monash University; Owen Evans, Senior Vehicle Dynamicist of Resonate Group Limited; and Professor S.L. Ho, Associate Vice President (Academic Support), Hong Kong Polytechnic University.

3. The Incident

3.1 At 08:29 hours on 17 September 2019, a train in passenger service approaching HUH platform 1 and operating in Automatic mode derailed at turnout P5116 north of the station at a speed of around 39km/h. Three cars (the 4th, 5th and 6th cars) of the 12-car incident Train 1 derailed and the train was divided between the 4th and 5th car as shown in Annex 1. At 08:32 hours, train service of EAL between HUH and Mong Kok East Station (MKK) was suspended.

3.2 At about 09:03 hours, passengers in the front 4 cars completed their detrainment to HUH Platform 1 by walking through the train compartments. Passengers in the rear 8 cars were assisted to walk to HUH platforms along the track. All the passengers in the train (about 500) completed the detrainment in a safe and orderly manner to HUH platform by about 09:43 hours.

3.3 The train service between HUH and MKK was resumed at 06:05 hours on 18 September 2019 using HUH platform 4 only. On 20 September 2019, both EAL platforms of HUH resumed service.

3.4 Eight passengers were reported injured on 17 September 2019. Two were admitted to hospital and both of them were discharged on 19 September 2019. Another 7 passengers reported unwell on 18 September 2019 and none of them were hospitalized.

3.5 Following the incident, enhanced measures were put in place at turnout P5116 and remain in effect:

- Cab ride by a supervisory grade staff twice a day
- Daily on-site day time inspection
- Speed restriction of 30 km/h was imposed

In addition, all the concerned sleepers at turnout P5116 were replaced.

3.6 HUH turnout P5116 together with all others in the vicinity were introduced as part of the interfacing works under the Kowloon Southern Link project which was opened in August 2009.

4. Cause of the Incident

4.1 Prior to the incident, at about 08:18 hours on 17 September 2019, the leading wheelset on the 8th car of Train number L086 [hereafter “Train 5”] hit the check rail of turnout P5116 and damaged it as shown in Annex 2. A check rail is laid parallel to a running rail to guide wheels through the rail crossing of all turnouts. The wheels of 3 subsequent trains [namely “Trains 4, 3 and 2”] hit and progressively further damaged the check rail but still took the

intended route to HUH platforms. Subsequent inspection found abnormal marks on the wheelsets of Trains 5, 4, 3 and 2.

4.2 At about 08:29 hours, the leading wheelset of the 5th car of Train 1 rode up on the remainder of the damaged check rail of turnout P5116 and took an unintended route towards Platforms 3 and 4 at turnout P5114 as shown in Annex 2, completely derailing the 4th, 5th and 6th cars and dividing the train between the 4th and 5th cars at a speed of around 39km/h.

4.3 The wheelset of Train 5 damaged the check rail due to widening of the dynamic track gauge (the distance between the rails under the load of a running train) beyond a critical level.

4.4 This dynamic gauge widening was initiated by:

a) lateral movement of the rail in the group of 6 synthetic sleepers (Zone 3 in Annex 3) immediately preceding the group of 5 deteriorating timber sleepers (Zones 1 and 2 in Annex 3) in front of turnout P5116 as a result of loosen/broken coach screws and elongation of the mounting holes under the baseplates. This prevented them from taking up their fair share of the lateral force resulting from train operation;

b) the subsequent localized uneven lateral track stiffness introduced after the replacement of 2 (Zone 1 in Annex 3) of the group of 5 deteriorating timber sleepers on 3^4 August 2019; then

c) the resultant high lateral force applied to the rail onto the coach-screws prompting elongation of the mounting holes of the base-plate on the sleepers and

d) the generation of excessive lateral force onto the newly replaced synthetic sleepers which contributed to the breakage of the coach-screws of the base-plate which secures the rail to the sleepers in front of the check rail of P5116,

e) the disengagement of the broken coach-screws at the

elongated mounting holes, followed by the tilting of the rail assembly, resulting in the dynamic track gauge widening beyond a level that led to the check rail being damaged by the train wheels.

4.5 The Panel concluded the cause of the derailment was due to dynamic track gauge widening at turnout P5116.

> *"Monash Institute of Railway Technology's (IRT) investigation confirmed that the excessive gauge widening contributed to the check rail impact by wheels and the subsequent derailment."*
>
> *IRT*
> *External Expert*

4.6 No evidence has been found to suggest that the condition or performance of the rolling stock and/or the signaling system contributed to the derailment. Nor was there any evidence to suggest any external influence in the derailment. The Panel concluded that broken rails identified at the incident site were the result of damage caused by the derailment.

5. Contributory Factors

5.1 There was an array of 17 sleepers preceding the check rail of P5116 as shown in Annex 3:

a) Zone 1: Two original timber sleepers replaced by synthetic ones on 3^4 August 2019;

b) Zone 2: Three original timber sleepers;

c) Zone 3: Six synthetic sleepers that replaced the original timber sleepers in 2015; and

d) Zone 4: Six original timber sleepers.

5.2 Replacement of 2 deteriorating timber sleepers with synthetic sleepers at the approach to the check rail (Zone 1 in Annex 3) on 3^4 August 2019 was intended to correct the track gauge at the incident location.

5.3 As a result of this replacement, Zone 1 had the highest track lateral stiffness and least lateral movement due to the two newly replaced sleepers and rail fastenings. Zone 2 (3 deteriorating timber sleepers) and Zone 3 (6 synthetic sleepers with elongated mounting holes) had comparatively less track lateral stiffness and hence allowed lateral movement as shown in Annex 3. The EAL Track Maintenance Team was unaware of such elongated mounting holes in the Zone 3 synthetic sleepers and its implication to the track lateral stiffness. The Zone 4 timbers had impaired but still reasonable lateral stiffness.

> *"The Maintenance Team was not aware that, after the replacement of the Zone 3 Sleepers in 2015, the Zone 3 Sleepers started to copy the oval holes in the Sleepers of Zones 1, 2 and 4. Within less than 4 years, very elongated holes were replicated in the Zone 3 Sleepers with no conspicuous visual signs because those oval holes on the Synthetic Sleepers were covered by the base-plates."*
>
> *Hong Kong PolyU*
> *External Expert*

5.4 The combination of the uneven localized track lateral stiffness over the sharp curve comprising of the 4 zones within the turnout P5116 eventually resulted in excessive lateral force on the rail at the 2 newly replaced synthetic sleepers at Zone 1, causing the coach-screws to break under load.

> *"In IRT's laboratory, for the East Rail operating conditions, the coach screw failure under fatigue mode has been recreated by when the coach screw becomes loose. The failure of the coach screws, together with the elongation of the screw holes led to a reduction of lateral- and roll- track stiffness."*
>
> *IRT*
> *External Expert*

> *"The variation in track lateral stiffness introduced additional dynamic forces to the rail, resulting from the rather abrupt reduction in dynamic gauge on the approach to the newly replaced sleepers. In addition, the lateral forces on rail along the incident turnout track were drawn to react through the stiffest path, which was essentially also at these two new sleepers. These had caused compound over-loading effects on the coach-screws in the newly replaced sleepers at Zone 1."*
>
> *Resonate Group Limited*
> *External Expert*

5.5 Follow up measures to inspect and rectify the track gauge, and to prepare reports, had not always been conducted strictly in accordance with the MTR procedure since the dynamic gauge threshold was first exceeded in July 2018. As shown in Annex 4, only 5 static follow up measurements from the 15 Track Geometry & Overhead Line Vehicle (TOV) measurements were taken in accordance with MTR procedure "Management of Track Geometry Measurement by TOV" since July 2018, though static measurements were also taken during 5 scheduled turnout maintenance activities. The Maintenance Team relied too heavily on their experience rather than the measurement data to observe the trend of track gauge widening, despite the fact that they had carried out the regular patrolling and preventative maintenance throughout the period. Senior management was not aware of this situation as it was not escalated, nor was it revealed by internal

management processes, such as routine management reports and audits.

6. Asset Management

6.1 Management of track assets is undertaken in accordance with MTR's Asset Management System (AMS) which is certified to ISO55001 – Asset Management. The AMS provides total asset lifecycle management and comprises inspection, preventive and corrective maintenance, asset condition assessment and asset replacement.

6.2 Asset replacement studies (ARS) are conducted to review asset condition and derive asset replacement programmes. A comprehensive ARS was conducted on EAL timber sleepers in 2016, followed by a condition assessment in April 2019.

6.3 The turnout P5116 is inspected using a three-tier approach in common with international practice, though the frequency varies in different countries:

a) Visual inspection by Patrolman: every 3 days

b) Inspection during Turnout Maintenance with static measurement: every 13 weeks

c) Dynamic measurement by TOV: monthly

6.4 Patrolman inspections and turnout maintenance are conducted by the EAL First Line Track Maintenance Management (MM) team and the TOV is operated by the Second Line Integrity Assurance Management (IAM) team within the Infrastructure Maintenance Department. Exception reports from the TOV are verified by the MM team and combined with preventative maintenance (PM) information from patrolmen and turnout inspections to determine the required corrective maintenance (CM) interventions.

6.5 According to MTR's procedures, track gauge measurements from the TOV which exceed a predefined threshold are to be inspected and rectified within 28 days. The MM team is required to send the "Follow Up Reports" to the IAM team for review and endorsement.

The IAM team is required to prepare a summary report of such exceedances on a quarterly basis.

6.6 To rectify the gauge exception, the following methods are be applied in the order of complexity:

a) Repair the elongated baseplate mounting holes;

b) Make a new baseplate mounting hole either by shifting the sleeper or re-orientating the baseplate;

c) Replace the sleeper completely

6.7 The majority of the existing EAL timber sleepers had been installed in the ballast track at the turnout areas since the early 1980's, while those at HUH turnout P5116 together with all others in the vicinity were introduced as part of the interfacing works under the Kowloon Southern Link project which was opened in August 2009. As timber is susceptible to wear and tear and biological degradation, a timber replacement programme was instigated in 2010 based on the then timber condition survey result. Up to the end of August 2019 approximately 4,000 synthetic sleepers were installed to replace the timber sleepers.

6.8 Synthetic sleepers were introduced, as the standard for replacement of timber sleepers since 2008 as difficulties were encountered in sourcing good quality timber sleepers from the market. Good experience of use in Japan supported the basis for its introduction. The six timber sleepers at Zone 3 of turnout P5116, as shown in Annex 3, were replaced with synthetic sleepers in 2015. Similar problems had not been encountered with the use of synthetic sleepers in the 10 years since their introduction in MTR.

6.9 Following the derailment, in November 2019 and February 2020 further rounds of condition assessment was conducted using enhanced assessment criteria. A total of 2,627 timber sleepers were identified as "high priority" and will be replaced by mid-February 2020 to give extra performance resilience to track integrity.

7. Maintenance Management

7.1 The maximum dynamic track gauge at turnout P5116, as measured by the TOV, first reached the threshold in July 2018. Fifteen rounds of TOV dynamic gauge measurement were conducted from July 2018 to August 2019. The Maintenance Team had addressed the gauge deterioration and turnout performance by five site verifications (September 2018 to July 2019) and five interleaving regular turnout preventative maintenances (27 July 2018 to 1 August 2019). Static gauge measurements in Zone 4 were within the acceptable range throughout, whereas Zone 3 first exceeded the threshold in September 2018 and Zone 2 in May 2019.

7.2 When the team confirmed the gauge at Zone 1 exceeded the threshold and Zone 2 further worsened in July 2019, the team planned the sleeper replacement.

7.3 Static follow up measurements had not always been conducted in accordance with the MTR procedure since the dynamic gauge threshold was first exceeded in July 2018. As shown in Annex 4, only 5 static follow up measurements from the 15 TOV measurements were taken in accordance with the procedure "Management of Track Geometry Measurement by TOV" since July 2018, though static measurements were also taken during 5 scheduled turnout preventative maintenances. TOV Follow Up Reports were not received by the IAM team from October 2018 and the Quarterly Exception Summary Reports of gauge exceedances were not prepared from January 2019. Senior management was not aware of this situation, nor was it revealed by internal management processes, such as audits. The panel opined that the monitoring of compliance of track gauge should be enhanced and escalated through reinforced internal governance.

7.4 The Panel considered that the existing procedures should be enhanced such that the TOV Quarterly Exception Summary Report should be submitted to the Departmental Asset Management Committee (Permanent Way), chaired by a General Manager, to enhance escalation and governance.

7.5 Other maintenance activities, such as the scheduled track patrolling and turnout PM works were conducted in accordance with the requirements. However, the panel opined that maintenance action should have been taken in accordance with the procedures once the threshold exceedance at Zone 3 had been identified. The Panel also opined that the condition of the sleepers and fastenings identified during track patrolling, particularly those before the incident, were early signs that should have warranted closer attention.

7.6 Following a TOV dynamic gauge measurement on 15^16 July 2019 which showed further dynamic gauge deterioration at the incident location, a static gauge verification measurement was conducted on 26 July 2019 and confirmed the existence of widening static track gauge. After scheduled turnout maintenance on 1 August 2019, CM was conducted to replace 2 timber sleepers (Zone 1 in Annex 3) on 3^4 August 2019, followed by special attention during inspection by the patrol team for 2 subsequent weeks. Measurement of the static gauge on completion of the sleeper replacement on 3^4 August showed the gauge widening had been reduced below the static gauge limit and as such the team believed the corrective action was effective until the TOV dynamic gauge measurement on 7^8 August 2019.

7.7 Whilst the team were aware of the gauge widening and took action to replace 2 of the deteriorating sleepers, they were unaware of the effect of the localized variation of the lateral stiffness along the sharp curve of the turnout P5116 resulting from:

a) the replacement of 6 timber sleepers by synthetic sleepers in 2015 which had embedded elongated baseplate mounting holes after some years of service,

b) the replacement of 2 timber sleepers by 2 new synthetic sleepers in Zone 1 on 3^4 August 2019, and

c) the 3 deteriorated timber sleepers in Zone 2 which had been repaired before, were effectively redundant in holding the track gauge shortly after the corrective maintenance on 3^4 August 2019.

7.8 Synthetic sleepers were first introduced in MTR 2008. With the past ten years of experience in using synthetic sleepers with no similar problems being encountered, the Maintenance Team believed that replacing 2 sleepers would suffice in correcting the track gauge.

7.9 The Panel considered there were knowledge gaps on:

a) understanding the behavior of synthetic sleepers once the baseplate mounting holes become oval i.e. Zone 3 synthetic sleepers, and

b) the effect of replacing the 2 timber sleepers i.e. Zone 1 sleepers in the array of the 17 sleepers that gave rise to the localized uneven lateral track stiffness at the sharp curve track geometry of turnout P5116.

7.10 Following replacement of the 2 sleepers on 3^4 August, the dynamic gauge measured by the TOV on 7 and 29 August had reduced slightly, but still exceeded the acceptable range. Thus, the maintenance interventions applied in addressing the track gauge at turnout P5116 were not sufficient.

> *"Maintenance staff made efforts based on their experience to correct the widen track gage at turnout P5116. The replacement of the two timber sleepers for the gauge correction on 3^4 August 2019 resulted in uneven track gauge spreading along the turnout due to a combination of several coincidental, albeit unexpected, factors. Eventually the unexpected factors caused the breakage of the mounting coachscrews of the two replaced sleepers to allow the gauge to widen within a very short time."*
>
> *Hong Kong PolyU*
> *External Expert*

> *MTR could deploy a senior maintenance manager who can combine good knowledge on ballasted track together with the lessons learnt to ensure the sleeper replacement can be realized smoothly and satisfactorily"*
>
> *Hong Kong PolyU*
> *External Expert*

7.11 The Panel considered that new technology with data analytics to monitor track gauge and track integrity in traffic hours should be implemented to assist the Maintenance Team to take proper action with criteria for escalation to senior management in a timely manner if necessary, particularly on any abnormality observed in the trend analysis. A Quarterly Exception Summary Report should be submitted to the Departmental Asset Management Committee (Permanent Way), chaired by a General Manager, to ensure reinforced governance.

8. Conclusions

8.1 The cause of the incident was dynamic track gauge widening at HUH turnout P5116.

8.2 The underlying factors contributing to the dynamic gauge widening were:

a) the interventions applied in addressing the track gauge widening at the incident turnout P5116 were not sufficient. The replacement of 2 out of a group of 5 deteriorating timber sleepers in an array of 17 sleepers created uneven lateral track stiffness at the turnout P5116 which has an atypical combination of sharp curve track geometry and high traffic intensity. This resulted in an unexpected excessive lateral force being applied to the rail under train operation which led to the breakage of the rail fastener coach screws on the two newly replaced synthetic sleepers;

b) the EAL Track Maintenance Team had a knowledge gap on the effect of this combination of circumstances to make an informed judgement on the scope, timeliness and effectiveness of remedial measures required to correct the dynamic track gauge. Similar problems had not been encountered with the use of synthetic sleepers in the 10 years since introduction in MTR.

c) follow up actions to inspect and rectify the track gauge, and to prepare reports, had not always been conducted in accordance with the MTR procedures since the dynamic gauge threshold was first exceeded in July 2018. The Maintenance Team should have relied more heavily on measurement data, rather than their experience, to observe the trend of track gauge widening, despite the fact that they had carried out the regular patrolling and preventative maintenance throughout the period. Senior management was not aware of this situation as it was not escalated, nor was it revealed by internal management processes, such as routine management reports and audits.

8.3 No evidence has been found to suggest that the condition or performance of the rolling stock and/or the signaling system contributed to the derailment, nor was there any evidence of external influence in the derailment. The broken rails identified at the incident site were the result of damage caused by the derailment.

9. Recommendations

9.1 The Panel has made recommendations as below based upon lessons learnt from this incident:

a) develop measures to address the variation in lateral stiffness when using synthetic sleepers in replacing timber

sleepers to avoid prolonged stress concentration on individual coach screws. (Completed);

b) accelerate the planned replacement of 2,627 East Rail Line timber sleepers to give extra performance resilience to track integrity. (To be completed by mid-February 2020);

c) refine maintenance action thresholds using a “step” approach and enhance monitoring of compliance of track gauge and escalation through reinforced governance (“lines of defence”), (Completed);

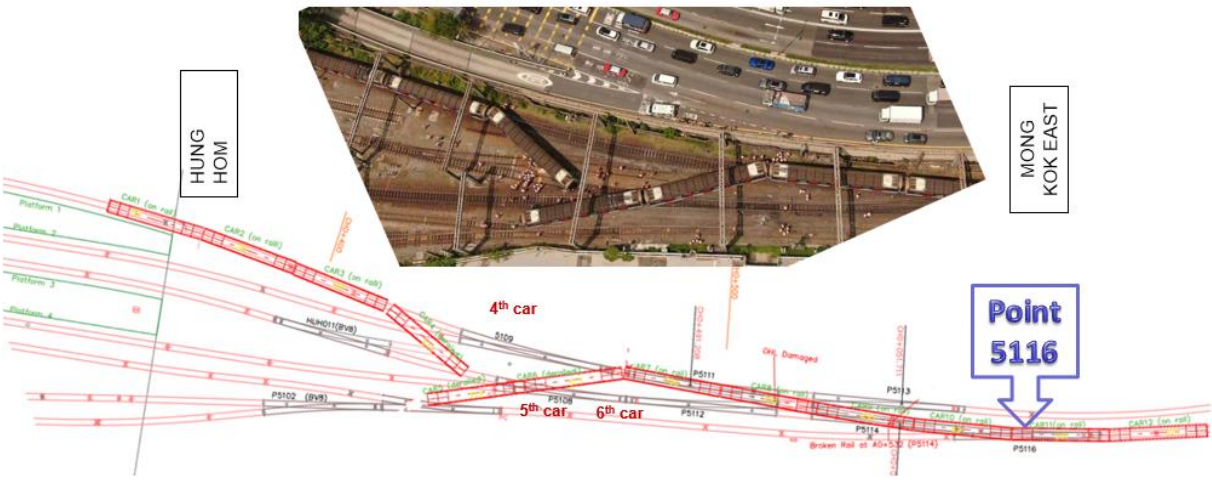
d) enhance change management of introducing new track technology, including site testing, staff competence enhancement to bridge any knowledge gap based on the lessons learnt. (Completed);

e) explore and implement new technology and data analytics to monitor track gauge and track integrity in traffic hours as well as its trend analysis for maintenance and criteria to trigger necessary escalation to senior management for attention. (Equipment to be delivered in February 2020 for trial)

Annex 1

Incident Site at North of Hung Hom Station (East Rail Line)

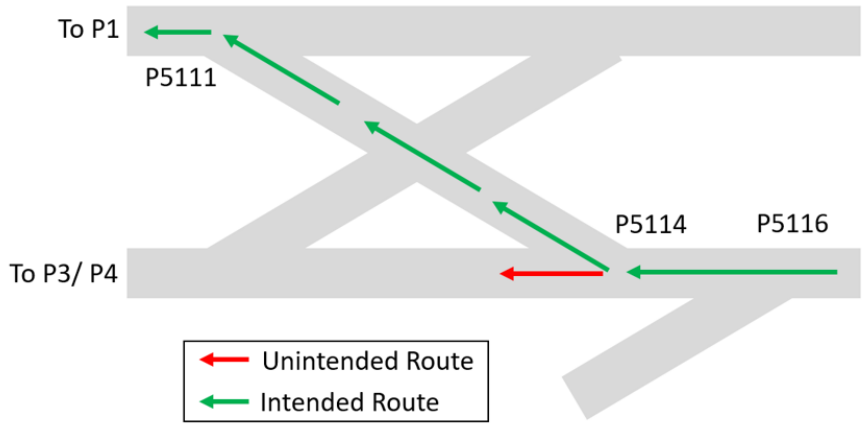
On 17 September 2019 at 08:29 hours, the train L094 ["Train 1] approaching Hung Hom Station (HUH) Platform 1 derailed at turnout P5116 north of the station. Three cars (4th, 5th and 6th car) derailed and the train was divided between the 4th and 5th car.



Annex 2

Illustration of Train Route (Intended/ Unintended) of Train 1

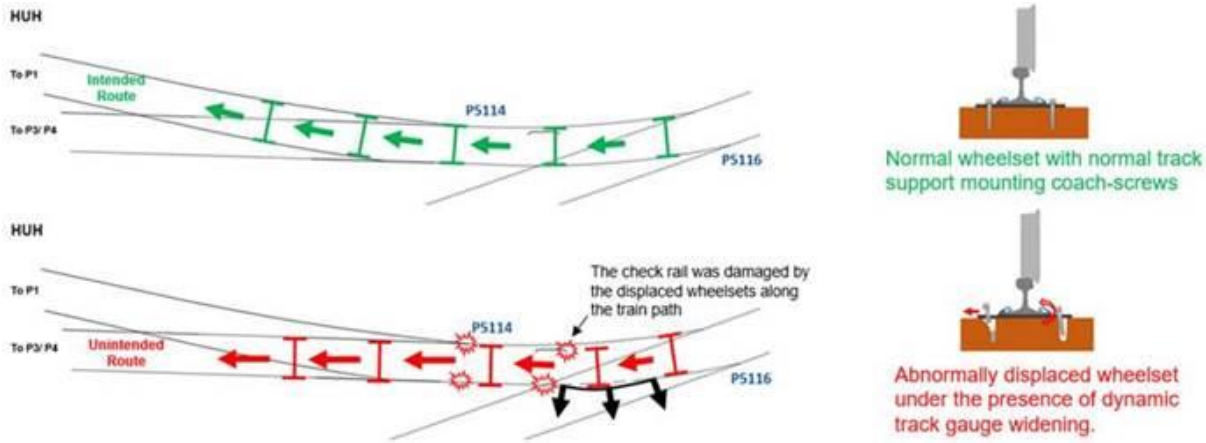
The Incident train, Train 1 travelled on diverged route at turnout P5114.



What Happened:

The immediate cause of the derailment was due to dynamic track gauge# widening at turnout P5116.

(#the distance between the rails under the load of a train)

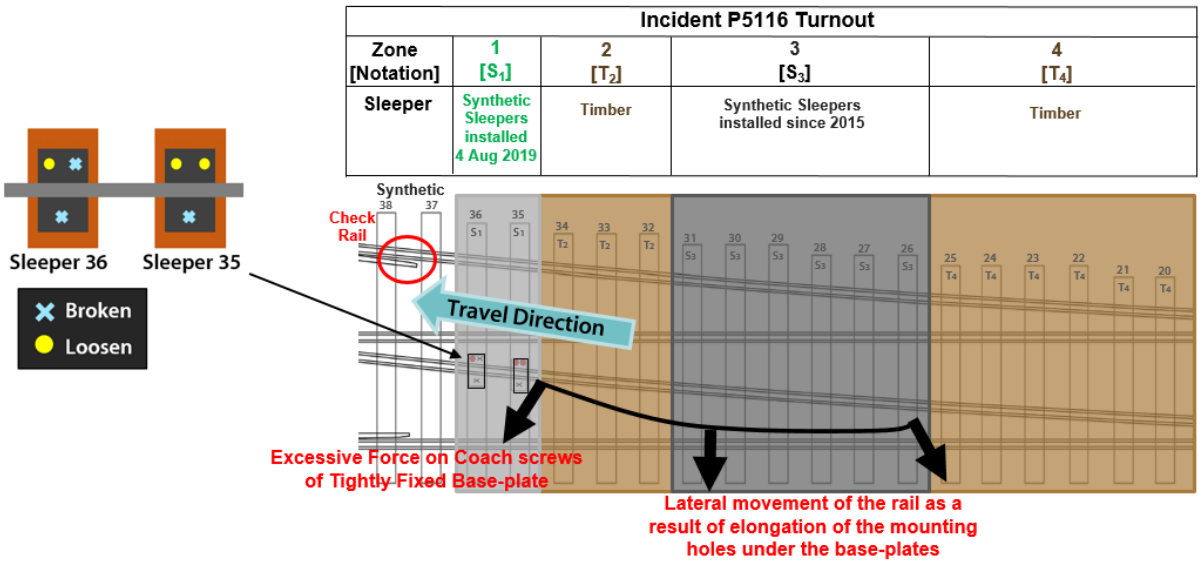


* Check rail is laid parallel to a running rail to guide wheels through rail crossing of all turnouts

Annex 3

Illustration of Sleeper Arrangement at Incident Turnout P5116

Timber sleeper (2 nos.) replacement at Zone 1 on 3^4 August 2019 to correct the track gauge had resulted in developing excessive force breaking the coach screws.



Annex 4

Track Gauge Maintenance Record at Turnout P5116 (since July 2018)

Activity	Date of measurement	Maximum dynamic gauge (mm)@	Follow-up action taken in accordance with "Management of Track Geometry Measurement by TOV"	TOV follow-up measured static gauge at sleeper #34 (Zone 2) (mm) @	Static gauge measurement (mm) @		
					Close to Zone 1 (Sleepers #37-38)	Close to Zone 3 (Sleeper #28-29)	Close to Zone 4 (Sleepers #20-21)
TOV 1	25^26 Jul 2018	1,458 [+23]	No				
Turnout M'tce 1	27 Jul 2018				1443 [+8]	1451 [+16]	1441 [+6]
TOV 2	22^23 Aug 2018	1,459 [+24]	No				
TOV 3	26^27 Sep 2018	1,460 [+25]	Static measurement on 29^30 Sept 2018	1453 [+18]	1449 [+14]	1456 [+21]	--
TOV 4	18^19 Oct 2018	1,460 [+25]	Static measurement on 29^30 Oct 2018	1451 [+16]	1443 [+8]	1456 [+21]	1451 [+16]
Turnout M'tce 2	1 Nov 2018				1443 [+8]	1446 [+11]	1443 [+8]
TOV 5	14^15 Nov 2018	1,460 [+25]	Static measurement on 17^18 Nov 2018	1454 [+19]	1450 [+15]	1456 [+21]	1446 [+11]
TOV 6	26^27 Jan 2019	1,463 [+28]	No	–			
Turnout M'tce 3	12 Feb 2019				1445 [+10]	1456 [+21]	1448 [+13]
TOV 7	24^25 Feb 2019	1,462 [+27]	No	–			
TOV 8	17^18 Mar 2019	1,464 [+29]	No	–			
TOV 9	3^4 Apr 2019	1,464 [+29]	No	–			
Turnout M'tce 4	21 Apr 2019				1453 [+18]	1459 [+24]	1433 [-2]

Activity	Date of measurement	Maximum dynamic gauge (mm)@	Follow-up action taken in accordance with "Management of Track Geometry Measurement by TOV"	TOV follow-up measured static gauge at sleeper #34 (Zone 2) (mm) @	Static gauge measurement (mm) @		
					Close to Zone 1 (Sleepers #37-38)	Close to Zone 3 (Sleeper #28-29)	Close to Zone 4 (Sleepers #20-21)
TOV 10	25^26 Apr 2019	1,466 [+31]	No	–			
TOV 11	9^10 May 2019	1,470 [+35]	Static measurement on 16^17 May 2019	1,466 [+31]	1455 [+20]	1464 [+29]	1446 [+11]
TOV 12	30^31 May 2019	1,469 [+34]	No	–			
TOV 13	15^16 Jul 2019	1,477 [+42]	Static measurement on 25^26 Jul 2019	1,471 [+36]	1463 [+28]	1466 [+31]	1446 [+11]
Turnout M'tce 5	1 Aug 2019				1454 [+19]	1460 [+25]	1444 [+9]
Sleepers replaced	3^4 Aug 2019			1,446 [+11]	1450 [+15]	1456 [+21]	1450 [+15]
TOV 14	7^8 Aug 2019	1,472 [+37]	No	–			
TOV 15	28^29 Aug 2019	1,469 [+34]	No	–			

@ The figure in the brackets "[ ]" is the difference between the measured gauge and the standard gauge (1,435 mm).

港鐵東鐵綫

紅磡站列車出軌事故

技術調查報告

Technical Investigation Report on

Train Derailment Incident at

Hung Hom Station on MTR East Rail Line

事故日期：2019 年 9 月 17 日

Date of Incident : 17 September 2019

英文版

English Version

機電工程署 EMSD

出版日期：2020 年 3 月 3 日

Date of Issue: 3 March 2020

CONTENTS

Executive Summary

On 17 September 2019, a passenger train derailed while it was entering Platform No. 1 of Hung Hom Station of the East Rail Line (EAL). This report presents the results of the Electrical and Mechanical Services Department's (EMSD) technical investigation into the causes of the incident.

The investigation of EMSD revealed that the cause of the derailment was track gauge widening[1]. The sleepers[2] at the incident location were found to have various issues including rotting and screw hole elongation, which reduced the strength of the sleepers and their ability to retain the rails in the correct position. The track gauge under dynamic loading of trains would be even wider, and this excessive gauge widening caused the train to derail at the time of incident.

After the incident, MTRCL have reviewed the timber sleeper condition across the entire EAL route and replaced the sleepers of dissatisfactory condition. MTRCL were requested to enhance the maintenance regime to closely monitor the track conditions with reference to relevant trade practices to ensure railway safety. MTRCL were also requested to install on-board real-time monitoring devices on passenger train to give greater and more timely visibility of track deficiencies and make good use of this monitoring and reporting system to improve track maintenance.

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[1] Track gauge is the distance between the inner side surfaces of a pair of rails. Excessive gauge widening might cause the train to derail.

[2] Rail is fixed onto the sleeper via baseplate to secure the position of the rail.

Technical Investigation Report on

Train Derailment Incident at Hung Hom Station on MTR East Rail Line on 17 September 2019

1 Objective

1.1 This report describes the technical investigation by the Electrical and Mechanical Services Department (EMSD) into the train derailment incident of 17 September 2019 on the East Rail Line (EAL). The purpose of the investigation is to find out the causes of the incident.

2 Background of Incident

2.1 At 8:29 a.m. on 17 September 2019, a derailment incident occurred on EAL when a 12-car passenger train of MTRCL was entering Platform 1 of Hung Hom Station. Upon receipt of notification from MTRCL at 8:36 a.m., EMSD immediately dispatched staff to the scene to carry out investigation. The sequence of events is listed in **Table 1**.

Table 1：Sequence of Events

Time	Description
17 September 2019	
08:29 a.m.	As train ID L094 was moving towards Platform 1 of Hung Hom Station, its 4th to 6th cars derailed, and its 4th and 5th cars were disconnected.
08:36 a.m.	EMSD was notified of the incident by MTRCL.
09:07 a.m.	EMSD staff arrived at the incident scene to carry out investigation.
09:43 a.m.	About 500 passengers were all evacuated to Hung Hom Station with assistance of MTRCL's staff.
11:40 a.m.	MTRCL commenced repair works.
18 September 2019	
06:05 a.m.	Platform 4 of Hung Hom Station resumed operation.
20 September 2019	
05:30 am	Platforms 1 and 4 of Hung Hom Station resumed operation.

2.2 At the time of the incident, the train was entering Platform 1 of Hung Hom Station. The 4th to 6th cars derailed, and the coupler connecting the 4th and 5th cars was disconnected. Eight passengers were injured. **Figure 1** shows the status of the train immediately after derailment.

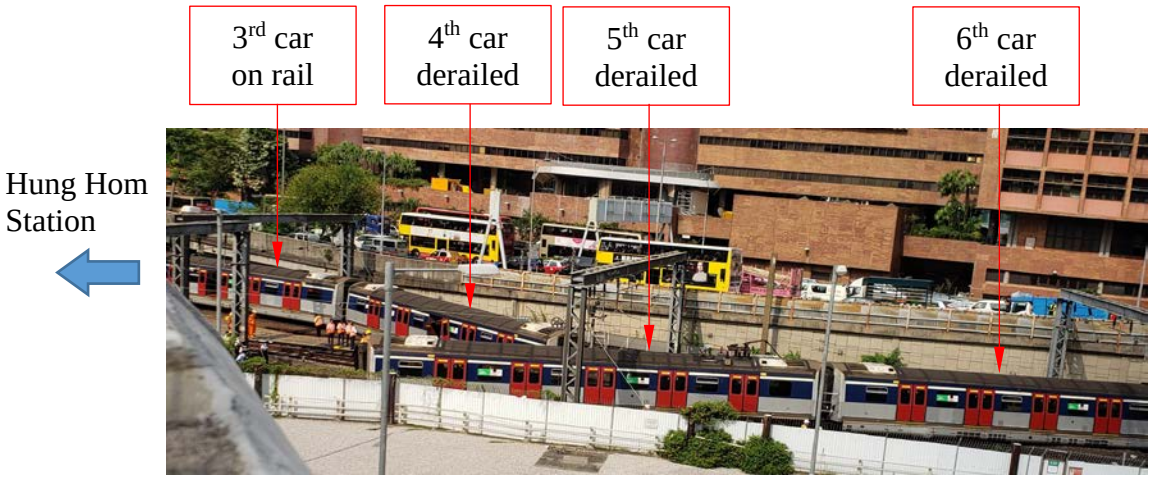

Figure 1 : Status of the incident train immediately after derailment

3 Technical Details Relating to Incident

3.1 Track design of EAL

EAL is a ballasted track. Sleepers are placed on the ballast and the baseplates[3] of rails are fixed onto the sleepers with screws. Rails are then placed and secured on the baseplates by clips. **Figure 2 and 5** show the typical ballasted track section with rail, clips, sleepers and baseplates on EAL.

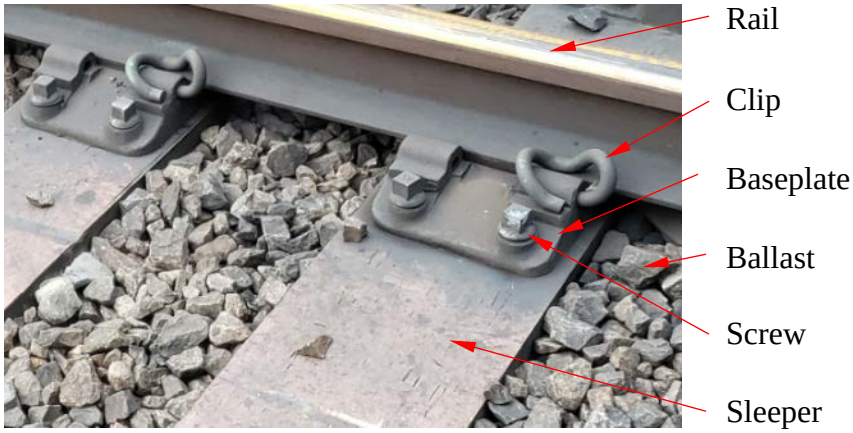

Figure 2 : Typical ballasted track section of EAL

[3] Baseplate is the component between the rail and the sleeper. In normal circumstances, the baseplate is fixed to the sleeper with screws and the rail is secured to the baseplate by clips.

3.2 Train routes at incident location

The normal routes of passenger trains passing through turnouts[4] P5116, P5114, P5111 and P5109 and turnouts P5116, P5114, P5112 and P5108 before entering Platform 1 and Platform 4 of Hung Hom Station of EAL, respectively, are shown in **Figure 3**. The incident train derailed just before entering Platform 1 at turnout P5116, which is located at a sharp curved track section on EAL. The speed limit of this section is 40 km/h. Each turnout consists of a point machine[5], switch rails[6], crossing[7] and two check rails[8]. The layout of a typical turnout is shown in **Figure 4**.

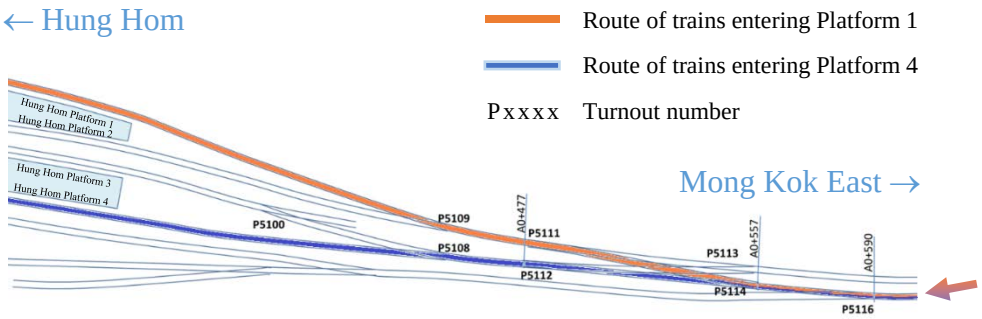

Figure 3 : Routes of trains entering Platform 1 and 4 of Hung Hom Station

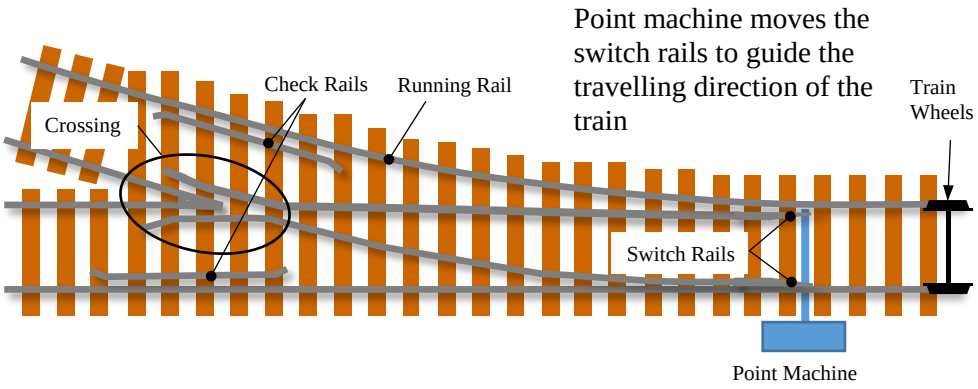

Figure 4 : Layout of a typical turnout

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4 Turnout is a mechanical device used to guide the train from one rail track to another.

5 Point machine is a power-driven device that moves the switch rails and controls the running path of train passing a turnout, often controlled by signalling system.

6 Switch rails are a pair of swinging rails that change the direction of turnouts.

7 Crossing has four rails to ensure that trains can safely pass through the turnout.

8 Check rail is an additional rail mounted alongside the inside rail of a curve or opposite of a crossing to restrict the lateral movement of wheels.

3.3 Sleepers

Sleepers of EAL are made of either concrete, timber, or synthetic[9] materials. Concrete sleepers are installed on plain tracks[10] and timber/synthetic sleepers are used at turnouts. Timber/synthetic sleepers have the flexibility of fine-tuning the position of baseplates and rails on site by drilling holes on the timber/synthetic sleepers so as to fit the curvature and profile of the route. There are over 9,800 timber/synthetic sleepers installed at turnouts of EAL. Since 2008, MTRCL have been replacing[11] timber sleepers with synthetic sleepers due to deterioration of timber sleepers. As at August 2019, MTRCL had replaced about 4,000 timber sleepers with synthetic sleepers in EAL.

3.4 Standard track gauge

Track gauge is the distance between the inner side surfaces of a pair of rails (see **Figure 5**). The standard track gauge of EAL is 1,435 mm. The gauge might exceed 1,435 mm due to a number of factors, such as lateral force exerted on the rail by running trains, wear and tear of rail, and loosening of fixing clips, etc. Excessive gauge widening might cause a train to derail. In this connection, periodic measurement and rectification of track gauge widening are of utmost importance.

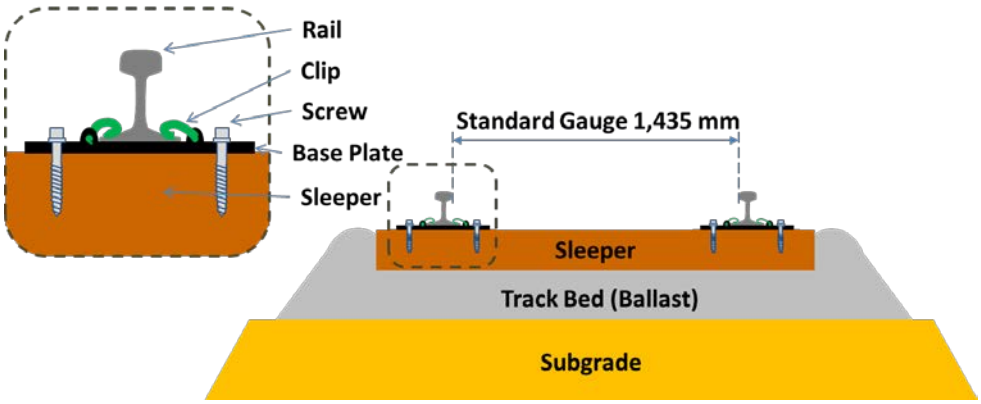

Figure 5 : Standard track gauge of EAL

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[9] Synthetic sleepers used on EAL are made of fibre-reinforced foamed urethane (FFU).

[10] Plain tracks are tracks without turnouts and crossings.

[11] Since the supply of natural timber suitable for use in railway becomes tight, sleepers that are made of synthetic materials are used to replace timber sleepers.

3.5 Maintenance procedures for track gauge

3.5.1 MTRCL's maintenance procedures for track gauge specify the following routine preventive and corrective maintenance work for the track of EAL.

(i) Patrolling with visual inspection of track conditions including rails, clips, screws, baseplates, and sleepers once every three days with tolerance of one day

(ii) Dynamic measurement of track gauge once every 30 days with tolerance of six days by the "Track and Overhead Line Vehicle" (TOV)[12] and comparing the figure against the maintenance threshold namely L1 Threshold[13] of 1,457 mm, which is 22 mm above the standard gauge of EAL

(iii) Turnout maintenance including inspection, measurement, and maintenance of major components such as crossings, check rails, switch rails and point machines once every 90 days with tolerance of 27 days

According to MTRCL's track gauge maintenance procedures entitled "Management of Track Geometry Measurement by TOV", when the TOV measurement reveals that the track gauge of EAL has reached the L1 Threshold, corresponding follow-up on-site verification by manual static measurement[14] is required within 28 days of the TOV measurement. If the on-site verification confirms that the track gauge reaches the Safety Intervention Limit[15], which is 20 mm and 30 mm above the standard gauge of turnouts and plain tracks, respectively, the gauge widening should be rectified within 28 days from the date of TOV measurement.

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[12] The Track and Overhead Line Vehicle (TOV) is an engineering train for measuring the geometry of the track and overhead line. The TOV measurement is commonly referred to as dynamic measurement, which measures the track gauge when the track is being subject to the loading of a train passing over it.

[13] Track gauge reaching the "L1 Threshold" does not imply immediate danger for train operation. However, on-site verification and the necessary rectification should be conducted within the predefined time frame to avoid further gauge widening that might cause derailment of train.

[14] Static measurement means manual measurement of track gauge when the track is not being subject to the loading of a train passing over it.

[15] If the Safety Intervention Limit is exceeded, rectification should be carried out within a predefined time frame according to maintenance procedures of MTRCL.

These rectification works should also be registered in MTRCL's maintenance management system namely "RailASSURE" for issue of corrective maintenance jobs. Follow-up Report and Quarterly L1 Exception Summary Report should be issued for monitoring the progress of maintenance work. MTRCL's maintenance procedures for track gauge maintenance and relevant monitoring mechanism are shown in **Figure 6**.

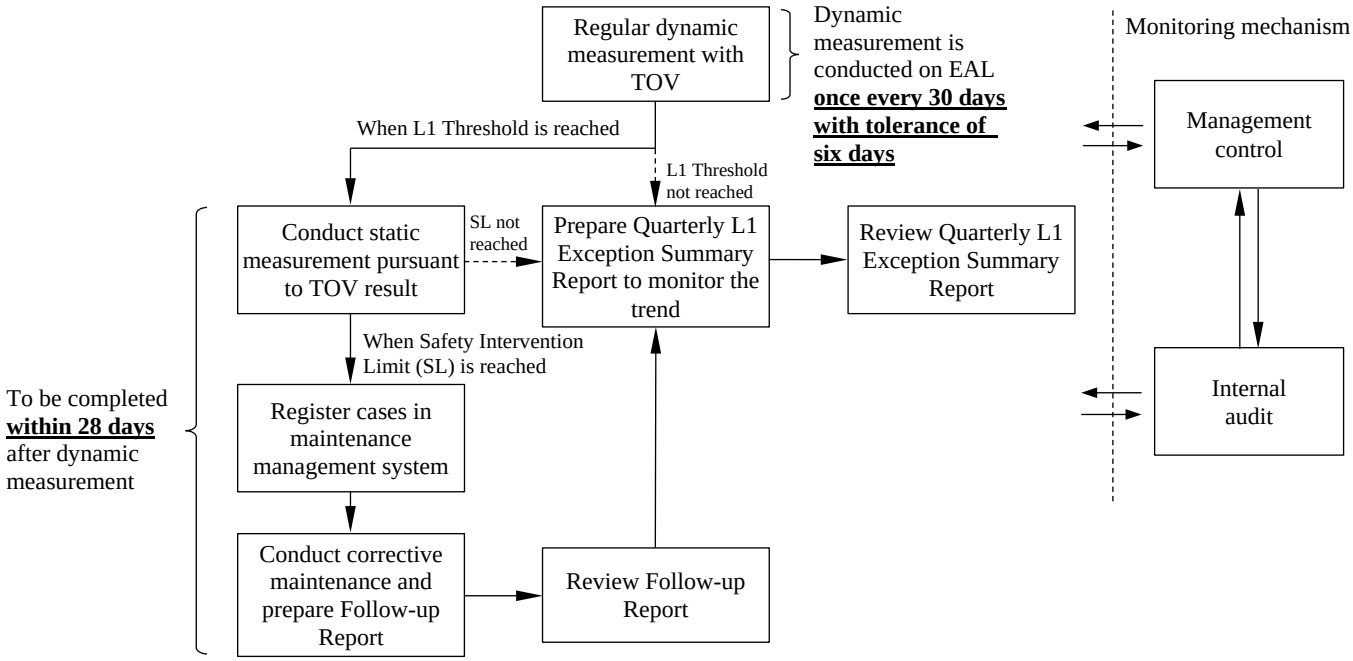


Figure 6 : MTRCL's maintenance procedures for track gauge maintenance and relevant monitoring mechanism

4 Incident Investigation

4.1 Approach of investigation

EMSD conducted an in-depth and comprehensive investigation into the causes of the incident. EMSD also appointed three railway safety experts, namely Technical Programme Delivery Limited (TPD)[16], Prof. Alan Lau[17]

[16] Technical Programme Delivery Limited is a UK railway safety consultancy company that employs experts with more than 40 years of experience in train derailment investigation.

[17] Prof. Alan Lau is an expert in failure analysis of materials and is the Pro Vice-Chancellor of the Swinburne University of Technology in Australia.

of Swinburne University of Technology, Australia, and Dr Eric C H Lim[18] of Safety Accident and Failure Expert Limited. The investigation included-

(a) examination of track gauge and sleeper conditions;
(b) examination of rail cracks, broken rails, and broken check rail;
(c) examination of point machines;
(d) examination of the incident train as well as the five trains immediately prior to the incident train;
(e) interviews with 34 relevant personnel of MTRCL, including train captains and permanent way maintenance staff;
(f) review of over 140 documents and records, mainly on maintenance and operation log for track, trains and point machines;
(g) review of the CCTV footage of the incident train entering Platform 1;
(h) seizing 50 items including the rails, sleepers and point machines from the incident site;
(i) joint site inspections with experts;
(j) joint inspection of the incident site and the incident train with the Hong Kong Police Force to identify any foreign objects; and
(k) laboratory tests on the material strength of sleepers.

4.2 Observations at Incident Location

The incident location revealed the following.

(a) The incident train was scheduled to enter Platform 1 of Hung Hom Station. During the incident, the 4th to 6th cars derailed, and the coupler connecting the 4th and 5th cars was disconnected. The first three cars and the last six cars remained on the track rail. There were eight turnouts at the incident location to control train movement to and from different platforms at Hung Hom Station. The status of the incident train after derailment and the damage to the nearby railway facilities are shown in **Figure 7**. Photos of wheel flange marks, broken rails, rail cracks, and damaged point machines are shown at **Appendix I**.

[18] Safety Accident and Failure Expert Limited is a local consulting firm. Dr Eric C H Lim is a material testing expert of the firm with extensive experience in failure analysis.

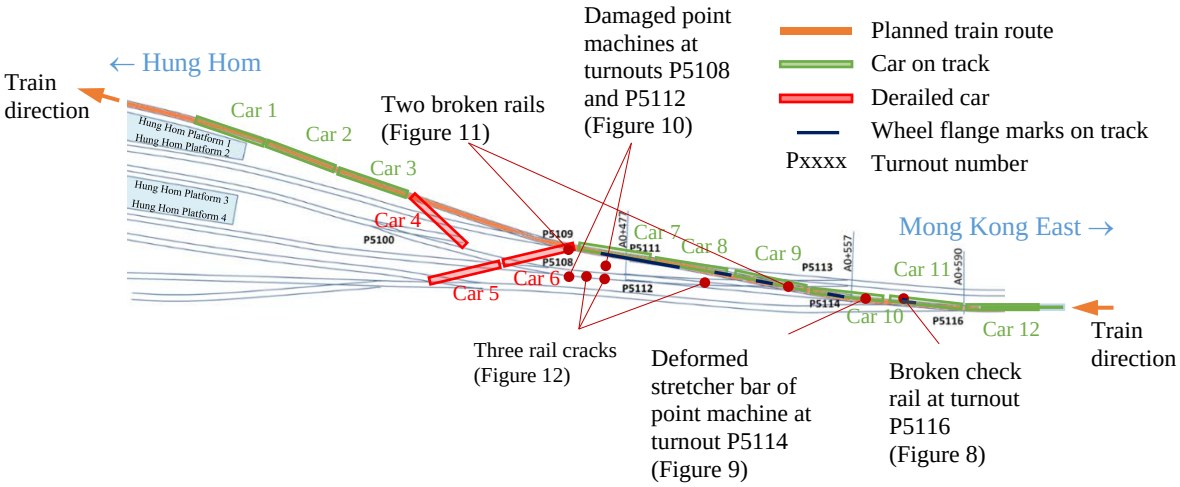


Figure 7 : Status of incident train after derailment and damage to nearby railway facilities

(b) The check rail at turnout P5116 towards Hung Hom Station was found broken (see **Figure 8**). The length of the broken section was measured to be 325 mm.

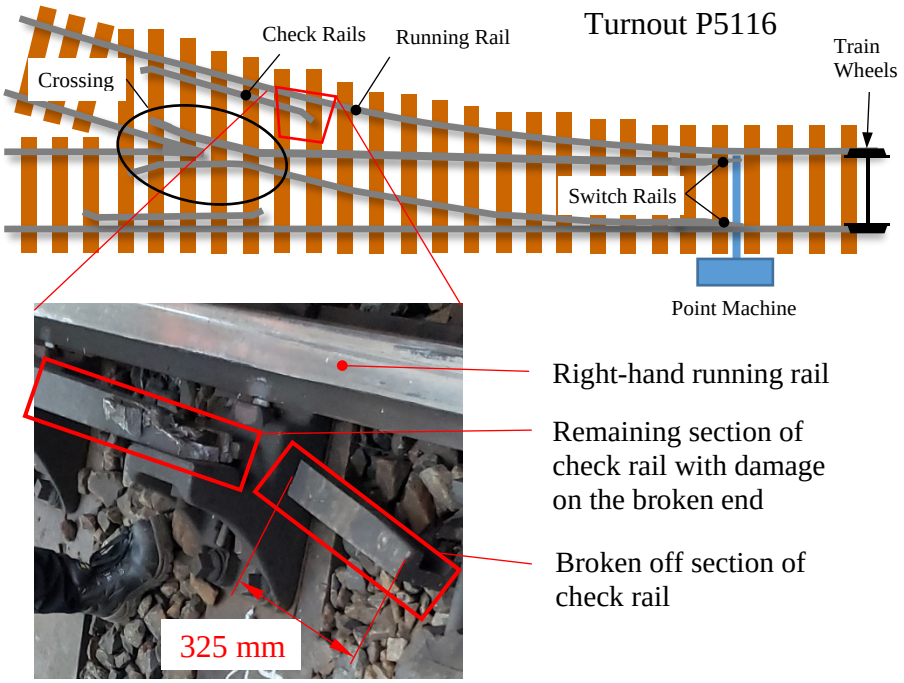


Figure 8 : Broken check rail at turnout P5116

(c) At turnout P5114, the components of the point machine [19] were deformed and damaged as shown in **Figure 9**. The motor drive of point machines of turnouts P5108 and P5112 were also damaged as shown in **Figure 10**.

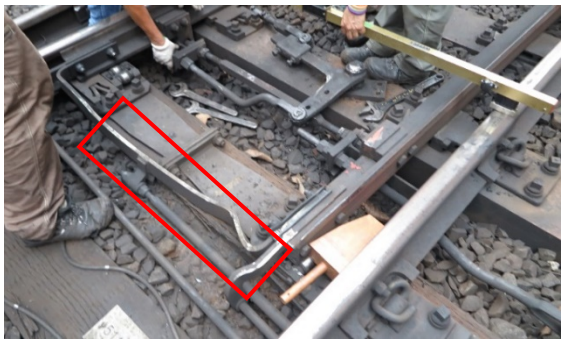


Figure 9 : Deformed stretcher bar of point machine at turnout P5114

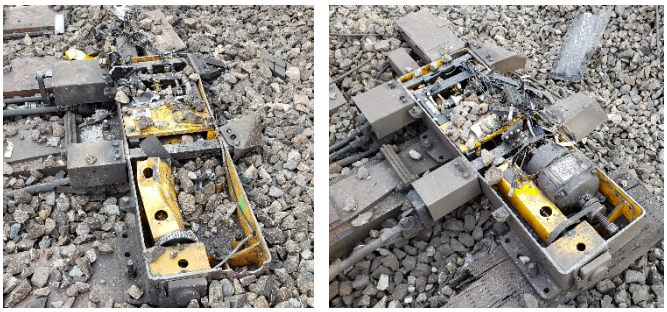


Figure 10 : Damaged motor drives of point machine at turnouts P5108 (left) and P5112 (right)

(d) Two broken rails (see **Figure 11**) and three rail cracks (see **Figure 12**) were found at the incident location.

Figure 11 : Two broken rails

[19] Point machine consists of an electric motor and movable mechanical linkages to move and lock the switch rails in the turnout so as to control the moving path of the train. A point machine is controlled by the signalling system.

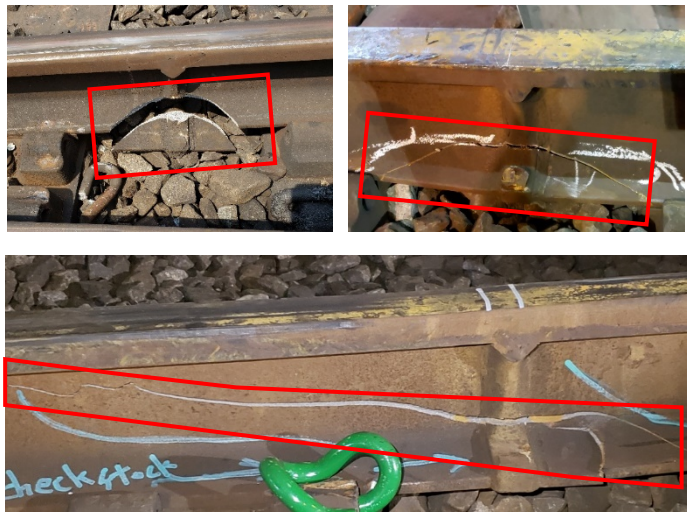


Figure 12 : Three rail cracks at the incident location

(e) During investigation at turnout P5116, some fastening screws for fixing the baseplates to the sleepers were found to have been taken out and put aside. MTRCL confirmed that these fastening screws were found loosened and removed by their staff without the use of any tools after the incident (see **Figure 13**). Some clips for retaining the rail on the baseplates at the inside of the right-hand rail near the broken check rail were missing.

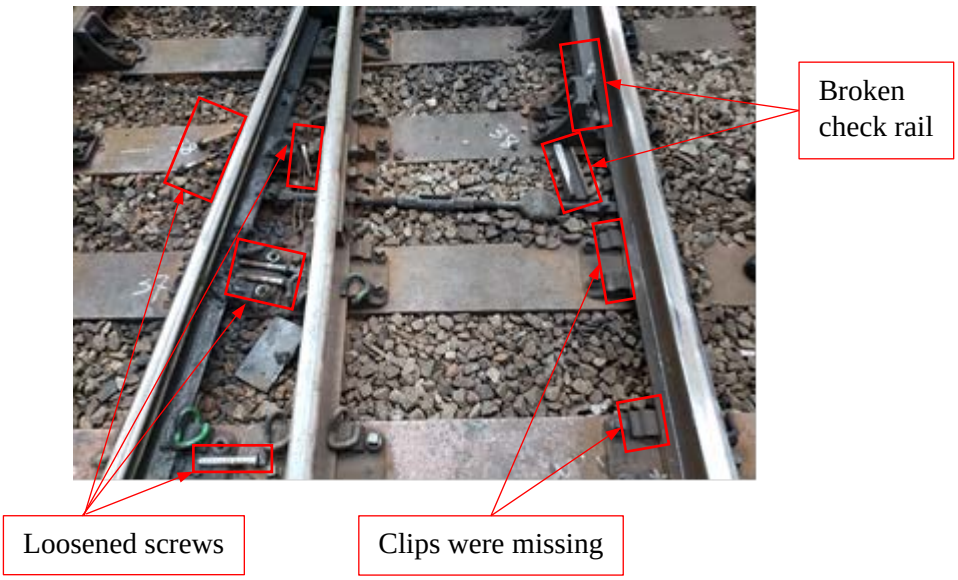


Figure 13 : Loosened fastening screws, missing clips, and broken check rail at turnout P5116

(f) Wheel flange marks, as caused by the wheel flanges[20], were observed on rail foot and sleepers along the tracks at the incident location. An example of wheel flange mark found on the running rail near 36th sleeper of turnout P5116 is shown in **Figure 14**.

(g) The track gauge of the running rails at turnout P5116 was measured after the incident and found exceeding the Safety Intervention Limit of 1,455 mm.

(h) The train operation log showed the train speed was 39 km/h at the time of derailment.

(i) No external object that was not part of the railway system was found at the incident location and nearby areas during site investigation with the Hong Kong Police Force.

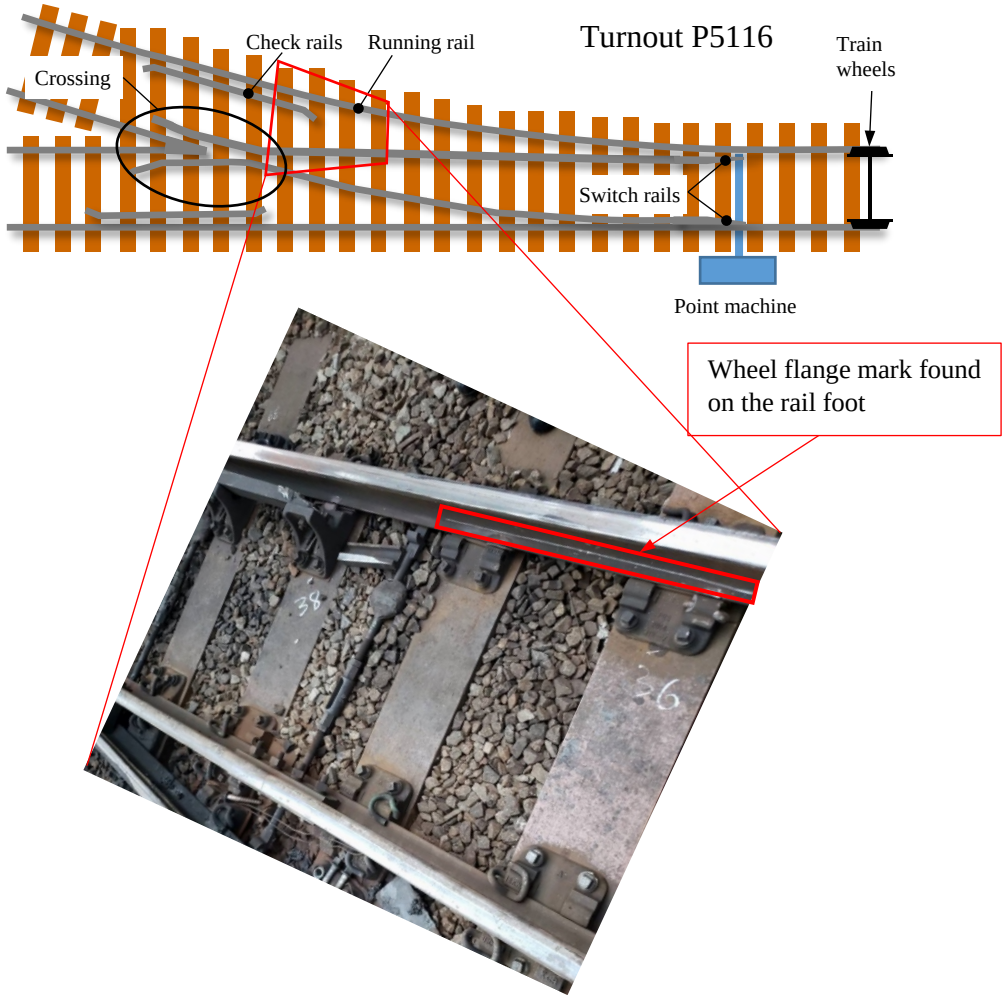


Figure 14 : Wheel flange marks on the rail foot

[20] Wheel flange is the extended portion of a rail wheel that provides it with direction guidance.

4.3 Examination of trains at MTRCL Ho Tung Lau Depot

4.3.1 EMSD examined the incident train (train ID L094, referred to as "Train A" in this report) and the five trains that arrived at Hung Hom Station immediately before the incident train (train ID M092, C090, M088, L086 and M084, referred to as "Train B" to "Train F" in this report) at MTRCL Ho Tung Lau Depot on 20 and 22 September 2019. **Table 2** shows Train A to Train E with hit marks found on the right-hand wheels and their respective arrival schedule at Hung Hom Station. No hit mark was observed on the wheels of Train F. **Figure 15** shows the record of hit marks on wheels.

Table 2：Trains with hit marks observed on right-hand wheels

Schedule of arrival at Hung Hom Station *	Train No.	Ref. No.	Platform	Hit mark on wheels	Remarks
08:12	M084	Train F	4	No	
08:14	L086	Train E	1	Yes	First hit mark observed on 8th car
08:17	M088	Train D	4	Yes	
08:19	C090	Train C	1	Yes	
08:22	M092	Train B	4	Yes	
08:24	L094	Train A	1	Yes	Incident train

* Actual train arrival time might be different from the scheduled arrival time

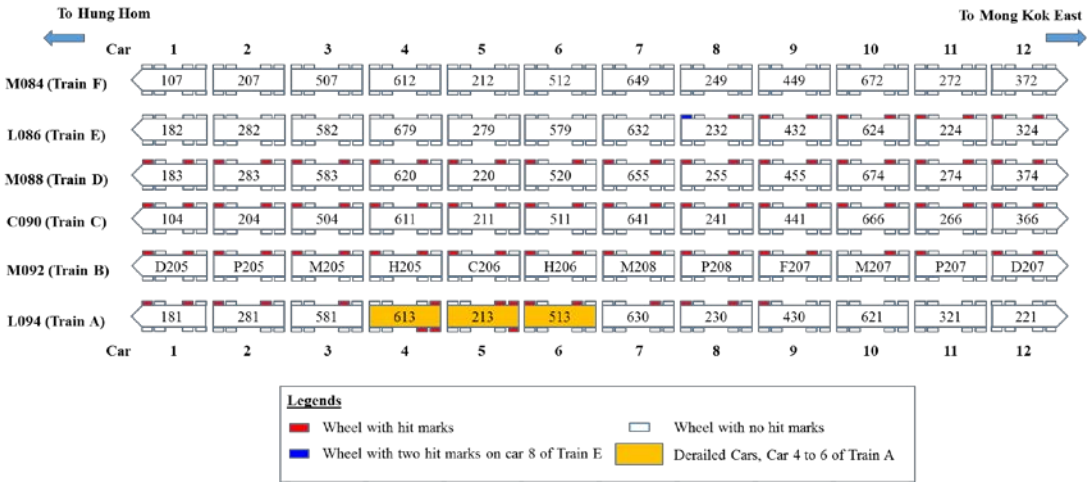


Figure 15：Record of hit marks found on wheels of Train A to Train F

4.3.2 EMSD examined and found two hit marks with a separation of 325 mm (see **Figure 16**) on the first right-hand wheel on the first bogie of the 8th car of Train E. The separation distance of these two hit marks matched with the

length of the broken check rail at turnout P5116. As no hit mark was found on the wheels of the 1st to 7th cars of Train E, it was evident that the 8th car was the first to have hit and broken the front end of the check rail of turnout P5116.

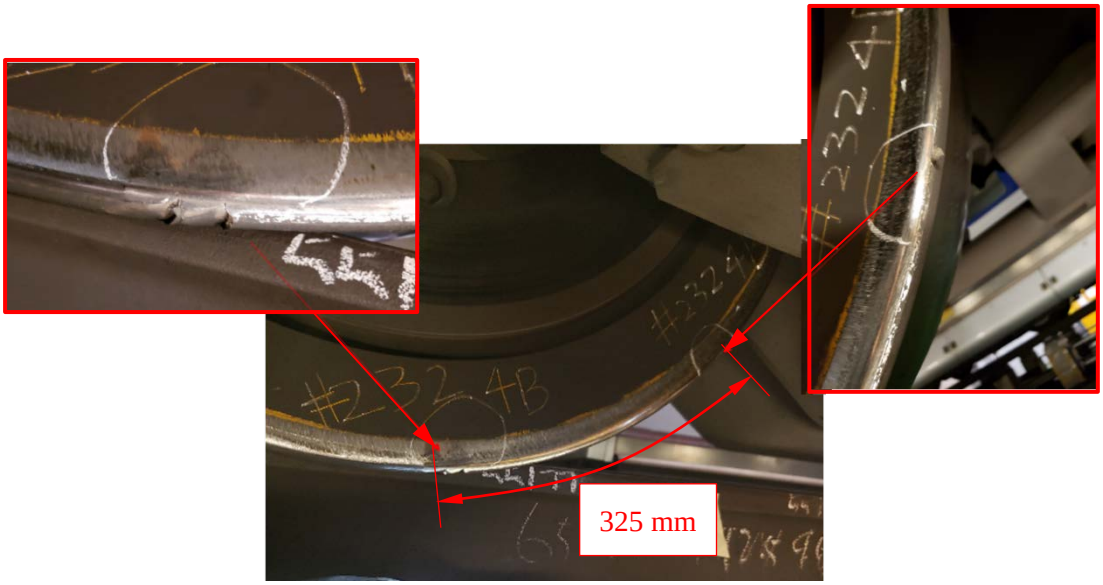


Figure 16 : Two hit marks separated by 325 mm on the first right-hand wheel of the 8th car of Train E

4.3.3 Hit marks were also found on the right-hand wheels of Train A to Train E. It was evident that these hit marks were caused by hitting the remaining section of the broken check rail at turnout P5116.

4.3.4 Examination of Train A included (a) measurement of the distance between the pairs of wheels, (b) measurement of the profile of wheels, (c) measurement of thickness of the brake discs, (d) functional test of the braking system, and (e) the conditions of the Automatic Train Protection system. All the above systems were found in normal working conditions. There was no evidence that the derailment was due to the condition of the incident train.

4.4 Examination of seized exhibits

4.4.1 Broken check rail

The check rail of turnout P5116 towards Hung Hom Station was found broken. The purpose of the check rail was to restrict lateral movement of wheels to ensure that trains take the correct route through the crossing. The detached

section of the broken check rail was of length 325 mm (see **Figure 17**). From the hit mark at the upper front edge of the check rail and the hit marks on the wheels of the 8th car of Train E, it was evident that the breakage was due to fracture failure from collision with the wheel of the 8th car of Train E, instead of material fatigue.

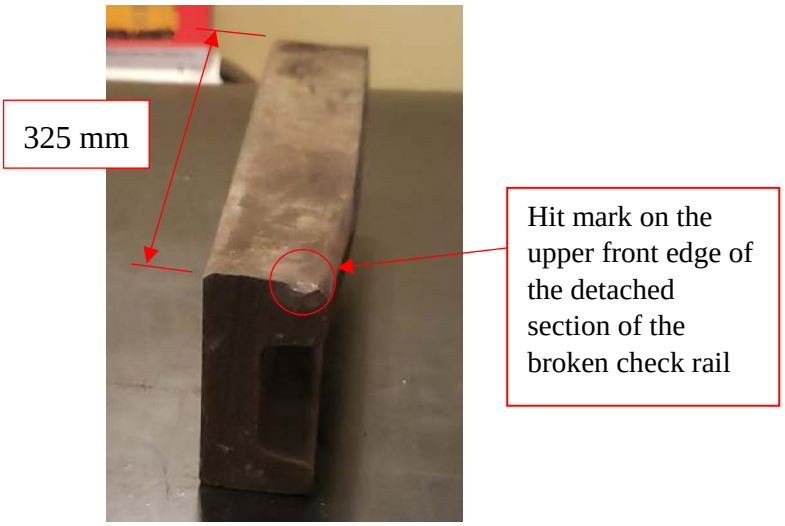


Figure 17 : Front view of detached section of broken check rail

Three smaller pieces of broken metal were found near the broken check rail on the track. The shape of the metal pieces, when putting together, matched with that of the fractured surface of the remaining section of the broken check rail (see **Figure 18**). It was evident that these metal pieces were shattered off from the fractured surface as a result of being hit by wheels of subsequent Train E to Train A.

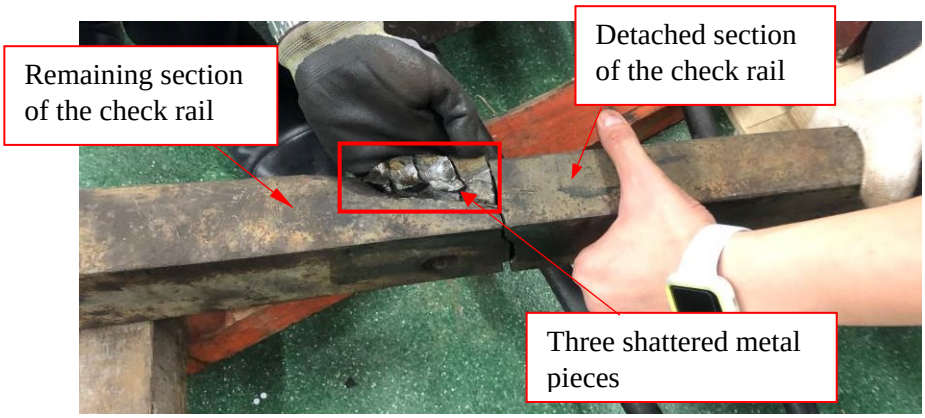


Figure 18 ：Broken check rail and shattered metal pieces

4.4.2 Examination of sleepers

Both timber and synthetic sleepers were used at the incident location. Some of the timber sleepers were found to have rotted (see **Figure 19**). EMSD seized some sleepers from the derailment location.

Figure 19 : Rotten timber sleeper

Elongated and enlarged screw holes were found on all the seized sleepers (**Figure 20**). These screw holes would not have been able to secure the positions of baseplates on the sleepers, thus failing to maintain the standard track gauge.

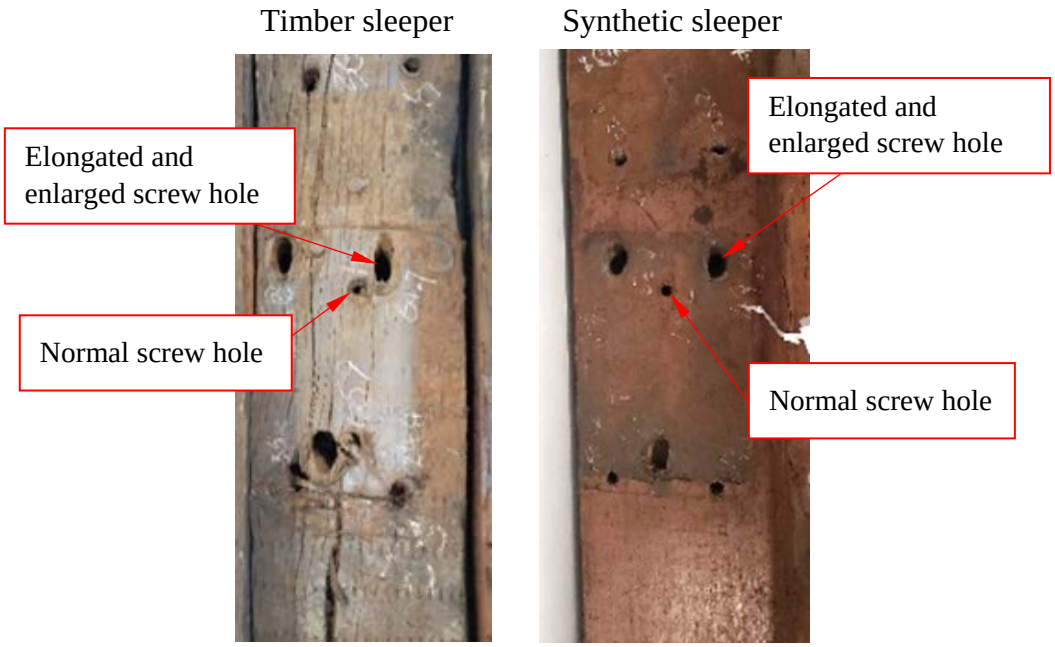


Figure 20 : Sleepers with elongated and enlarged screw holes

More than one set of screw holes underneath the baseplate were observed on some seized sleepers. During track maintenance, a loosened baseplate may be fixed by shifting and re-orientating the baseplate and mounting it with a new set of screw holes on the existing sleeper. The new screw hole should be separated from existing screw holes with

sufficient distance to ensure the integrity of the new screw hole. Three sets of screw holes were found underneath the baseplate of left hand rail of the incident route on the 32nd sleepers of turnout P5116 (see **Figure 21 and Figure 22**). Some screw holes were very close to each other, which would weaken the timber and its restraint of the baseplate.

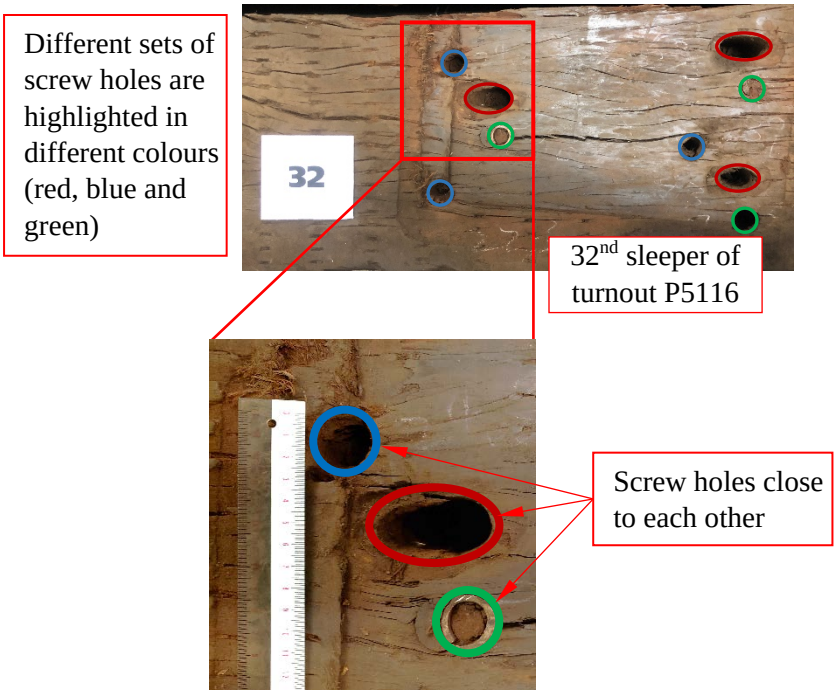


Figure 21 : Screw holes underneath the baseplate of left hand rail of the incident route on the 32nd sleeper of turnout P5116

4.5 Examination of signalling system

4.5.1 Signalling system

EMSD examined the operation records of the signalling system and associated field equipment. There was no abnormality or equipment fault of the signalling system in the course of the incident.

4.5.2 Cyber-attack

EMSD examined MTRCL's security event analysis report and confirmed no network security breach of MTRCL's corporate networks on 17 September 2019. EMSD also verified the design of the signalling system of EAL and confirmed that it was a closed system and was not connected to the internet or any other networks of MTRCL.

4.6 Material testing of synthetic sleepers used in EAL

Material testing of sampled synthetic sleepers was conducted to confirm their compliance with the standard JIS E 1203:2007[21]. There was no evidence that the derailment was due to any inferior mechanical properties of the synthetic sleepers.

5 EMSD's Findings

5.1 Point of derailment

EMSD's investigation team, including the appointed experts, conducted detailed inspections at the incident location to determine the point of derailment. Given the travelling direction of trains, the investigation team found that the wheel flange mark first appeared on the rail foot between the 35th and 36th sleepers of turnout P5116. Considering the train speed and the time taken for the wheel to fall and touch the rail foot, it was evident that the point of derailment was between the 33rd and 34th sleepers of turnout P5116. **Figure 22** shows the location of the point of derailment at turnout P5116.

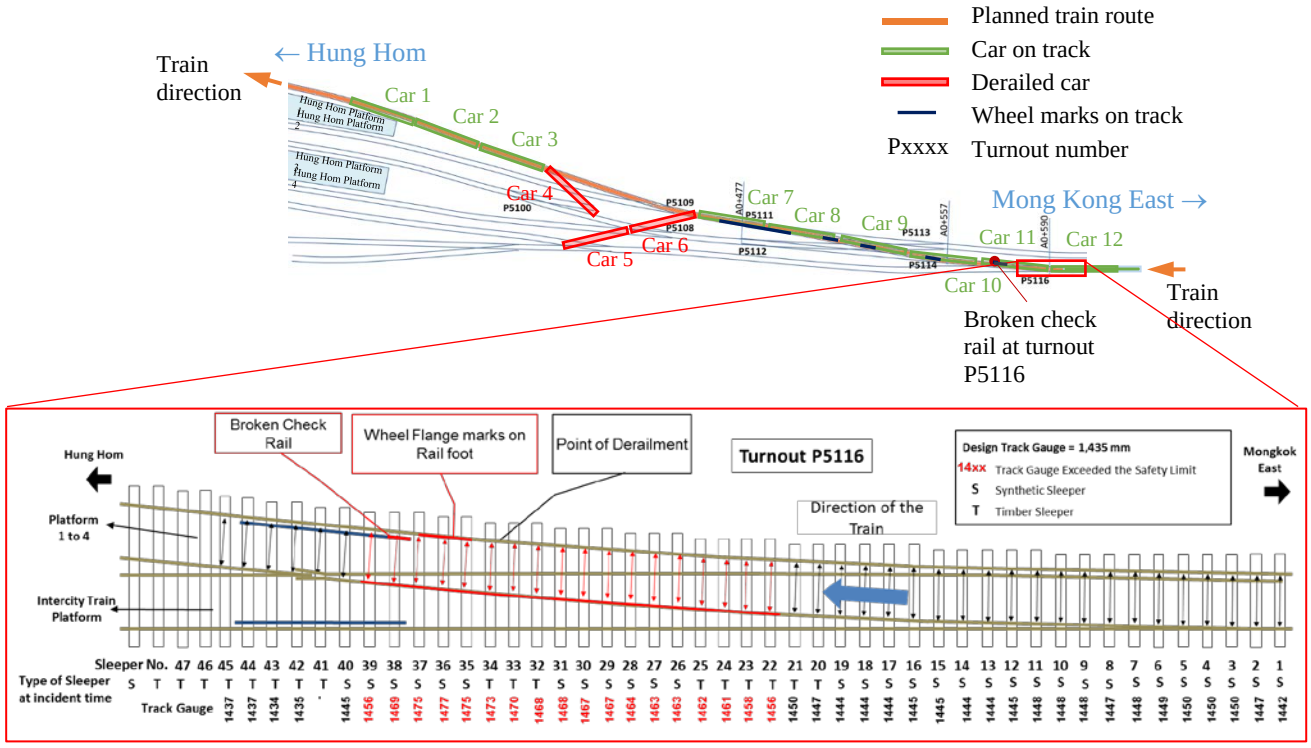


Figure 22 : Point of derailment and track gauge at turnout P5116

[21] JIS E 1203:2007 – "Synthetic sleepers – Made from fiber reinforced foamed urethane" is the standard on synthetic sleepers for use on the permanent way.

Wheel flange marks were found on the top of the check rail at turnout P5116 (**Figure 23**). It was evident that some wheels of Train A to Train E had hit the check rail and climbed onto the top of the check rail.

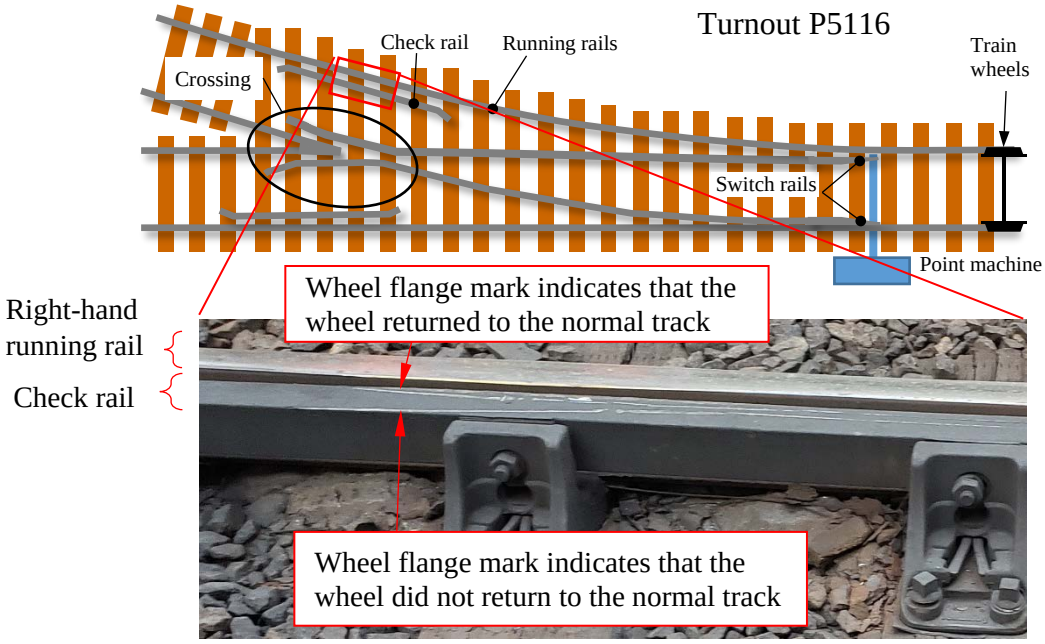


Figure 23 ：Wheel flange marks on top of the check rail

Two broken rails and three rail cracks were found at five different locations around the incident location. All points of fracture were located at welded joints. All broken points and cracks were recent fracture, instead of fatigue failure. It was evident that these fractures and cracks were caused by the derailed wheel flange striking the protruding part of the weld collar (see **Figure 24**), which were not uncommon in train derailment incidents.

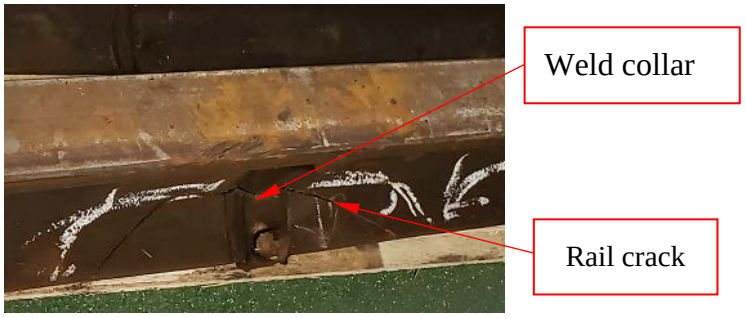


Figure 24 : Wheel flange mark on the weld collar of a cracked rail

5.2 Deterioration of sleepers

The investigation team examined the sleepers that were seized from site at or near the point of derailment. Many of the timber sleepers were found to have rotted internally. Longitudinal surface cracks and splitting were noted on some timber sleepers. The type of surface cracks present was evidence of internal rotting of timber. Deterioration of the integrity of the timber due to rotting reduces the ability of the screws to hold the baseplate firmly in place on the sleeper, resulting in gauge widening. **Figure 25** shows the condition of a rotten timber sleeper with longitudinal surface crack and splitting.

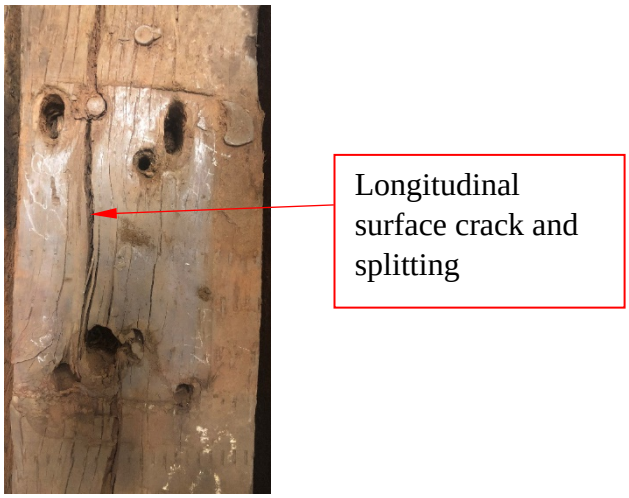


Figure 25 : Rotten timber sleeper

Elongated and enlarged screw holes were found on all the seized sleepers. The enlarged screw holes were unable to securely retain the screws of the baseplates in position on the sleepers. Some of the screws at the incident location were loosened as mentioned in paragraph 4.2(e) and shown in **Figure 13**. When the trains travelled on the curved section of track rail, the lateral force exerted by the train on the rail would cause the outer rail to move or rotate outwards, resulting in the gauge widening. To avoid excessive gauge widening, proper monitoring and maintenance of track gauge were essential to ensure railway safety.

5.3 Gauge widening

According to the static gauge measurement immediately after the incident, the gauge of the track section between the 22nd and 39th sleepers of turnout P5116 were all measured to have exceeded the Safety Intervention Limit of 1,455 mm as marked in red at **Figure 22**. The track gauge at the point of

derailment at the 34th sleeper at turnout P5116 was 1,473 mm, which was 38 mm wider than the standard gauge of 1,435 mm. In view of the rotted condition of sleepers, the track gauge under dynamic loading of trains would be even wider, and this excessive gauge widening had caused the train to derail at the time of incident. The investigation team concluded that the cause of the derailment was excessive gauge widening.

6 Conclusions

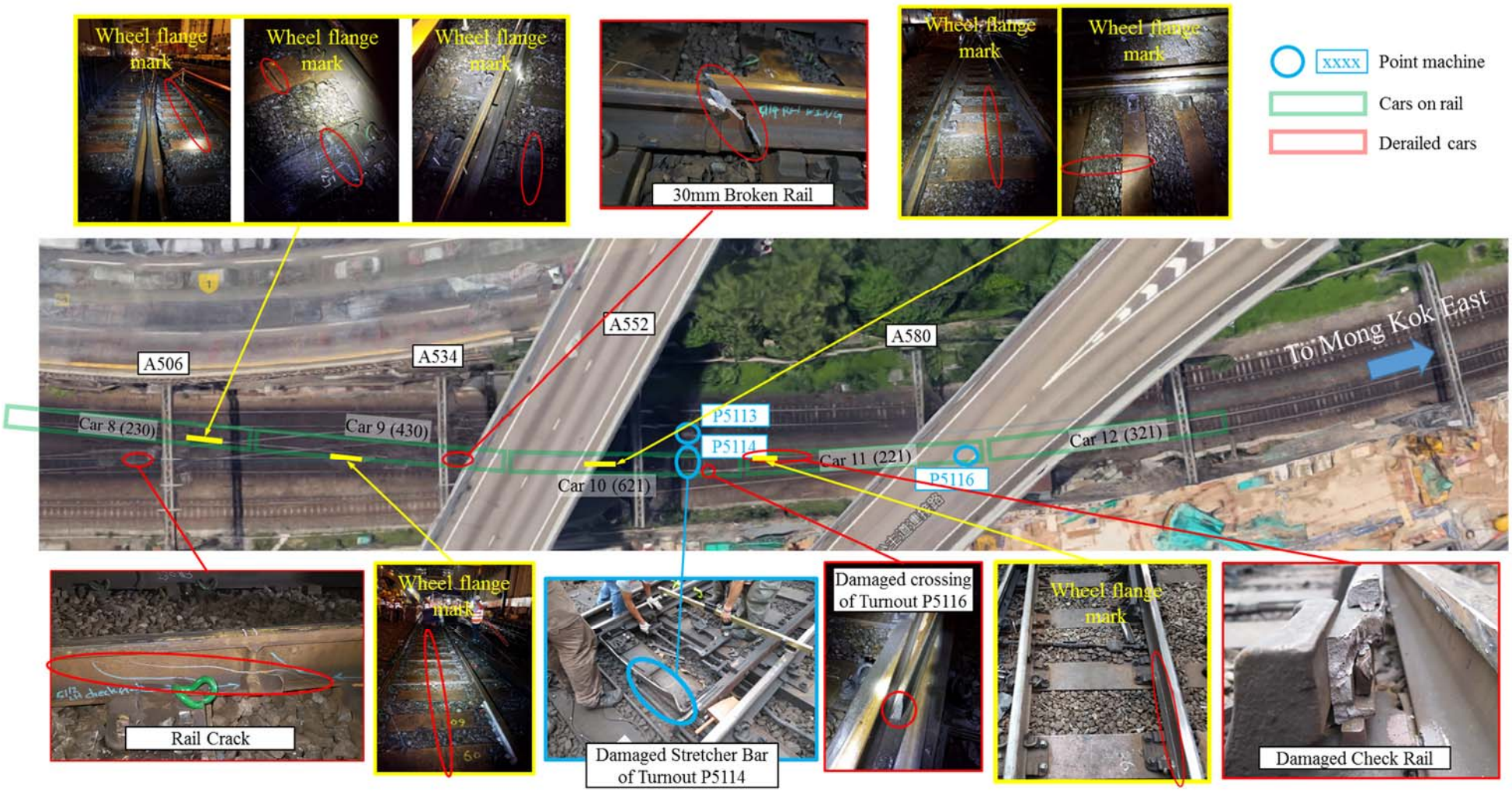
6.1 The investigation of EMSD revealed that the cause of the derailment was track gauge widening. The sleepers at the incident location were found to have various issues including rotting and screw hole elongation, which reduced the strength of the sleepers and their ability to retain the rails in the correct position. The track gauge under dynamic loading of trains would be even wider, and this excessive gauge widening caused the train to derail at the time of incident.

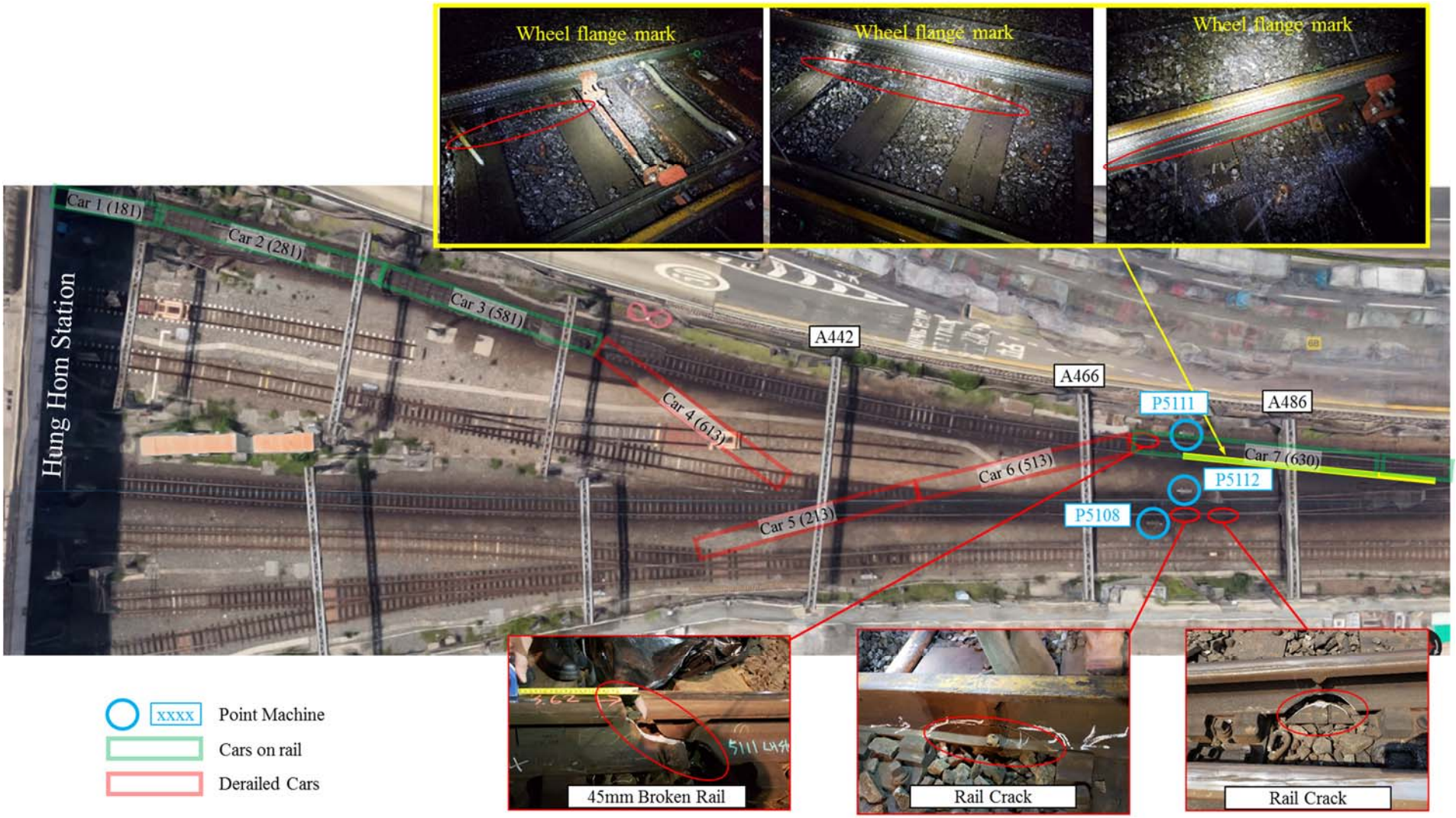
7 Measures Taken after Incident

7.1 MTRCL have reviewed the timber sleeper condition across the entire EAL route and replaced the sleepers of dissatisfactory condition. MTRCL were requested to enhance the maintenance regime to closely monitor the track conditions with reference to relevant trade practices to ensure railway safety.

7.2 MTRCL were also requested to install on-board real-time monitoring devices on passenger train to give greater and more timely visibility of track deficiencies and make good use of this monitoring and reporting system to improve track maintenance.

Appendix I – Photos of Wheel Flange Marks, Broken Rails, Rail Cracks and Damaged Point Machines On-Site




Wheel flange mark
Wheel flange mark
Wheel flange mark
Car 1 (181)
Car 2 (281)
Car 3 (581)
Car 4 (613)
Car 5 (213)
Car 6 (513)
Car 7 (630)
Hung Hom Station
A442
A466
A486
P5111
P5112
P5108
xxxx
Point Machine
Cars on rail
Derailed Cars
45mm Broken Rail
Rail Crack
Rail Crack

Annex 3

Derailment Incident at Hung Hom Station (HUH) on East Rail Line (EAL) on 17 September 2019

Sequence of Events

Date／Time (Approx.)	Event
17 September	
8:18 a.m.	The leading wheelset on the 8th car of Train number L086 hit the check rail of turnout P5116 of HUH. The wheels of three subsequent trains hit and progressively further damaged the check rail.
8:29 a.m.	The leading wheelset of the 5th car of Train number L094 rode up on the remainder of the damaged check rail of turnout P5116 and took an unintended route towards Platforms 3 and 4 at turnout P5114, completely derailing the 4th, 5th and 6th cars and dividing the train.
8:32 a.m.	The train service between EAL HUH and Mong Kok East Stations (MKK) was suspended and the West Rail Line (WRL) service was adjusted.
8:39 a.m.	Informed the media of the incident on EAL.
9:30 a.m.	A free shuttle bus route running between Tai Wai and Diamond Hill stations was arranged to divert passengers travelling between Kowloon and New Territories.
9:43 a.m.	All the passengers in the train (about 500) completed the detrainment in a safe and orderly manner to HUH platform.
11:40 a.m.	Repair works commenced and WRL Service was gradually resumed.
5:30 p.m.	MTR representatives briefed the incident at a Media Stand-up.
18 September	
6:05 a.m.	One platform at EAL HUH resumed service after recovery works.
20 September	
From the start of services	The full recovery works of EAL HUH generally completed. All platforms of HUH resumed service.

Annex 4

Contingencies during the Derailment Incident at Hung Hom (HUH) Station on East Rail Line (EAL) on 17 September 2019

Notification and information dissemination

1. The MTR Corporation Limited (MTRCL) immediately notified the Emergency Transport Coordination Centre (ETCC) of the Transport Department (TD) and issued a " Red Alert" at 8:32 a.m. representing serious service disruption. The Corporation also notified Electrical and Mechanical Services Department (EMSD), TD and media thereafter, so that TD could coordinate with other transport operators to enhance their services to meet passenger demand.

2. Upon receiving the MTRCL's notification, taking into account the severity of the incident, ETCC of TD escalated its operation level to Tier 3[1], led by directorate staff of TD, and deployed additional staff to coordinate with other public transport operators and to provide emergency support. ETCC urged MTRCL to disseminate information to passengers and closely monitor and manage passenger flow in stations. ETCC also immediately requested franchised bus companies to enhance its services as well as the operator of Cross Harbour Tunnel to monitor the traffic throughput of that area. During the period, TD disseminated the latest traffic and public transport information to the public through the media, website and mobile applications. EMSD also deployed staff to monitor the repair works.

3. Besides, the MTRCL informed passengers about the service disruption and information about other transportation modes via its mobile apps "MTR Mobile", broadcast at stations and in train compartments, signage installed at stations and at ground levels, and Passenger Information Display System located next to the entry gates. During the incident, ticket gates of affected stations were switched to a specific mode of which passengers leaving HUH and Mong Kok East Station (MKK), their fares were not deducted.

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[1] Under normal circumstances, the Emergency Transport Coordination Center (ETCC) of the Transport Department, operating 24 hours a day, handles daily minor traffic accidents at Tier 1. In the event of small-scale pre-planned activities, serious road or tunnel incidents, serious or widespread disruption of public transport services, the operation of the ETCC will be escalated to Tier 2 and additional staff will be deployed. The operation of ETCC will be escalated to Tier 3 to handle large-scale planned events or major incidents that warrant high level steer and coordination among departments.

4. Subsequently, the MTRCL continued to update its train service information via its mobile applications and the media.

Manpower

5. During the incident, the MTRCL deployed about 300 engineering staff to assist in recovery, and an additional 130 staff (including train service staff, station assistants, passenger support teams and Customer Service Rapid Response Unit) to assist passengers at affected stations, including crowd management at stations, advising passengers on using other transportations, etc..

MTR shuttle bus

6. During the incident, the MTRCL had arranged a free shuttle bus route running between Tai Wai and Diamond Hill to divert passengers. 343 free shuttle buses trips were run and carried over 1,400 passengers.

Other transport services

7. During the period, ETCC continued to closely liaise with franchised bus and the operator of Cross Harbour Tunnel, requesting them to enhance services and monitor the traffic throughput of the area. With TD's coordination, 20 routes of franchised bus enhanced its service during the incident to assist in picking up affected passengers. ETCC also maintained close liaison with the MTRCL on the day, and disseminated information concerning the latest development of the incident and transportation arrangements to the public through media and mobile applications. TD also advised the public through radio to plan their trips well in advance, and consider other routing and transportations, in order to minimise the impact of the incident.