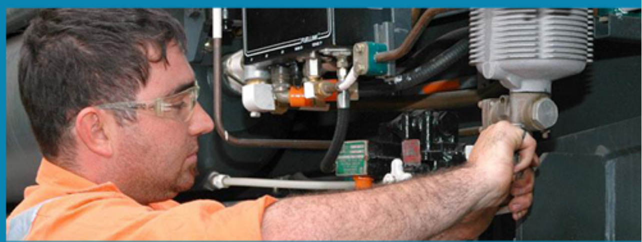
LITERATURE REVIEW

DERAILMENT LEARNINGS

FROM PASSENGER TO HEAVY HAUL

EDPM-AU-5208528-001-B (28/09/2021)

Briefing Note

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Subject **Derailment Learnings from Passenger to Heavy Haul – Literature Review**

1. Executive summary

Train derailments are a relatively frequent occurrence in the Heavy Haul industry in Australasia, with large economic and safety repercussions. In comparison, the frequency of derailments of passenger rolling stock is significantly lower. ACRI has identified an opportunity to apply derailment risk mitigation strategies from the passenger rail industry to Heavy Haul and has engaged SNC-Lavalin Atkins to lead the investigation as a research and stakeholder engagement-based project.

This report summaries a review of literature from the public domain which was undertaken to determine the main causes of derailments in the passenger train industry and identify the mitigation strategies subsequently put in place to prevent incidents from reoccurring.

It has been found that with the Australasian and UK regions, passenger train derailments were largely caused by either a momentary lack of awareness or concentration by drivers leading to a catchpoint-induced derailment or alternatively by insufficient rail maintenance to address defects such as excessive gauge widening or fatigue-related fractures. These causes were addressed by upgrading signalling and infrastructure to enhance signal visibility, ensuring all safety infrastructure is compliant and compatible with network standards and vehicles, increasing an emphasis on safety briefings and implementing automatic train protection technologies to minimise human factors involvement.

In other jurisdictions such as Canada and the United States, a broad investigation into train derailments identified leading causes of incidents as being human factors-related, faults in track infrastructure, and equipment defects with similar prescribed mitigation strategies as those for the Australasian and UK jurisdictions.

As part of the literature review, several trends were identified in relation to derailment incidents. One trend in particular highlighted that incidents in Australasia in both passenger and freight are more likely to occur when vehicles are operating at lighter loads and travelling at higher speeds. This was suggested to be due to the combination of these conditions being associated with off-peak and out-of-service running during which train operators may feel less pressure to maintain alertness. This finding further emphasises human factors as a leading cause of train derailments in both passenger and Heavy Haul.

2. Background

Derailments are a common type of heavy haul-train related accident which have large economical and safety repercussions for operators, asset owners and rail infrastructure maintainers. Defining 'heavy haul' as 'freight' to include iron ore, coal and intermodal transport, there were 36 freight derailment incidents reported in Australia in the 2019-2020 financial year alone [REF 1] with incidents estimated to typically result in costs up to $1 million based on vehicle, freight goods and infrastructure damage and operational delays.

Given the relatively low frequency of passenger derailments yet high report of near misses and reporting accounts in comparison, stakeholders approached the Australasian Centre for Rail Innovation (ACRI) with an idea to investigate technological, procedural and cultural learnings for derailment risk mitigation in the passenger rail industry. The intention is for key findings from this investigation to be transferred over to the freight sector to reduce the frequency of freight train derailments.

ACRI has engaged SNC-Lavalin Rail & Transit Pty Ltd (SNC-Lavalin Atkins) to undertake this project. SNC-Lavalin Atkins (formerly Interfleet) has a rich history supporting rail asset owners, maintainers, operators and suppliers across the full asset lifecycle and the team nominated for the project have extensive experience in derailment risk mitigation and have also supported train derailment damage assessments.

3. Introduction

The initial phase of the investigation consists of a global literature review and investigation report scan from sources in the public domain. The main output from this activity is a preliminary list of the main passenger train derailment causes which will be expected to have direct analogies to Heavy Haul rail.

An assessment of the strategies used to manage each passenger derailment cause can then be explored to facilitate the transfer of learnings to Heavy Haul. This process will be supported by a workshop with key stakeholders including the Australasian Centre for Rail Innovation (ACRI) participants, Rail Industry Safety Standards Board (RISSB), the Office of the National Rail Safety Regulator (ONRSR) and the Australian Transport Safety Bureau (ATSB).

4. Key research findings

4.1. Passenger derailment causes in Australasia and the UK

A review of literature available in the public domain led to the identification of twenty-nine (29) passenger derailment incidents which occurred locally in Australia, all within the past fifteen years. Information on each incident was sourced primarily from ATSB Incident reports in conjunction with summaries published in Annual ONRSR reports. A summary of these incidents is provided in Table 3 in Appendix A.

In addition to the Australian case studies, a review of passenger derailment reports from the past fifteen years in the UK compiled by the Rail Accident Investigation Branch (RAIB) revealed eighteen (18) incidents from that jurisdiction. These incidents are summarised in Table 4 in Appendix A.

An assessment of the passenger derailments incidents described above enabled the research team to establish 9 key derailment causes.

These items are described in Table 1 and Figure 1.

#	Passenger derailment main cause	Number of incidents in Australia past 15 years	Number of incidents in UK past 15 years
1	Loss of driver concentration or possible loss of consciousness resulting in a SPAD and necessitating an induced derailment to prevent infrastructure damage and/or vehicle collision.	**12**	1
2	Failure of or inadequate safety-critical infrastructure at a level crossing leading to a collision with a road vehicle.	2	0
3	Collision with track obstruction. (i.e., fallen equipment, Environmental debris)	1	3
4	Axle or bearing failure due to crack propagation caused by ballast strikes or improper maintenance practices.	2	1

#	Passenger derailment main cause	Number of incidents in Australia past 15 years	Number of incidents in UK past 15 years
5	Lack of lubrication to maintain low L/V ratio on small radii curves, leading to wheel climb above safe limits.	2	1
6	Miscommunication between network control and Driver about changes to route and/or operational procedures such as a temporary speed restriction.	1	4
7	Uncontrolled wheel slide due to contaminants on railhead leading to a SPAD and necessitating an induced derailment.	1	0
8	A fault in track infrastructure including gauge widening due to flange and web wear or fractures in the rail caused by RCF.	0	**7**
9	Non-compliant servicing and maintenance procedures performed resulting in train parameters exceeding manufacturing safety limits (e.g., Misalignments of bogie, causing uneven load distribution)	0	1

Table 1: Passenger derailments main causes Australia and UK

As shown, driver intervention or lack thereof leading to a signal passed at danger (SPAD) was identified as the leading cause of derailments in Australia based on the incidents reviewed.

In the UK in comparison, faults with track infrastructure caused the highest number of derailments.

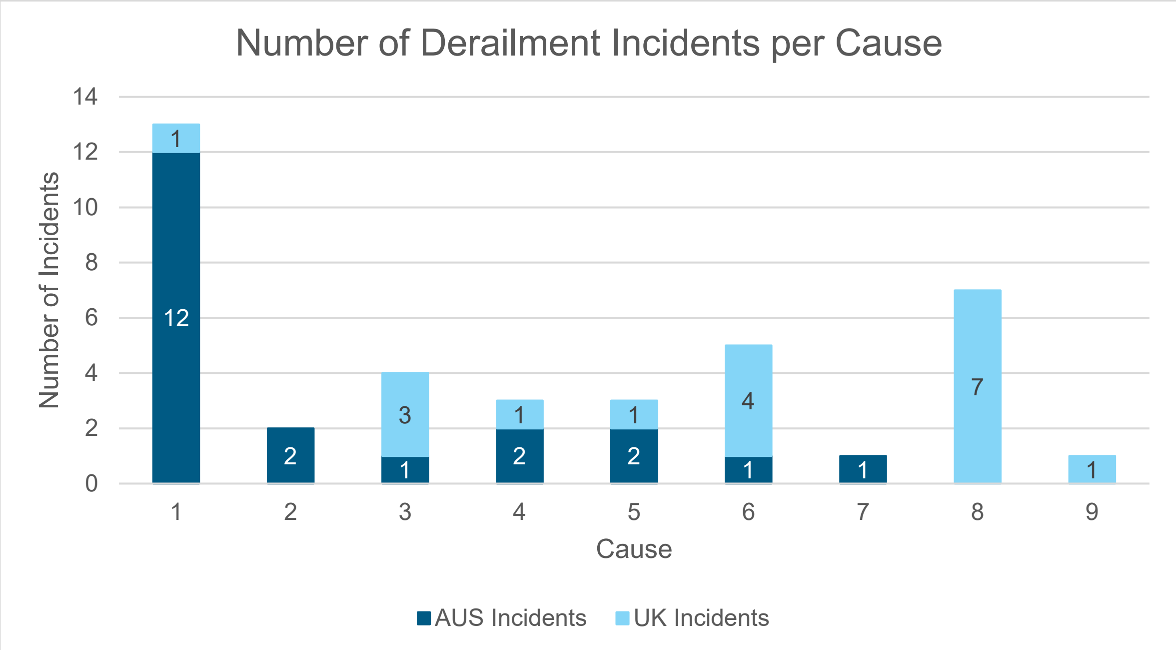

Figure 1: Count of incidents per derailment cause Australia and UK

4.2. Derailment causes in other jurisdictions

A broader review of passenger derailment statistics in the US and Canada was also undertaken for comparative purposes with Australian and UK data to add to the statistical significance of the findings in the Australian data.

The Bureau of Transportation Statistics compiled a summary of freight and passenger train derailment statistics between 2005 and 2016 in all railroads in the United States [REF 3] as summarised in Figure 2.

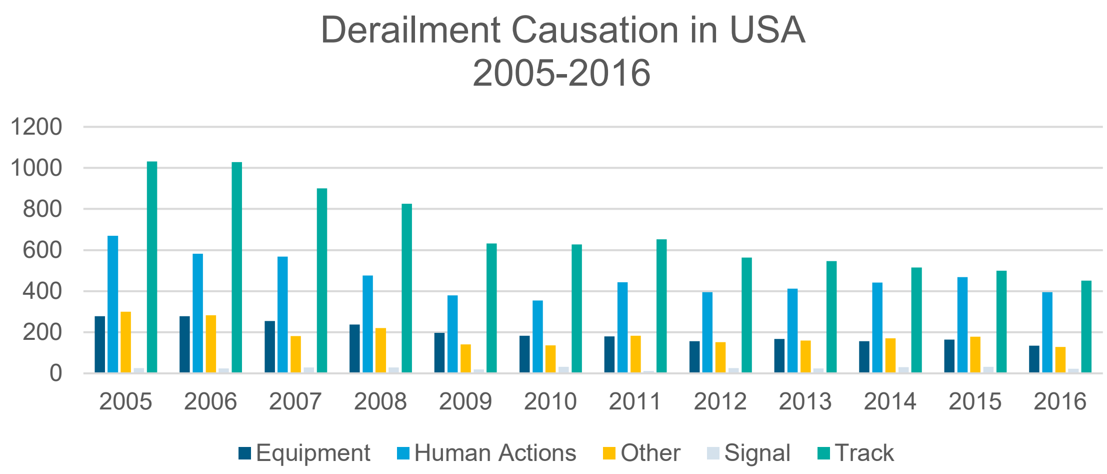

Figure 2: Causation factors for derailment of freight and passenger trains in the USA between 2005 and 2016 [REF 3]

A total of 18,703 derailment incidents within this timeframe were summarised. Contrary to the trend established for the Australian incident statistics presented in Table 1 where SPADs were established as the primary causation of derailments, track infrastructure is the primary contributing factor in the United States. Human factors have also been a common contributing factor for this jurisdiction. Signalling system, equipment and other causation factors on the other hand are consistently of lower prominence over this time period.

In Canada, the Transportation Safety Board of Canada (TSB) compiled a summary of freight and passenger train mainline and non-mainline derailment statistics between 2009 and 2019 [REF 4] as presented in Figure 3 and Figure 4.

A total of 6,770 derailment incidents were recorded over this period. For mainline derailment incidents, the main causation factors were equipment faults, track faults and human factors causes but none of these form one clearly discernible dominant causation factor. For non-mainline derailment incidents, human action or lack thereof is the dominant contributing factor to derailments over this time period.

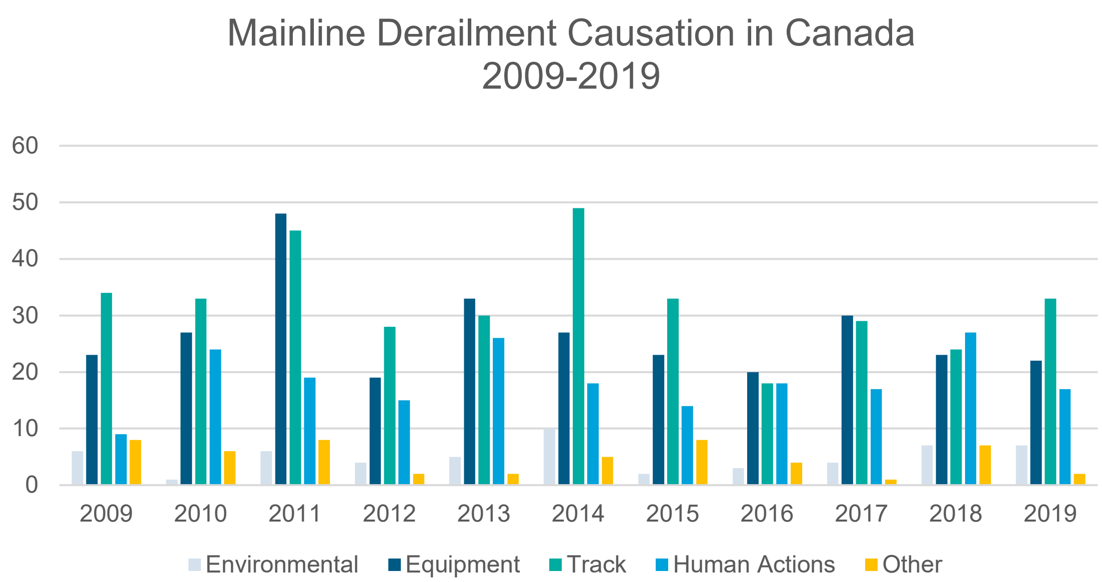

Figure 3: Causation factors for mainline derailment of freight and passenger trains in Canada between 2009 and 2019 [REF 4]

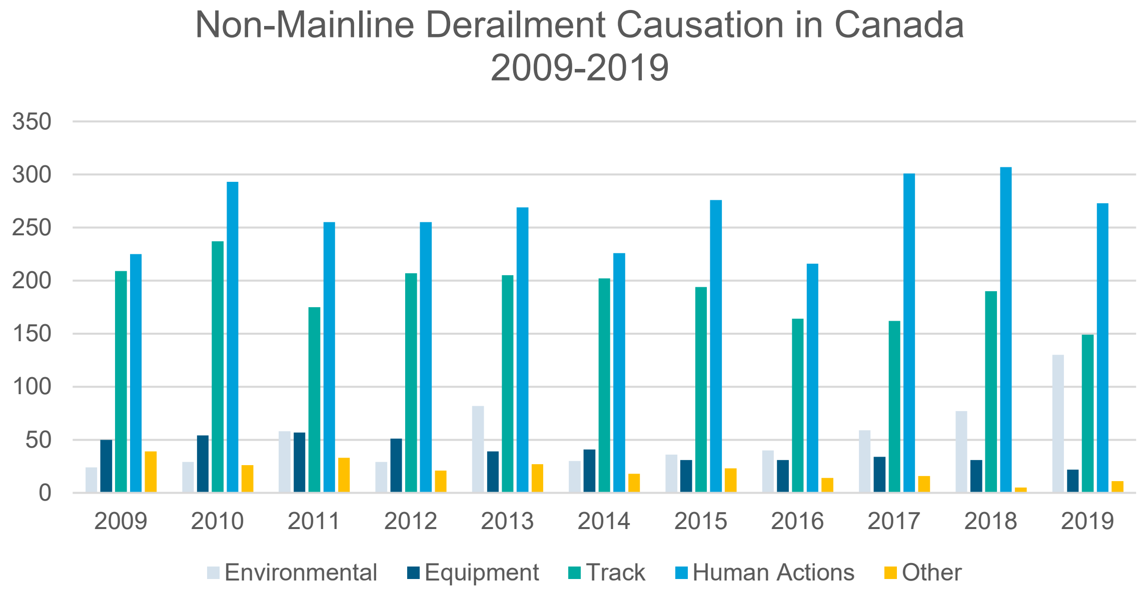

Figure 4: Causation factors for non-mainline derailment of freight and passenger trains in Canada between 2009 and 2019 [REF 4]

5. Discussion on key findings

The passenger derailment incidents in Australasia and the UK discussed in Section 4.1 were analysed to identify commonalities in incidents and provide insight into mitigation strategies which were implemented for the following incidents.

To supplement this investigation, 6 US and 3 Canadian sample case studies of passenger derailments were reviewed using reports published by the National Transportation Safety Board (NTSB) and Transportation Safety Board of Canada (TSB) respectively. These incidents are summarised in Table 5 in Appendix A.

5.1. Loss of driver concentration or possible loss of consciousness

As portrayed in Table 1 and Figure 1, a lapse in driver concentration or loss of consciousness was identified as a major contributing factor of passenger train derailments within the research scope of interest for the Australian region. In numerous cases, this lapse in concentration has caused the drivers to pass a signal at danger and thus derail upon contact with catchpoints or derailers that were in place to prevent front-on collisions. It was also shown that in multiple cases the trains had been empty of passengers, this may have led to the driver's lack of focus and increased complacency.

The incident investigation RO-2018-004 for Waratah train A42 [REF 5] outlines that although one of the major contributory factors of the incident was the lapse of concentration, there were other factors that affected the severity of the consequences. In this incident, the collision of the buffer-stop had significantly increased the severity of the derailment and subsequent injuries. This was due to the incompatibility of the buffer-stop with the onboard Crash Energy Management System (CEMS), which resulted in minimal impact reduction.

Furthermore, as outlined in RAR-16-02 [REF 6] the lapse of concentration or loss of focus can be instigated by very minor events such as drivers diverting their attention to listen to safety radio alerts. Therefore, it is paramount to minimise all factors that can cause a lapse in focus and concentration in order to prevent future incidents from occurring.

Thus, in order to prevent these contributory factors, several mitigation strategies were implemented:

- Reassessment and development of improved track signalling and infrastructure to improve signal visibility and colour;

- Conducting focused safety briefings to ensure all staff are compliant with network rules and procedures in order to minimise in-cab distraction or other factors that could cause a lapse in concentration and focus of the driver;
- Ensuring all safety infrastructure is compliant and compatible with network standards and vehicles; and
- Implementation of positive train control to prevent further incidents.

5.2. Failure/inadequate safety critical infrastructure at level crossings

Although lack of safety critical infrastructure for level crossings did not cause a large volume of incidents, inadequate safety critical infrastructure was a key cause for incidents that occurred within more isolated and rural areas.

ATSB Incident investigation RO-2013-008 [REF 7] investigated an incident which resulted in the collision between the passenger train and semi-trailer. Several contributory factors had led to this incident occurring, such as the acute angle in which the road intersects the track, resulting in difficulties in long-range visibility as well as local flora obstructing driver line of sight upon approach. However, these incidents would be largely avoidable if suitable and adequate level-crossing infrastructure had been in place.

Thus, in order to minimise the possibility of these incidents occurring, several mitigation strategies were implemented or recommended to the relevant track authority. These included:

- Development and restructuring of level-crossing infrastructure; and
- Reassessment of key level-crossing locations to determine risk and safety levels as well as assessment of local infrastructure and obstructions to determine whether removal is necessary, or implementations of risk mitigations are required.

5.3. Collision with track obstruction

It was also evident that collisions with track obstructions are a common underlying cause of derailment incidents. One of the most common track obstructions that causes derailments in the UK are debris and wreckage from environmental events, such as landslips.

RAIB report 10/2018 [REF 8] and report 11/2017 [REF 9] outlines that due to the direct collision between the train and debris covering the track, the train had redirected and thus derailed. Despite there being infrastructure in place to prevent debris from such events to reach the track infrastructure, as the preventative measures were under-maintained or poorly designed, these measures were overwhelmed. Other obstructions recorded include livestock and fallen equipment from previous services.

Another incident which was investigated, NTSB/HAB-16/07 [REF 10], outlined that external factors can also lead to a collision. This incident indicated that despite all rail procedures being correctly implemented and performed, due to the complacency of the road vehicle driver and their lack of knowledge of the area, the road vehicle was stopped and parked within level-crossing boundaries and thus caused a derailment due to collision.

Thus, in order to prevent further incidents, the following were implemented or recommended to relevant train and track authorities.

- Implementing improved surface drainage methods, to prevent build-up of large volumes of liquids that could result in a landslip;
- Improving local geographical mapping data to provide road users with additional safety cues and to reduce the likelihood of crashes and illegal parking near or on level-crossings and local rail infrastructure;
- Development of additional visual signage and boundary cues to alert road users of incoming level-crossing;
- Improving and redeveloping preventative measures, such as more structurally rigid fencing;
- Introducing additional alarm systems to notify when there is significant ground movement; and
- Improve process of locating and identifying sub-surface fluid concentrations, in order to implement pre-emptive procedures to reduce risks of landslips.

5.4. Axle or bearing failures

Minimising train component failures is critical as the nature of incidents involving such failures can have catastrophic consequences depending on the localisation and timing of the incident. As shown in Table 1, for derailment incidents the most common train components to fail are the train axles or the axle bearings.

Incident ATSB report RO-2014-001 [REF 11] had stated that the cause of derailment was due to axle failure that had been caused by the inappropriate usage of non-compliant repair methods on the axle which had been damaged previously. This coupled with the complacent communication of the apparent symptoms of a component failure (e.g., a burning smell and smoke) leading up to the derailment caused the incident to occur.

Furthermore, RAIB report 01/2012 [REF 12] had determined that the axle failure had been caused by a stiffened bearing in conjunction with it being poorly fitted. This led to the axle freely rotating within the inner bearing and thus resulted in a higher temperature due to friction and load, eventually leading to the axle failure.

In order to combat these factors, the following mitigation strategies were implemented or recommended to the relevant authorities.

- Ensuring train servicing and maintenance incorporate wheelset and axle box inspections to ensure adequate lubrication and fit;
- Ensuring servicing and maintenance procedures incorporate adequate assessments with torque checks to ensure all bolts and fixings were appropriately fastened;
- Introduction of infra-red thermometers to checks at specified stops to ensure train components are operating within the specified manufacturers safety limits;
- Utilisation of additional ultrasonic axle testing (UAT) to ensure all axles are compliant with relevant standards; and
- Development of prototype axle guards to prevent repetitive minor collisions with track ballast as this could lead to surface damage which could propagate and eventually lead to major axle failure.

5.5. Lack of wheel lubrication to prevent wheel climb

There were incidents in which derailments occurred due to wheel climb. Conventionally, train services utilise adequate amounts of lubrication to avoid higher levels of friction, which can lead to wheel climb. However, in the event where the application of lubrication is flawed or inadequate, the risk of derailments increases significantly.

ATSB report RO-2016-002 [REF 13] and RAIB Report 07/2014 [REF 14] explain that both incidents occurred due to the lack of lubrication between the wheelsets and rail coupled with other external factors such as the tight track geometry.

Thus, several mitigation strategies have since been implemented.

- Ensure all track geometry is compliant with standards and that check rails are fitted where necessary;
- Ensure all services are fitted with adequate lubrication to avoid excessive levels of friction, which is likely to cause wheel climb;
- Ensure all track infrastructure is serviced and maintained to schedule; and
- Review of locomotive maintenance sheets, investigations on alternative improved lubrication distribution systems.

5.6. Miscommunication between network control and Driver

It is paramount that all staff and signallers are assessed to be competent and compliant with all relevant train and track standards and regulations. Despite this however, miscommunication or lack of communication can cause confusion and lead to train incidents, such as derailments.

There were numerous incidents in the UK which were caused due to the signaller providing authorisation to pass a signal at danger, this led to the driver assuming that the whole route had been correctly set for themselves and that they may proceed on through the entire junction. However, due to lack of knowledge and miscommunication between the signaller and support staff, some points were not set correctly, thus leading to the derailment of the train and subsequently incurring damage to the track infrastructure and undercarriage of the vehicle.

Similarly, there were incidents in the US and Canada, such as those investigated in RAR-19-02 [REF 15] and TSB R12T0038 [REF 16], where the miscommunication and lack of signalling knowledge caused train drivers to either derail due to exceeding the safe speed limit of a turnout or by colliding into a stand-by service.

To prevent further instances such as these, the following were implemented or recommended.

- Ensure that signallers confirm that the route is correctly set before providing authorisation to pass signals at danger;
- Ensure that signallers comply with relevant procedures and do not assume equipment operational status through unauthorised methods;
- Amendment in procedures to include confirmation of safety receipt of safety critical information by train crews;
- Development of procedures for ease of access to safety surveillance systems;
- Development and implementation of in-cab signals with automatic train control (ATC) and Advanced Civil Speed Enforcement Systems (ACSES); and
- Development and implementation of Interoperable Electronic Train Management Systems (I-ETMS) or Positive Train Control (PTC).

5.7. Uncontrolled wheel slide due to railhead contaminants

In contrast with derailments due to lack of lubrication, excessive lubrication caused by railhead contaminants such as insect residue or oil have also been shown to cause derailments if they are not removed in a timely manner.

ATSB report RO-2013-005 [REF 17] is a key example of a derailment incident with the underlying cause being oily contaminants and moisture on the railhead. The report specifies that the current standards and inspection procedures at that point in time were inadequate in identifying and mitigating such risks.

Thus, to prevent further incidents, the following strategies were implemented or recommended.

- Rail operator are to implement a procedure for Network maintenance staff to identify, treat and prevent rail contaminants in order to ensure mitigation of further incidents; and
- A sanding system on a 3-car unit for the fleet involved is being trialled to determine whether this technology mitigates the risks of wheel slide by improving adhesion at the wheel rail interface.

5.8. Track infrastructure faults

Although uncommon in Australia, Figure 1 and Figure 3 indicates that track infrastructure faults were a major and leading contributor to passenger train derailments within the UK, Canada and the US for the past several years. In the vast majority of cases, the lack of maintenance and appropriate remediation procedures were the main causes of faults in track infrastructure.

RAIB Safety Digest D01/2018 [REF 18] and D04/2017 [REF 19] outline that due to the lack of inspections and thus absence of appropriate repair procedures, the rail gauge had significantly widened beyond safe operational limits. In addition, RAIB Safety Digest D08/2020 [REF 20] also outlines faults in electrical power resulting from faulty batteries that had been overlooked and thus caused a set of points to incorrectly position itself leading to derailments. The Canadian incident TSB R19W0329 [REF 21], also investigated a derailment incident due to track infrastructure faults in which the rail joint had been completely severed due to a shear fracture and lack of remediation procedures being applied. Furthermore, there were also numerous other incidents in relation to sleeper degradation or fastener shear fracturing which also resulted in derailment.

Thus, it is evident that implementation of mitigation strategies is paramount in order to minimise any track infrastructure faults from occurring and thus prevent fatalities and economic consequences. The following mitigation strategies were found to be applied or recommended upon investigation of track infrastructure derailment incidents.

- Ensuring all boundaries of responsibility for maintenance are to be correctly documented and compliant with all relevant standards;

- Ensuring adequate support infrastructure to be in place to ensure all inspection and patrols are completed correctly and are compliant with relevant standards and regulations;
- Assessing all document managerial procedures to ensure work requests have been received and actioned by the Route Asset Management team; and
- Not re-prioritising (deferring) maintenance work unless the people involved have a good knowledge of the work required and the reasons for it, so that the safety of the railway is assured.

5.9. Maintenance & Service Issues

To ensure train longevity and safety capabilities, constant monitoring and servicing of all assets are paramount to prevent all safety incidents. However, all personnel involved must also ensure that relevant servicing and repair procedures are actioned within the standards and regulations set by the manufacturing company.

In RAIB Report 03/2015 [REF 22], an incident in which the introduction of a new method for servicing train components led to the misalignment of the train bogies and subsequently the derailment due to uneven load distribution. The uneven load distribution caused the left side of the wheel sets to be constantly underloaded. Thus, this issue coupled with twist induced by unbalanced vertical track forces caused the wheel to climb and derail.

Thus, to counteract further incidents, the following strategies were implemented.

- Revision of all bogie procedures to be performed to ensure that all actions taken are compliant with manufacturers safety limits;
- Implement appropriate post-procedure checks to ensure all train parameters are within manufacturers safety limits before authorising release for operation; and
- Rail network authority to ensure all relevant track is compliant with standards.

6. Other relevant trends

A study by the Co-operative Research Centre (CRC) for Rail Innovation [REF 2] summarised accident data from the ATSB between 1997 to 2010. A total of 59 incidents for both passenger and freight trains were identified of which 38% were derailment related (22 incidents).

The speed, mass, length and kinetic energy distributions of the incidents were recorded. On average, derailed freight and passenger trains have the following characteristics:

Parameter	Freight	Passenger
Velocity	82 km/h	72 km/h
Mass	3579 t	355 t
Length	1222 m	186 m
Kinetic Energy	983 MJ	83 MJ

Table 2: Average parameters of derailments in Australia between 1997 and 2010 [REF 2]

In addition to the averages, it can be discerned from the data that the majority of freight train derailment incidents occur at high speeds when the trains are low in mass (hence low kinetic energy). These trends are shown in Figure 5 through Figure 8 below.

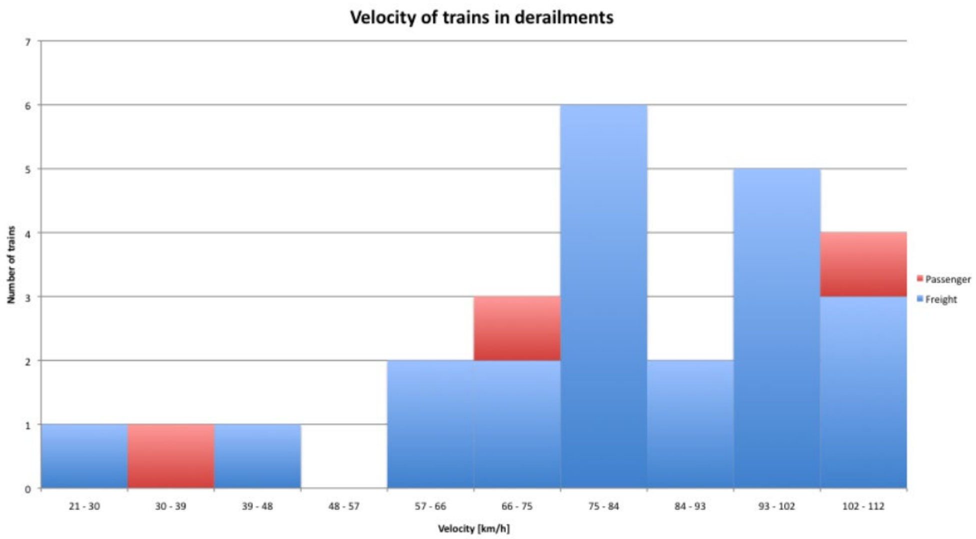

Figure 5: Distribution of train speed for derailment incidents between 1997-2010 [REF 2]

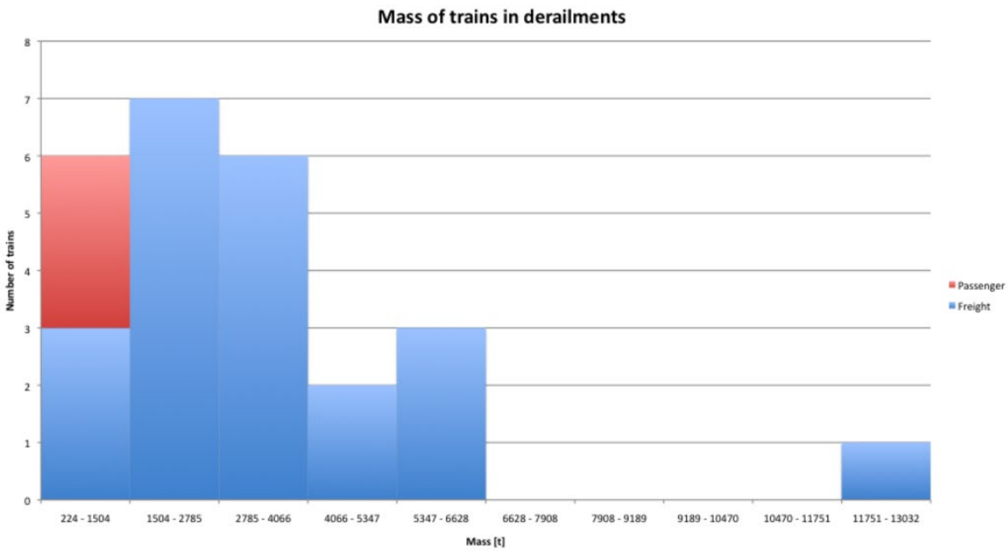

Figure 6: Distribution of train mass for derailment incidents between 1997-2010 [REF 2]

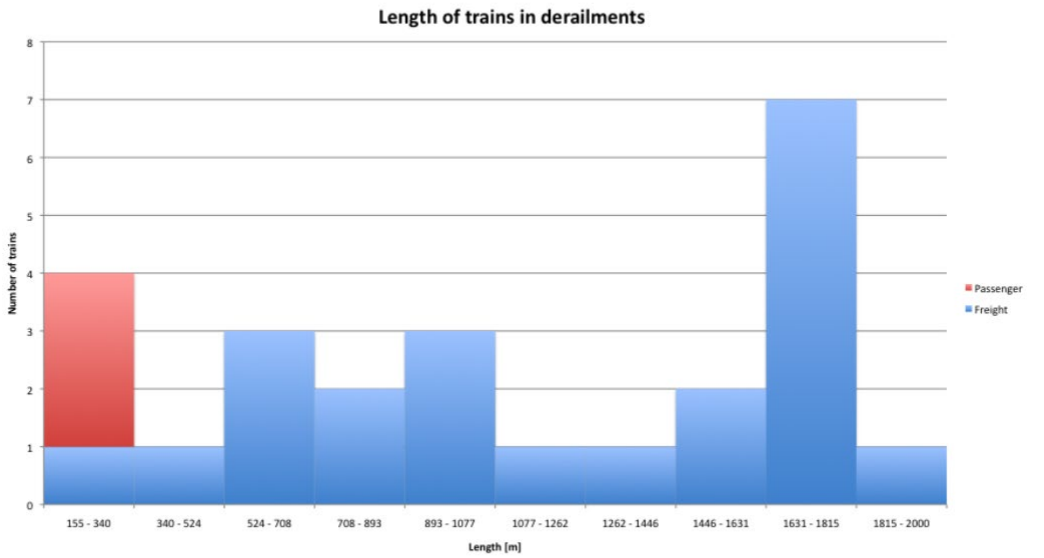

Figure 7: Distribution of train length for derailment incidents between 1997-2010 [REF 2]

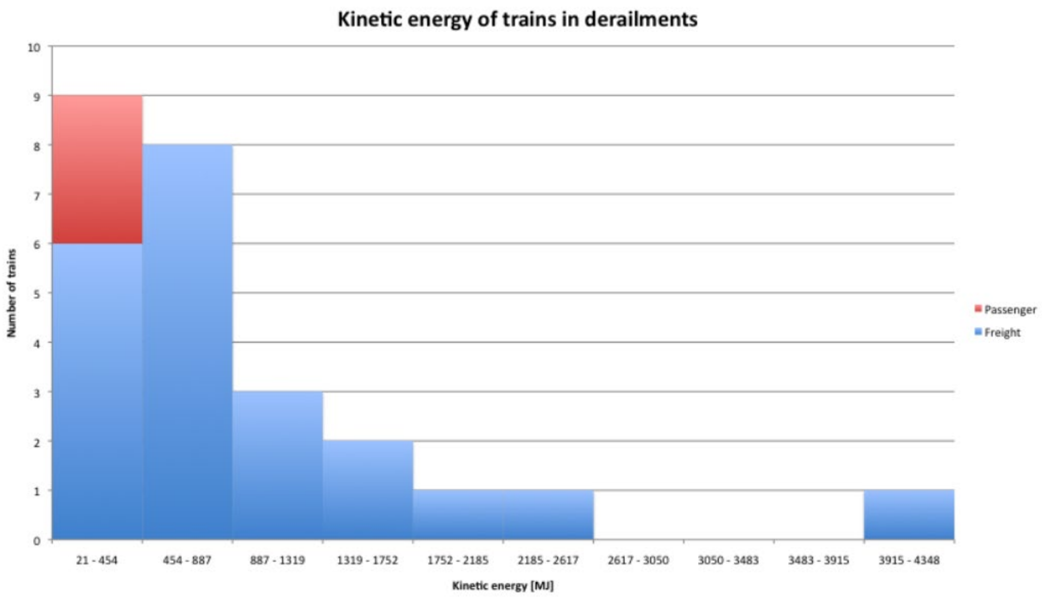

Figure 8: Distribution of train kinetic energy for derailment incidents between 1997-2010 [REF 2]

7. Conclusion

From this literature review, it was found that derailments due to catchpoints or derailers were the highest cause of passenger derailments incidents in Australia. These incidents occurred when the driver temporarily lost concentration or consciousness, resulting in a SPAD. Mitigation strategies employed to minimise future incidents due to driver interaction or lack thereof included an overhaul of track signalling to improve visibility and clarity and an increased focus on safety briefings to ensure staff are competent and compliant.

Fundamentally, deployment of positive train control and/or automatic train protection systems such as TPWS and ETCS can all but eliminate incidents of derailments caused by SPADs. This is evident from a review of UK and US passenger derailments incidents, where it was found that the highest number of incidents were instead caused by faults in track infrastructure. Methods used to manage these causes included clarification of responsibilities for track maintenance amongst stakeholders and improving assurance processes concerned with the sign-off of maintenance work.

In other jurisdictions, namely Canada, there was an even split of derailment incidents caused by human factors, track faults and equipment faults. Actions used to address these items mirrored that used in Australia, the UK and the US. To address human factors-related causes, TSB also recommended amendments and revisions in procedures involving allowing trains right-of-way. It is once again noted however that implementation of positive train control could have eliminated the majority of these incidents.

8. Next steps

With the main passenger derailment causation factors from Australasian and overseas jurisdictions identified, the next step in the derailment learnings investigation is to approach heavy haul stakeholders with an aim to identify potential relationships between passenger derailments and freight derailments. These links can then be used to highlight relevant mitigation strategies implemented in the passenger space.

Furthermore, discussions with Australasian passenger network operators, ONRSR and ATSB is recommended to obtain additional details on the Australian derailment incidents investigated which could enrich the existing findings from the literature review.

9. References

[REF 1] Office of the National Safety Regulator, Rail Safety Report 2019-2020

[REF 2] Engineering Characteristics of Rail accidents from 1997 to 2010 revision 0, CRC for Rail Innovation, May 2013

[REF 3] Bureau of Transportation Statistics, https://www.bts.gov/content/train-fatalities-injuries-and-accidents-type-accidenta

[REF 4] Transportation Safety Board of Canada, https://www.bst-tsb.gc.ca/eng/stats/rail/2019/sser-ssro-2019.html

[REF 5] Australian Transport Safety Bureau, Collision of passenger train A42 with buffer stop, RO-2018-004, 22 January 2018

[REF 6] National Transportation Safety Board, Derailment of Amtrak Passenger Train 188, NTSB/RAR-16/02, 12 May 2015

[REF 7] Australian Transport Safety Bureau, Level crossing collision between passenger train and semi-trailer, RO-2013-008, 12 February 2013

[REF 8] Rail Accident Investigation Branch, Landslip and derailment at Loch Eilt, north-west Scotland, Report 10/2018, 22 January 2018

[REF 9] Rail Accident Investigation Branch, Derailment due to landslip, and subsequent collision, Watford, Report 11/2017, 16 September 2016

[REF 10] National Transportation Safety Board, Train and Truck Crash on Railroad Right-of-Way and Subsequent Fire, NTSB/HAB-16/07, 24 February 2015

[REF 11] Australian Transport Safety Bureau, Derailment of Sydney Trains Passenger Train 602M, RO-2014-001, 15 January 2014

[REF 12] Rail Accident Investigation Branch, Passenger train derailment near East Langton, Leicestershire, Report 01/2012, 20 February 2010

[REF 13] Australian Transport Safety Bureau, Derailment of MTM train TD1064, RO-2016-002, 6 February 2016

[REF 14] Rail Accident Investigation Branch, Locomotive derailment at Ordsall Lane Junction, Salford, Report 07/2014, 23 January 2013

[REF 15] National Transportation Safety Board, Amtrak Passenger Train Head-on Collision with Stationary CSX Freight Train, NTSB/RAR-19/02, 4 February 2018

[REF 16] Transport Safety Board of Canada, Railway Investigation Report, R12T0038, 26 February 2012

[REF 17] Australian Transport Safety Bureau, Collision of passenger train T842 with station platform, RO-2013-005, 31 January 2013

[REF 18] Rail Accident Investigation Branch, Derailment of a passenger train near, Wimbledon, South-west London, D01/2018, 6 November 2017

[REF 19] Rail Accident Investigation Branch, Charter train derailment near Southampton Eastern Docks, D04/2017, 5 November 2016

[REF 20] Rail Accident Investigation Branch, Passenger train derailment at Bognor Regis Station, West Sussex, D08/2020, 22 October 2020

[REF 21] Transport Safety Board of Canada, Railway Investigation Report, R19W0329, 31 December 2019

[REF 22] Rail Accident Investigation Branch, Derailment of an empty passenger train at Paddington station, Report 03/2015, 25 May 2014

10. Appendix A – Derailment case studies

Source	ATSB Investigation Number	Date	Description	Location	Cause
ATSB Incident Reports	2006002	9 February 2006	Derailment of XPT Passenger Train, ST22	Harden, NSW	Axle failure, likely due to collision with track ballast
ATSB Incident Report	RO-2013-005	31 January 2013	A Queensland Rail passenger train (T842) failed to stop at the Cleveland station platform and collided with the end-of-line buffer stop, the platform and the station building at a speed of about 31 km/h	Cleveland Station, Qld	Lack of adhesion due to contaminant substance on rail running surface causing difficulties braking
ATSB Incident Reports	RO-2014-001	15 January 2014	Derailment of Sydney Trains Passenger Train 602M near Edgecliff station, Sydney, NSW on 15 January 2014	Edgecliff Station, NSW	Axle repair incorrectly implemented, rendering it more susceptible to further damage. Lack of staff communication caused delay action
ONRSR Annual Report	RO-2014-013	11 July 2014	A train derailed at low speed on the standard gauge network 1.7 km from Southern Cross Station. The train was carrying approximately 180 passengers, with some suffering minor injuries.	Southern Cross Station, VIC	Wheelset dimensions not compatible with turnout gauge width
ATSB Incident Reports	RO-2014-023	09 December 2014	Derailment of empty passenger train near Teepookana, Tas, on 9 December 2014	Teepookana, Tas	Lack of lubrication causing rail climb
ATSB Incident Reports	RO-2015-026	17 December 2015	Signal passed at danger and derailment of empty Tangara service 109D	Hornsby, NSW	SPAD
ONRSR Annual Report	RO-2016-002	06 February 2016	A metropolitan passenger train derailed. One passenger was reported to have been taken to hospital, with approximately 200 passengers detrained between stations.	Near Rushall Station in Fitzroy North, VIC	Lack of lubrication between wheel flange and outside rail, causing flange climb, which led to derailment. The track geometry for small radius broad curve were likely to be unsuitable
ONRSR Annual Report	RO-2018-004	22 January 2018	An electric urban passenger train derailed when it struck a buffer stop at a speed of approximately 35 km/h. 16 people from the train were treated at the scene, including the train driver and guard. A total of 15 people were transported to hospital for further treatment.	Richmond Station, NSW	Collision with buffer stop
ONRSR Annual Report	RO-2020-002	20 February 2020	A passenger train travelling from Sydney to Melbourne derailed while traversing a set of points. Two workers in the driver's cabin sustained fatal injuries. Several passengers were transported to hospital.	Wallan, Vic.	Over speeding through a turn point
ONRSR Annual Report	N/A	21 December 2018	A passenger tram derailed while traversing a set of points. There were no reports of injuries.	Helensvale, Qld.	catch point derailment

Source	ATSB Investigation Number	Date	Description	Location	Cause
ONRSR Annual Report	N/A	29 November 2013	Empty heavy rail passenger train derailed all wheels of one bogie while travelling through points. No injuries reported.	Lidcombe, NSW	Catchpoint derailment
ONRSR Annual Report	N/A	29 August 2012	Heavy rail Passenger train derailed one carriage after striking a piece of equipment that had fallen from the locomotive of a previous freight service. Passengers were escorted from the train. No injuries reported.	St Marys, NSW	Collision with equipment fallen from prior service
ONRSR Annual Report	N/A	15 February 2017	There was a collision between a passenger train and a road vehicle on the running line which resulted in derailment of the lead bogie. Eight passengers were treated for minor injuries.	Kangaroo Flat, Vic.	Collision with road vehicle
ONRSR Annual Report	N/A	13 July 2016	There was a collision between a passenger train and a semi-trailer at a level crossing which resulted in the locomotive and all four carriages derailing. The driver of the semi-trailer, the train driver, conductor and 19 passengers all sustained injuries and were conveyed to hospital.	Phalps Rd level crossing, Pirron Yallock, Vic.	Collision with semi-trailer
ONRSR Annual Report	N/A	17 May 2016	While docking from sidings to a platform, a suburban passenger train derailed after passing a signal at stop without authority, resulting in the main line being fouled. No passengers were on board	Southern Cross Station, VIC	SPAD
ONRSR Annual Report	N/A	11 February 2015	Passenger train passed signal at stop and derailed at catch points. No injuries, passengers escorted back to the platform at Campbelltown station.	Campbelltown, NSW	SPAD, derailed at catch points
ONRSR Annual Report	N/A	23 October 2014	Passenger service derailed at catch points after the driver passed a signal at stop. There were no reported injuries. Passengers detrained and walked back to Mulgrave Station	Mulgrave, NSW	SPAD, derailed at catch points
ONRSR Annual Report	N/A	15 April 2014	Empty passenger train passed signal without authority and derailed at catch points. No injuries reported.	Waterfall, NSW	SPAD, derailed at catch points
ONRSR Annual Report	N/A	05 April 2014	Empty heavy rail passenger train passed signal without authority and derailed at catchpoints. No injuries reported.	Newport, Vic.	SPAD, derailed at catch points
ONRSR Annual Report	N/A	06 August 2013	Empty heavy rail passenger train passed signal at stop without authority and derailed over catch points. No injuries reported.	Blackwood, SA	SPAD, derailed at catch points
ONRSR Annual Report	N/A	15 September 2019	A passenger train travelling out of service passed a signal at danger and derailed after traversing a set of catch points.	Redfern, NSW	SPAD, derailed at catch points

Source	ATSB Investigation Number	Date	Description	Location	Cause
ONRSR Annual Report	N/A	14 March 2017	An empty passenger train passed a signal at stop resulting in a derailment at catch points.	Port Kembla North, NSW	SPAD, derailed at catch points
ONRSR Annual Report	N/A	26 November 2017	The Indian Pacific passenger train derailed a car carrier while departing the East Perth Terminal. No injuries were reported.	East Perth Terminal, W	Not disclosed
ONRSR Annual Report	N/A	10 November 2017	The Ghan passenger train derailed a carriage carrying road vehicles while travelling at low speed. No injuries were reported.	Torrens Junction, SA	Not disclosed
ONRSR Annual Report	N/A	06 September 2017	The first bogie of an out-of-service electric urban passenger train derailed when it was entering a yard. No injuries were reported.	North Melbourne, Vic	Not disclosed
ONRSR Annual Report	N/A	21 December 2015	An empty suburban passenger train exiting a siding derailed at a set of points, blocking the main line.	South Geelong, VIC	Not disclosed
ONRSR Annual Report	N/A	26 June 2014	Sydney to Melbourne passenger train service derailed and then re-railed over set of points. No injuries reported	McIntyre, Vic	Not disclosed
ONRSR Annual Report	N/A	31 January 2014	Heavy rail Long distance passenger train service derailed. Two passengers transported to hospital for treatment.	Currabubula NSW	Not disclosed
ONRSR Annual Report	N/A	30 January 2013	Heavy rail Long distance passenger train ('The Ghan') en-route from Darwin to Adelaide derailed while traversing points. A crew car and luggage van derailed and the train blocked the mainline. No injuries reported.	Katherine, NT	Not disclosed

Table 3: Australian passenger derailments

RAIB Report/Safety Digest Number	Date	Description	Location	Cause
D08/2020	22/10/2020	Passenger train derailment at Bognor Regis	Bogner Regis Station, West Sussex	a set of batteries for a set of points had depleted, causing the points to fail to properly connect. Despite indicators clearly illuminating this issue, due to a proper service successfully traversing to the station and a build-up of fatigue the operator did not perceive this issue and thus verbally authorised a signal pass at danger.
Report 13/2020	13/11/2019	Collision and derailment at Neville Hill	Maintenance depot arrival line on Neville Hill	Although it is not recommended, the two trains were authorised to utilise the same line within close proximity of each other in order to approach the maintenance depot. At first the trains were traversing cautiously, however, due to a lapse in the driver's attention the trailing service had accelerated too quickly and had collided with the service in front causing the subsequent derailment. The driver had been unfamiliar with the train's onboard systems and thus became preoccupied when reinstating the APCO using the TMS touch screen. The high-speed couplers utilised where susceptible to large degrees of freedom in the pitch and yaw directions as the design of the train did not take into consideration the possibility of derailment due to low-speed collisions.
D03/2019	28/01/2019	Passenger train derailment at Penryn	Penryn	Authorised signal passed at danger lead to train derailing at a point that wasn't correctly set. The point machine had energised and consequently moved the points despite no command.
report 10/2018	20/01/2018	Derailment of a passenger train after hitting a landslip at Loch Eilt	between Mallaig and Fort William in north-west Scotland	A landslip caused by the weather conditions caused debris and mud to cover the track. The collision with this debris caused the train to derail. There were preventative fences that were in place to prevent debris from falling onto the track, however the combination of rapid thawing snow and heavy rainfall overwhelmed these preventative measures.
D01/2018	06/11/2017	Derailment of a passenger train near Wimbledon, south-west London	Wimbledon, South-West London	Due to degradation of the track over-time, the rail gauge exceeded the standard gauge of 1435mm and had gone well over 1485mm. The rail is to be inspected regularly to ensure corrective work can be implemented when necessary, however as this section of rail was located on the boundaries of 2 infrastructure owner's area of responsibility, this area was overlooked and thus caused the derailment.
D17/2017	20/08/2017	Passenger train derailment, London Paddington	London, Paddington	The wheels had derailed due to the wear on the longitudinal timbers utilised for the rails. The Timber had gone through significant wear and was scheduled to be replaced. However, due to delays to allow for other maintenance projects, the repairs were not completed and thus caused the derailment as the wear caused the rail gauge to widen.
D04/2017	05/11/2016	Charter train derailment near Southampton Eastern Docks	between Northam Junction and Southampton Eastern Docks	There had been significant wear on the rail and thus caused the rail to widen over 51mm above the standard gauge width. This caused the wheelsets to derail. The regular inspection that was supposed to take place at a fortnightly interval had not been completed for almost 3 years and thus caused the wear on the rails to be overlooked.
Report 11/2017	16/09/2016	Derailment due to a landslip and subsequent collision, Watford	entrance to Watford slow lines tunnel	Due to prior rainfall, a landslip had occurred and deposited debris and mud onto the rail. The collision between the debris caused the train to derail. Furthermore, due to the direction of the derailment, there was an additional Collision with an oncoming passenger vehicle. Fortunately, as the vehicle had been notified prior, the damage was kept to a minimum.
D05/2016	16/06/2016	Derailment at London Paddington.	Outside Paddington Station	Due to a sudden change of scheduling and lack of communication. The train driver had passed a signal at danger and assumed that his route was set. However, as a set of trap points were not set for his vehicle, the vehicle derailed and collied with an OLE mast

RAIB Report/Safety Digest Number	Date	Description	Location	Cause
Report 24/2016	02/03/2016	Derailment of a passenger train at Ealing Broadway	Outside Ealing Broadway station, London	Due to lack of knowledge and poor communication, a set of points were not set correctly for the train service involved. Despite this, the train was authorised to pass a signal at danger as they assumed the turn points were correctly set and this caused the derailments.
Report 16/2016	07/11/2015	Derailment at Knaresborough	set of points on the approach to Knaresborough station	The service was authorised to pass a signal at danger, despite the set of points not being correctly set. This was due to the lack of knowledge from the assigned signaller at the time as his main duties were to deal with faults and other issues.
Report 05/2016	26/07/2015	Derailment at Godmersham, Kent.	Godmersham in Kent, between Wye and Chilham stations	The train service had collided with livestock which had strayed onto the track. The livestock had been able to traverse onto the track as the surrounding fences were not maintained appropriately. Furthermore, the service had not been equipped with appropriate obstacle deflectors on the head of the train, furthermore increasing likelihood of derailment due to collision.
Report 03/2015	25/05/2014	Derailment of an empty passenger train at Paddington station	platform 3 at London Paddington station	Due to the servicing and repairs performed, the bogie alignments were not correct. This lead to the left wheel of the bogie to be constantly unloaded beyond the manufacturing limits. This combined with the track twist which had been scheduled to be repaired caused the train to derail.
Report 07/2014	23/01/2013	Locomotive derailment at Ordsall Lane Junction, Salford	Ordsall Lane Junction in Salford	The main cause of derailment was due to the lack of lubrication on the wheel set, which resulted in higher frictional forces and allowed for wheel climb. Furthermore, the lack of a check rail for the curve, despite standards requiring it, further contributed to the derailment. In addition, the track had undergone wear and had widened slightly larger the standard gauge.
Report 27/2014	23/01/2013	Derailment at Liverpool Street station, London	London Liverpool Street	The train had derailed due to the deterioration of the track fixings, which lead to the track being non-compliant with regulatory standards. This coupled with the tight nature of the curve caused the derailments. The deterioration of the track fixings had not been picked up as the manual inspections had a lack of knowledge and competency to do so
Report 24/2012	03/02/2012	Derailment at Bletchley Junction, Bletchley	Bletchley Junction	The train driver had accelerated too fast and caused the train to approach a diverging route that had a speed limit of 15mph at the speed of 65.5mph.
Report 18/2012	27/07/2011	Derailment at Princes Street Gardens, Edinburgh	Princes Street Gardens area, on its approach to Edinburgh Waverley station	The left-hand switch rail did not correctly steer the vehicle onto the route. This caused the train to derail. The switch rail had been repaired but not to the appropriate angle. This followed up by the lack of proper inspections on the switch point in accordance to relevant standards caused the rail to stay in operation and cause the incident
Report 01/2012	20/02/2010	Passenger train derailment near East Langton, Leicestershire	Midland Main Line near East Langton	The main cause of the derailment was due to an axle failure. The axle had fractured due to it undergoing a rise in temperature and load as it was rotating within the inner bearing ring. The bearing itself had stiffened and thus locked into place resulting in the axle rotating.

Table 4: UK passenger derailments

NTSB/TSB Report number	Date	Description	Location	Cause
RAR-16-02	12/05/2015	Passenger train derailed at the Frankford Junction curve	Philadelphia, Pennsylvania, US	The speed restriction for this curve is 50mph whereas the train was doing 106mph at the time of the derailment. Driver lost situational awareness after being distracted by radio report of nearby safety incident
HWY15MH006	24/02/2015	Commuter train collided with road vehicle near level crossing	Oxnard, California, US	Metrolink commuter train collided with an unoccupied service truck towing a two-axle utility trailer which had been parked on the track near a level crossing. During the collision all 4 of the train's cars derailed. Cause was found to be truck driver mistakenly turning onto the railroad right-of-way due to fatigue and unfamiliarity
RAB1412	01/12/2013	Train consisting of 7 passenger cars and 1 loco in push configuration derailed on curve	Bronx, NY, US	Curve authorised speed was 30 mph, train was travelling at 82 mph. Driver had fallen asleep due to undiagnosed severe obstructive sleep apnoea exacerbated by a recent circadian rhythm shift required by his work schedule.
RAR-19-02	04/02/2018	Passenger train diverted from main track and collided head-on with a freight train	Cayce, South Carolina, US	Probable cause of this collision of trains was the failure of the CSX Transportation Corporation to assess and mitigate the risk associated with operating through a signal suspension, which created conditions that permitted the crew of CSX local freight train F777 to leave a switch in the reverse position, routing National Railroad Passenger Corporation (Amtrak) train P91 onto a track where it collided with a standing CSX train.
RAR-19-01	18/12/2017	Train consisting of 10 passenger railcars, 1 power car, 1 baggage car and 1 loco either end derailed from a bridge due to overspeed on curve	DuPont, Washington, US	probable cause of the Amtrak 501 derailment was Central Puget Sound Regional Transit Authority's failure to provide an effective mitigation for the hazardous curve without positive train control in place, which allowed the Amtrak engineer to enter the 30-mph curve at 78mph due to his inadequate training on the territory and inadequate training on the newer equipment. Secondary failure of articulated railcar-to-railcar connections that enabled secondary collisions with the surrounding environment causing severe damage to railcar-body structures
RAR1702	03/04/2016	Amtrack collision with track maintenance equipment. Leading locomotive derailed	Chester, Pennsylvania, US	Probable cause of the accident was the unprotected fouled track that was used to route a passenger train at maximum authorized speed; the absence of supplemental shunting devices, which Amtrak required but the foreman could not apply because he had none; and the inadequate transfer of job site responsibilities between foremen during the shift change that resulted in failure to clear the track, to transfer foul time, and to conduct a job briefing.
R12T0038	26/02/2012	Passenger train derailment through a turnout due to overspeed	Burlington, Ontario, Canada	Crew misinterpreted the signal causing them to believe that they were authorized to proceed at track speed, when in fact they were authorized only for slow speed—a maximum of 15 mph (24 km/h)—in order to switch tracks. Derailment then resulted from turnout overspeed
R19W0329	31/12/2019	Train consisting of 2 head-end locos, 1 baggage car, 2 passenger coaches, 1 dining car and 1 sleeper car derailed after experiencing a train-initiated EB application	Canora, Saskatchewan, Canada	Point of derailment was a failed rail joint in the south rail on the west approach to the bridge. Upon inspection of rail, fatigue related fracture characteristics in several areas.
R15D0118	11/12/2015	Minor derailment of locomotive in passenger train consists derailed as the set traversed the crossover at 55mph vs crossover speed 15mph.	Montréal, Quebec, Canada	Train swayed side to side during crossover traversing causing excessive wheel lift leading to derailment. Crew did not comply with signal ahead which indicated 15mph reduced speed. The regular route of the train, as well as the foreman's instructions, which did not include the freight track, led the crew members to anticipate that they would remain on the north track at Turcot-Ouest and that they could proceed without reducing speed.

Table 5: US and Canada passenger derailments

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