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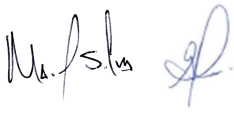
Toronto Transit Commission

Scarborough Rapid Transit (SRT) Vehicle Accident Investigation Report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HATCH						

Version History

Revision	Date	Description of Change
A	2023-09-28	Original release

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List of Acronyms

Acronym	Definition
TTC	Toronto Transit Commission
SRT	Scarborough Rapid Transit
LIM	Linear Induction Motor
Kph	Kilometres per hour
km	Kilometres
OEM	Original Equipment Manufacturer
mm	Millimetres
TOR	Top of (Running) Rail
S/N	Serial Number
ATC	Automatic Train Control
RHS	Right Hand Side
LHS	Left Hand Side

1. Executive Summary

1.1 Introduction

On July 24, 2023, a Scarborough Rapid Transit (SRT) 4-car train, designated “63 Run”, travelling southbound derailed south of Ellesmere Station, at 6:43 PM. The train was travelling at a speed of 39.5 kph, carrying a total of 44 passengers. Five passengers received treatment for minor injuries.

Surveillance footage from Ellesmere Station captured the moment the last trailing car of the consist (car 3001) appears to suddenly collide with a guideway obstruction, causing the car to come to a complete stop while the trailing truck of car 3001 derails and is displaced to the wayside. Car 3001 separated from the other cars in the consist; none of other cars derailed. The train onboard computer detected the separation of car 3001 and stopped the other cars of the consist shortly after, just south of car 3001.

Hatch was retained by the Toronto Transit Commission (TTC) to conduct a thorough investigation of the accident from a vehicle’s perspective and determine whether conditions on the vehicles had any influence on the event. Additional consulting firms were also contracted by TTC to investigate the event from the track infrastructure perspective. This document is being submitted by Hatch in complete fulfillment of Hatch’s scope of work agreed with TTC.

1.2 Summary of Findings and Conclusions

Hatch has conducted a thorough investigation, from the vehicle’s perspective and reached the following conclusions from the data collected:

1. Hatch did not find any evidence of conventional mechanisms associated with wheel/rail interaction that typically lead to derailments: no flanging marks on the rails due to truck hunting, no rail rollover, no track panel shift, no severe wheel flanging marks on the rails. Therefore, the primary event was a collision with a track infrastructure obstruction that subsequently led to the truck being lifted from the rails and displaced to the wayside (secondary event). In other words, the accident was not a conventional derailment but rather a collision.
2. Hatch found evidence of collision damage associated with a guideway obstruction on four trucks of the inspected cars (“63 Run” and “61 Run” trains), as shown in Figure 1. The damage caused by the collision on all four trucks were very similar, strongly suggesting that they were all struck by the same object.

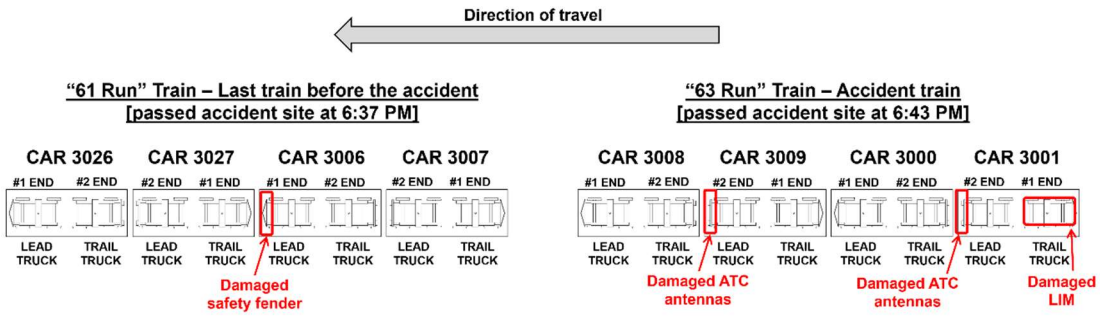


Figure 1 - Location of Damaged Trucks

3. Hatch did not find any evidence of improper LIM heights that could potentially have caused an interference with the reaction rail or to lift it in any way that would cause a collision.

4. Hatch did not find any evidence suggesting the vehicles had caused or contributed in any manner to the accident on July 24, 2023.

2. SRT Line and Vehicles

The Scarborough Rapid Transit system (SRT), also known as TTC's Line 3, is a 6.4-kilometre intermediate capacity rapid transit line with six stations that opened in 1985 [1].

The vehicles' Original Equipment Manufacturer (OEM) was the Urban Transportation Development Corporation (UTDC), a Crown corporation later sold to Bombardier Transportation. The vehicles have been in service 10 years past their intended design life, with overhaul programs implemented by TTC in recent years to ensure safety and reliability are maintained until the complete decommission of the line, which is scheduled to occur in November 2023 [1].

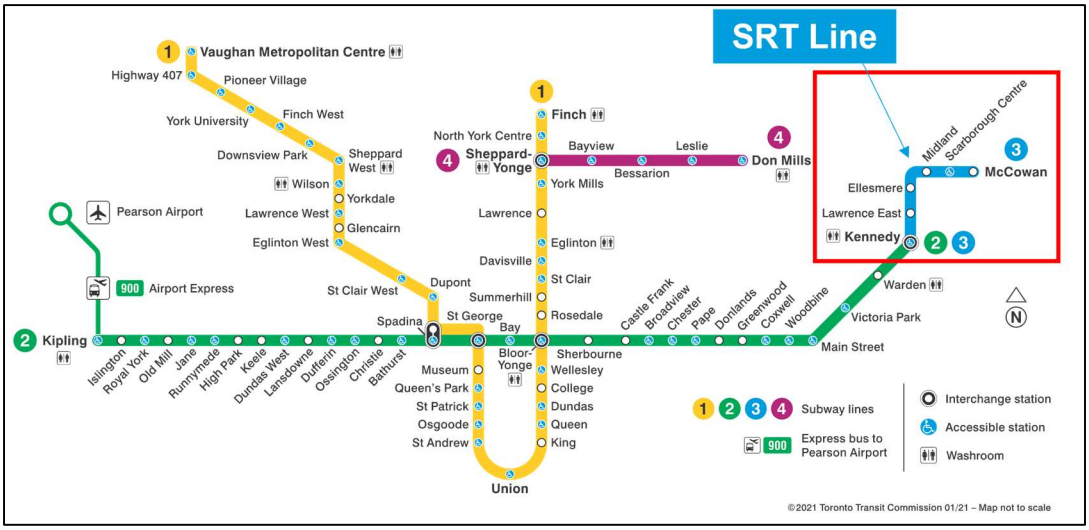


Figure 2 - Scarborough Rapid Transit (SRT) Line

Each SRT vehicle (shown in Figure 3) contains two 2-axle trucks with steerable mechanisms. The steering mechanisms allow the axles to assume a radial position in a curve, which minimizes lateral forces on flanging wheels, leading to a reduced risk of flange climbing the running rail (derailment).

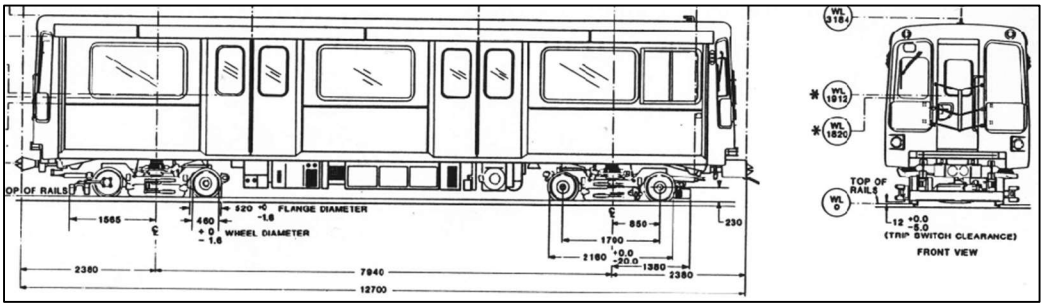


Figure 3 - SRT Car Outline

The main vehicle characteristics are shown in Table 1 [13]:

Table 1 - Main SRT Vehicle Characteristics

CHARACTERISTIC	VALUE
Length of couplers	12.7 m (41’ 8”)
External width	2.5 m (8’ 2½”)
Height (top of rail to top of roof)	3.13 m (10’ 3”)
Rail gauge	1435 mm (4’ 8½”)
Seating passengers	30
Weights	W1 (tare): 15,450 kg (34,050 lb)
	W4 (service): 21,190 kg (46,700 lb); 81 passengers
	W5 (crush): 23,150 kg (51,025 lb); 109 passengers
Vehicle construction	Welded aluminum frame, aluminum skin, fiberglass caps, honey comb aluminum roof
Truck	Radial (steerable axles), forged aluminum side frames and bolsters, minimum curve radius 18 m (60 ft.)

Each truck assembly contains primary and secondary suspension components. The primary suspension components consist of high stiffness resilient sleeves in the axle bearing housing and resilient shear pads between the sideframe and the top of the bearing housing, as depicted in Figure 4.

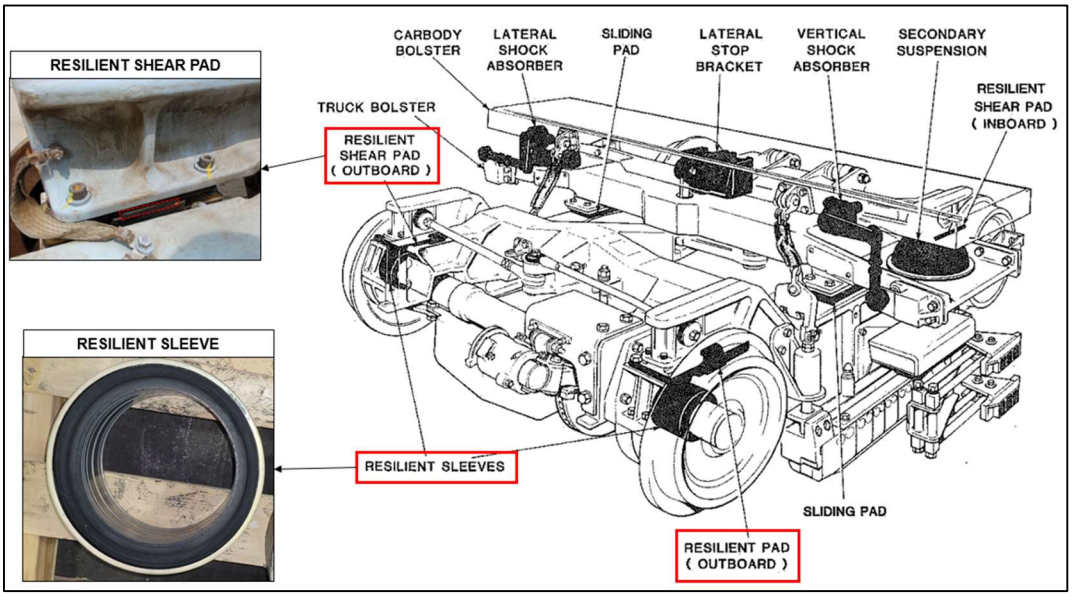


Figure 4 - SRT Truck Primary Suspension Components

In addition, each truck is equipped with a Linear Induction Motor (LIM), which provides the tractive and dynamic braking power. This technology differs from conventional rail transit vehicles, which are typically equipped with rotary induction traction motors (see Figure 5). The LIM system is basically a conventional rotary induction motor stretched out flat. The LIM system uses electrically induced attractive and repulsive forces to pull itself along a metal plate, which is mounted in the center of the track. The basic LIM system configuration is shown in Figure 5.

The LIM system consists of a primary system composed of the stator of the motor that is mounted on the vehicle, and a secondary system, which is equivalent to the rotor of the motor, that is secured to the track guideway. Seeking to align this report with the terminology commonly adopted by TTC, the term “LIM” in this document will be used when referring to the LIM primary system (vehicle mounted), and the term “reaction rail” will be used when referring to the LIM secondary system (track mounted). Please refer to Figure 5 and Figure 6.

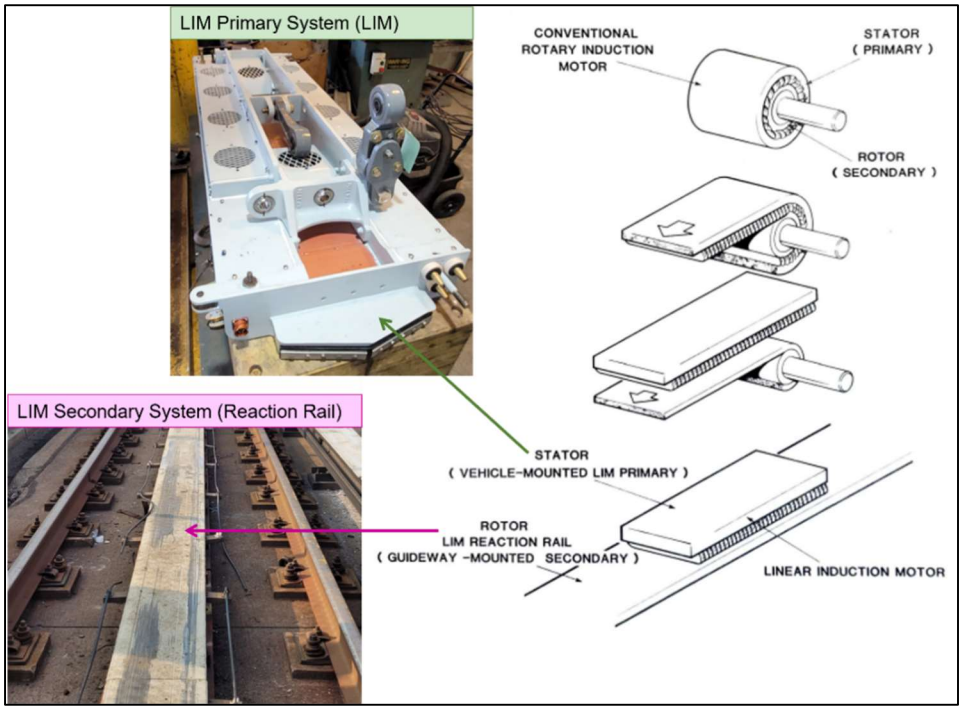


Figure 5 - LIM System

When accelerating, the LIM produces motoring thrust in the direction of travel. In deceleration mode, the LIM produces braking thrust. Simultaneously, the LIM produces a significant vertical attraction force on the reaction rail, which is limited at 25 kN for normal operation and 90 kN for an isolated fault case [14]. The produced thrust and vertical force are dependant on the vehicle travel speed [14].

For the LIM system to properly function and obtain optimum thrust and energy consumption, the air gap between the LIM and the reaction rail must be strictly maintained. The OEM recommended a nominal air gap of 11 mm [2]. This gap was adjusted by TTC in 2020 to an ideal gap of 12 mm, per Bombardier Transportation's recommendation, to optimize operational/maintainability costs and account for top of running rail wear [3] [4].

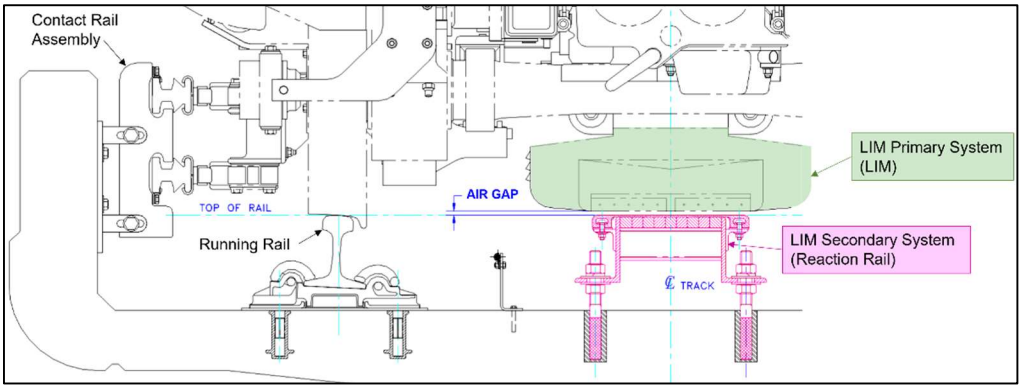


Figure 6 - LIM System Interfaces

The LIM is vertically suspended and attached to the truck steering arms (also known as "yoke assemblies") through three primary vertical connection links, identified in green colour in Figure 7. Secondary (safety) links are also used to prevent the LIM from falling onto the guideway in case of failure of the primary connection elements. Thrust and lateral links are also used, but they do not have any significant influence on the LIM height. High stiffness resilient bushings are used in the vertical connection links to limit vertical deflection of the LIM motor.

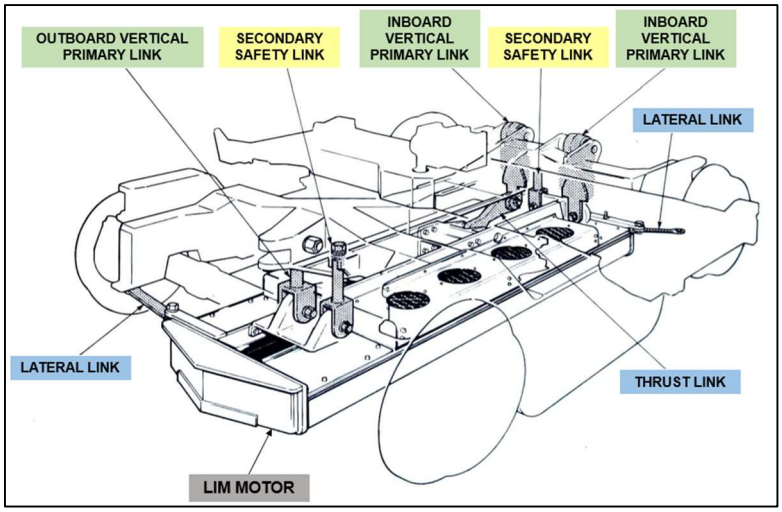


Figure 7 - LIM Connection Links

The primary vertical links are equipped with cams that allow adjustment of the LIM height with respect to the top of the running rails. This adjustment is performed by turning the cam hexagon screws shown in Figure 8. Once the height is properly set, fixed gear tooth mechanisms (lock plates) are used to ensure the cam is secured and the height is maintained. The spacing of the teeth in the locking mechanism teeth is sufficiently small to readily allow for 0.5 mm adjustments.

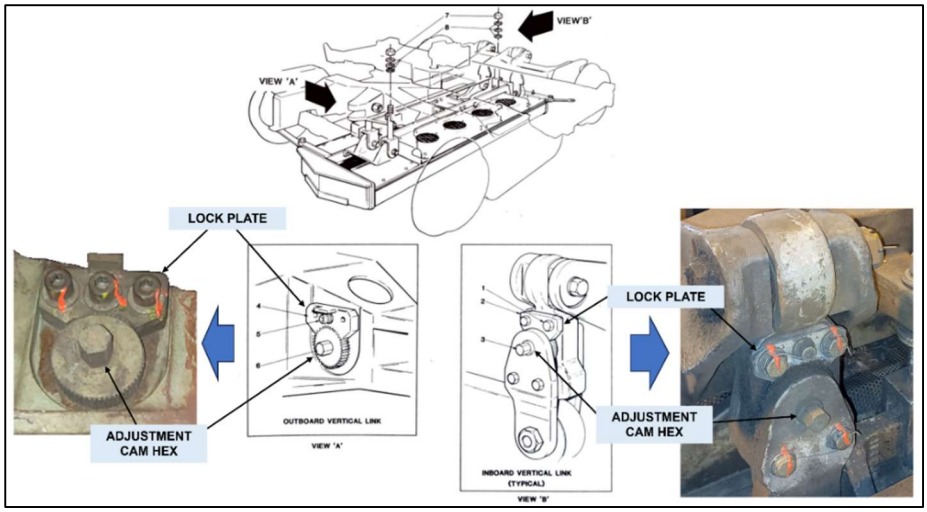


Figure 8 - LIM Primary Vertical Connection Links and Cams

Per TTC's latest procedure [4], depicted in Figure 9, the LIM height with respect to the top of the running rails must be within 12.5 mm and 13.5 mm. This acceptable range is used during maintenance interventions at the carhouse to set the LIM height for all cars. Along with the reaction rail height tolerance (-1/+5 mm with respect to TOR), the resulting operational air gap range is between 7.5 mm and 14.5 mm.

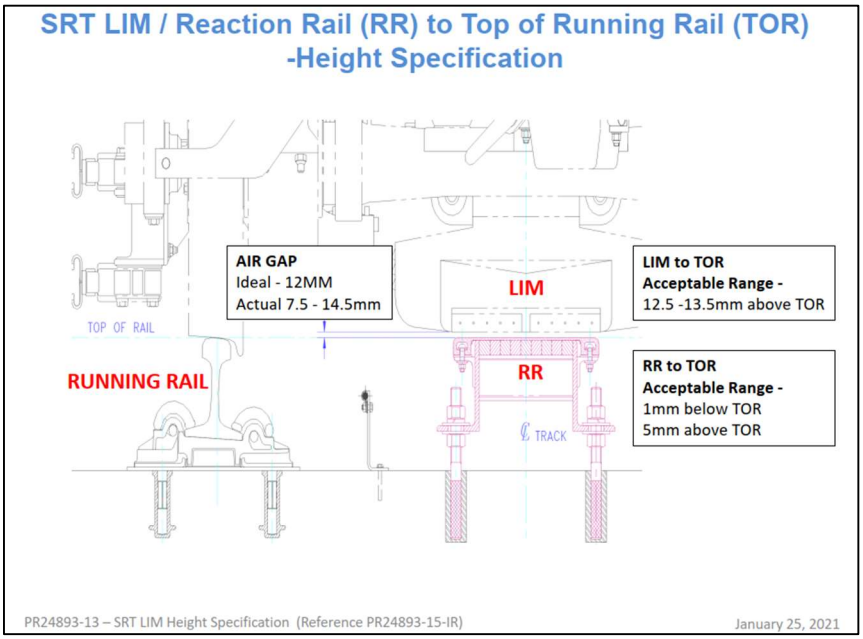


Figure 9 - TTC's LIM Height Specifications [4]

TTC measures the LIM height of all vehicles at McCowan Carhouse every 30-36 days, as part of their safety and standard inspections [5] [6] [7] using a gauge provided by the OEM – drawing number 127E-610-005 [9] – depicted in Figure 10. If the LIM height measured during the inspections is found to be outside of the acceptable range (between 12.5 mm and 13.5 mm), then it is adjusted to bring it to compliance. With the vehicle over an inspection pit, the gauge is placed on the top of the running rails and projects the plane created by the top faces of the running rails across the entire span of the track. The feeler gauge (Figure 11) is then placed between the gauge and the bottom of the LIM core to measure the height. Hatch observed though that the feeler gauge contains graduations spaced every 1 mm, which necessitates judgement when measuring half-millimetre dimensions, as required per the tolerance range (between 12.5 mm and 13.5 mm). Hatch recommends TTC modifying the design of the feeler gauge to include half-millimetre graduations, as a minimum, to improve accuracy of the measurements. However, the feeler gauge accuracy and possible measurement reading errors are not considered to have contributed to the accident on July 24, 2023. Since the feeler gauge translates the vertical gap between the LIM and the top of the running rails to an enlarged horizontal scale, relatively large reading errors on the horizontal scale would only generate small errors on the LIM height (e.g., a 5 mm reading error on the horizontal scale would represent a 0.25 mm error on the LIM height). Such small errors are considered negligible when compared with the height of the object colliding with the vehicles on July 24, 2023.

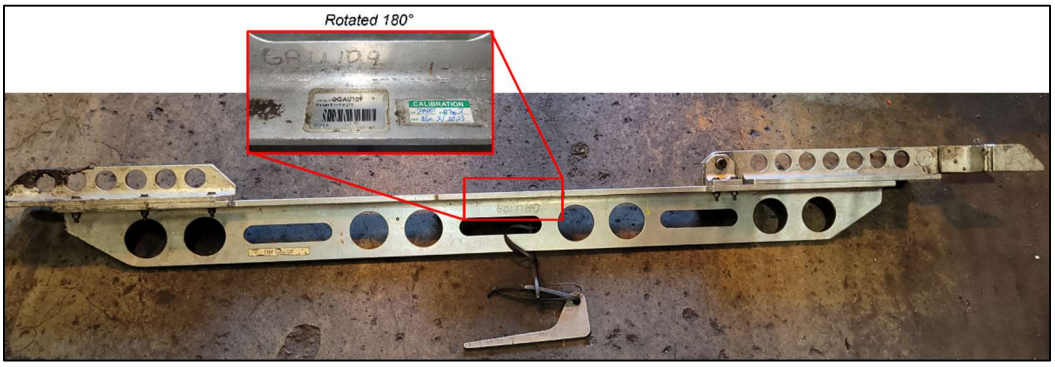


Figure 10 - LIM Height Measurement Gauge

Figure 11 - LIM Height Measurement Feeler Gauge

Per TTC's inspection procedures [6] [7] and OEM's recommendation [2], four separate height measurements were taken on each LIM, longitudinally aligned with the vertical connection links. Figure 12 depicts an example of a measurement being taken. For simplicity, this report does not include images of all LIM height measurements taken on the inspected cars, but instead only the results are provided.

Figure 12 - LIM Height Measurement Being Taken

Condition of the LIM links and their connections to the yoke assemblies are also checked during these inspections. The vehicles' OEM required the LIM height to be measured and adjusted, if necessary, every 15,000 km of service [8]. According to TTC, the running average for an SRT car is approximately 10,000 km per month. Hence, the current inspection interval (every 30-36 days) complies with the OEM recommendation.

Since the LIM is mounted on suspended components (yoke assemblies, which are above the primary suspension resilient sleeves and pads), relative displacement between the LIM and the wheelsets may occur, as a result of different loading conditions on the suspension components (e.g., passengers' weight, vibrational loads, carbody roll, etc.). However, given the relative high stiffness of these suspension components, these displacements may be considered negligible (see Appendix A: Primary Suspension Deflection Due to Additional Loads). In addition, Hatch believes the OEM has considered any possible vertical displacements due to passenger/operation loads when defining the original nominal air gap of 11 mm.

The LIM also includes non-metallic frangible scraper blades, mounted on each end, for clearing any debris on the reaction rail. There are also skids (pads) installed at each end of the LIM (see Figure 13). They are made from fiberglass material and protrude below the lower surface of the LIM. The skids are intended to protect the LIM's core (electrical windings) assembly from damage should a sliding contact with the reaction rail occur [14].

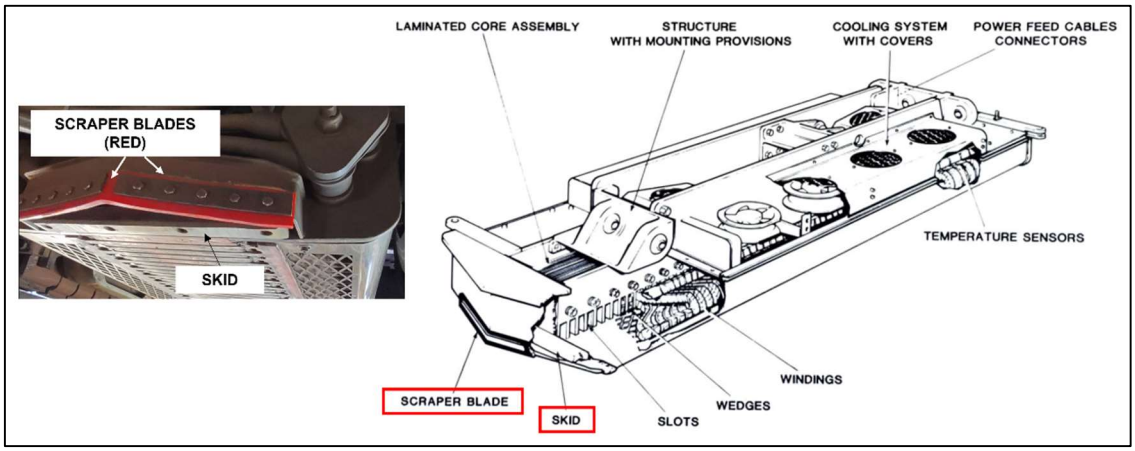


Figure 13 - LIM Scrapper Blades and Skid

Additionally, the #1-end truck of each SRT car is equipped with a non-frangible safety fender, while the #2-end truck is equipped with ATC antennas, as shown in Figure 14. The bottom of the safety fender is positioned at a height of 50 mm above the top of the running rails, while the bottom of the ATC antennas sits at 40 mm above the top of the running rails. Hence, both components are positioned higher than the LIM.

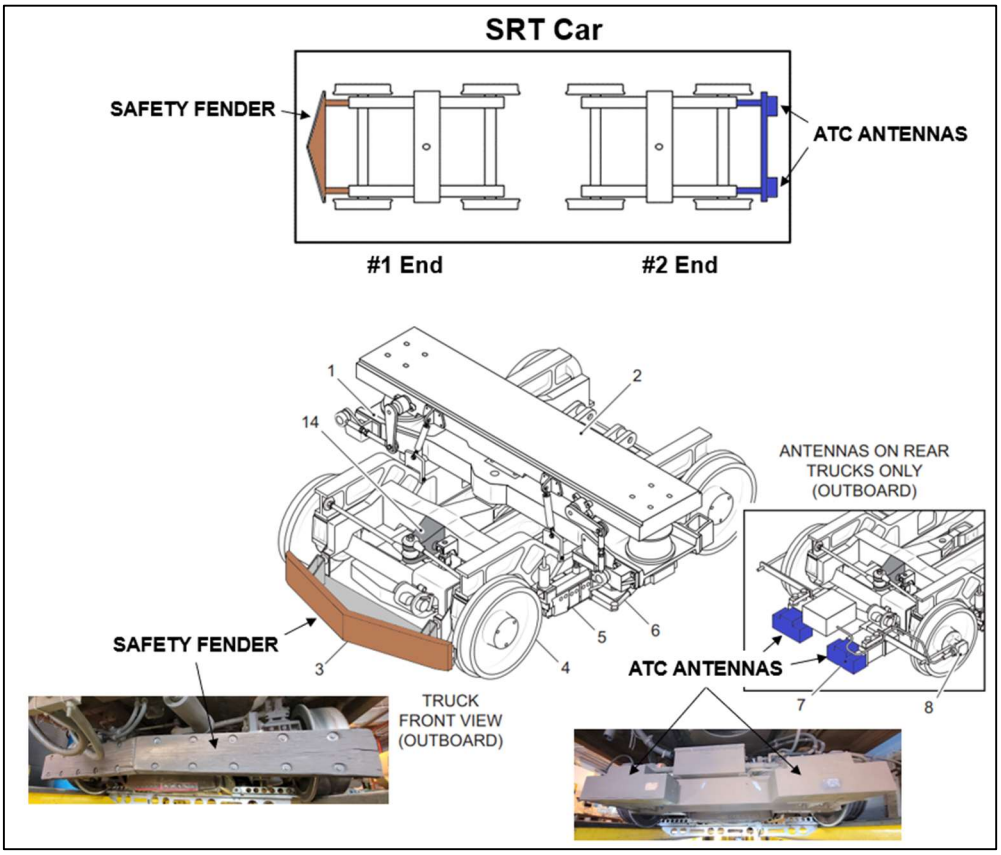


Figure 14 - SRT Truck Safety Fender and ATC Antennas

3. Accident Description

The accident occurred at chainage 135+10 of the southbound SRT line, between Ellesmere Station and Lawrence East Station, approximately 60 metres past Ellesmere Station's platform.

The SRT 4-car train designated as "63 Run" was travelling southbound on a tangent track with no superelevation, when the last car of the train derailed, at 6:43 PM. Car 3008 was leading the consist, followed by cars 3009, 3000 and 3001, as shown in Figure 15.

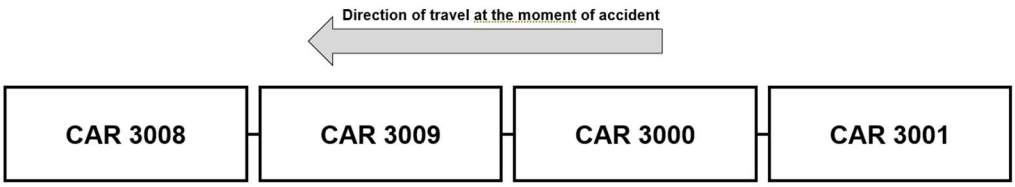


Figure 15 - "63 Run" Train Configuration

Conditions were dry at the time (no precipitation), temperature was approximately 22°C, with a southeast wind blowing at a speed of approximately 7 kph [12]. The train was travelling at a speed of 39.5 kph, carrying a total of 44 passengers.

Surveillance footage from Ellesmere Station shows the consist accelerating out of the station when the last trailing car of the consist (car 3001) appears to suddenly collide with a track obstruction, lift off the tracks in a pitching motion (rear end of the car lifted significantly more than the front end) and halt to a complete stop. The first three cars of the consist separated from car 3001 and continued traveling southbound. In the footage, the trailing truck of car 3001 can also be seen coming off the running rails. Shortly after, the train onboard computer detected an abnormality (due to the separation of car 3001) and the first three cars of the consist also stopped, about 50 metres south of car 3001 (see images on Figure 16). Other than the lost connection with Car 3001 after the accident, the onboard computer fault log did not record any abnormalities/faults with any of the cars' major operational systems prior to the event.

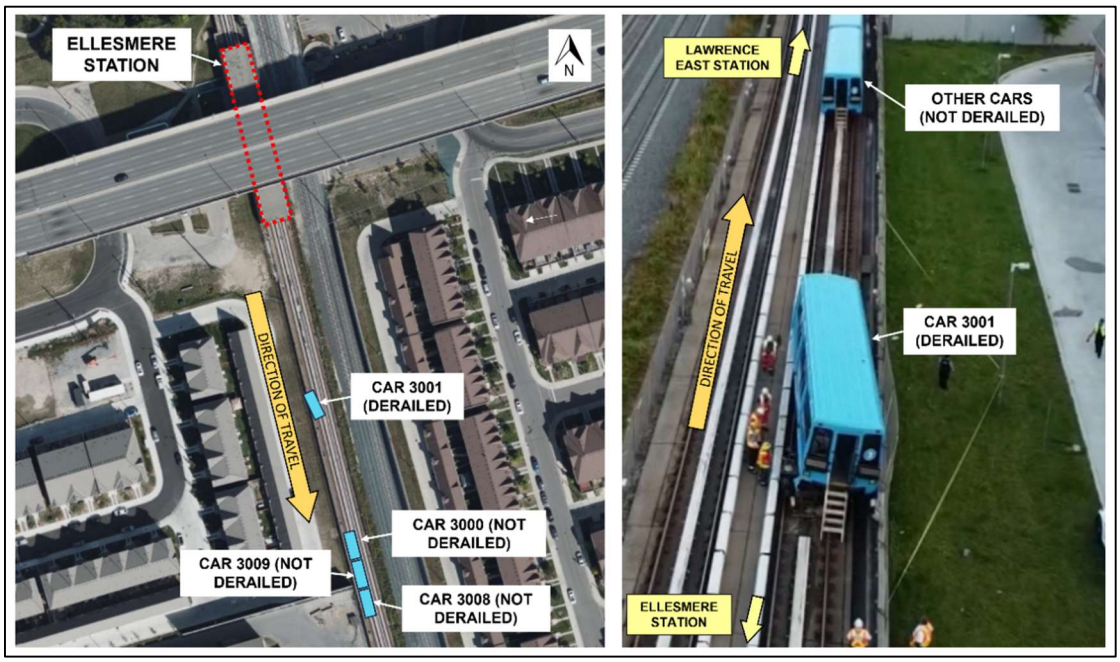


Figure 16 - Accident scene

City of Toronto emergency crews and TTC staff attended the scene, taking five passengers to the hospital for treatment of minor injuries.

After the accident, TTC's maintenance personnel removed car 3001 from the scene and moved it to McCowan Carhouse. Hence, when Hatch was engaged to assist TTC with this investigation

on July 25, 2023, Hatch's experts could not inspect the conditions of car 3001 at the scene, as only cars 3008, 3009 and 3009 (not derailed cars) were still on the site.

Figure 17 shows the locations of relevant trains on the SRT line, where trains run in a closed loop fashion, at the moment the accident occurred. Special attention is given to train "61 Run", which was the last train to pass the section of track where the accident occurred without any incidents, at approximately 6:37 PM. "61 Run" train was composed of cars 3026, 3027, 3006 and 3007, as shown in Figure 18, and was also part of Hatch's investigation, to assist determining whether any abnormalities existed prior to the "63 Run" train accident.

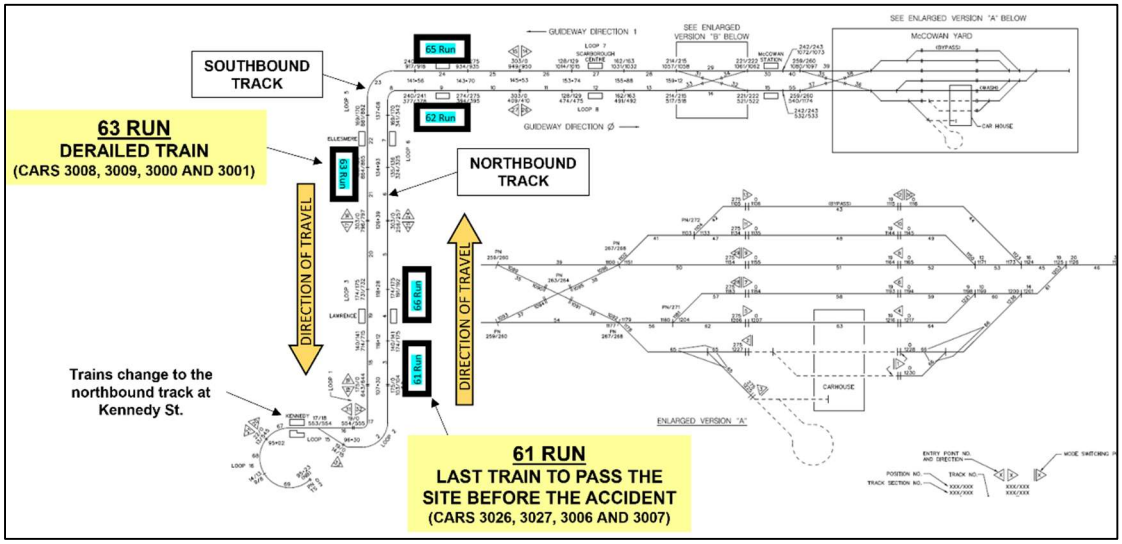


Figure 17 - Positions of Relevant Trains on the System at the Time of the Accident

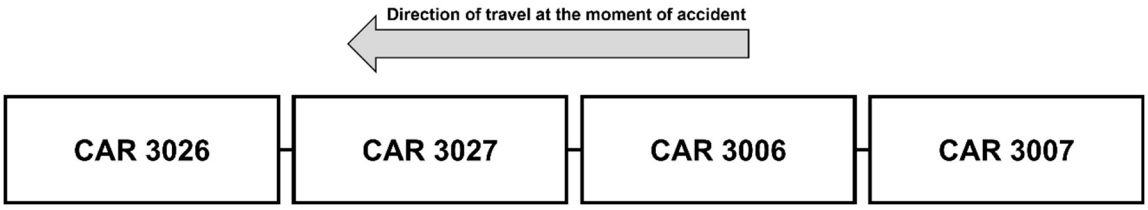


Figure 18 - "61 Run" Train Configuration

4. Inspection of Accident Site

Hatch's rail vehicle expert performed an initial inspection of the site where the accident occurred on July 25, 2023, a day after the accident. A subsequent inspection of the site by a Hatch's track infrastructure expert followed on July 26 and 27, 2023.

Since TTC has contracted a separate infrastructure consultant to conduct the investigation from the track/wayside perspective, Hatch's inspection of the site and its observations in this report are not intended to serve as a thorough investigation of the track/wayside infrastructure. Instead, the intent of the site inspection was to obtain evidence that could assist in establishing the chain of events that led to the accident, and determining whether the vehicles had any influence on it.

4.1 Site Inspection Observations

Below are Hatch's findings upon assessment of the accident site:

1. The running rails were in reasonably good condition, without any excessive wear/damages, neither on the gauge corner nor the top.
2. The train accident site is in an area of direct fixation. The running rails are fastened to a concrete bearing pad on top of a concrete invert. No timber railway ties were observed at this location.
3. The running rail track fasteners at the derailment location were found to be in good condition. Compression clips fasten the running to the tie plates at the derailment site. The compression clips are mechanically fastened to the tie plates. The tie plates are mechanically fastened to the concrete invert by two anchor bolts per tie plate. The tie plates sit on top of a resilient rubber pad. Only superficial damaged was observed to the running rail fasteners due to the derailment of the SRT train consist. Figure 19 below shows a typical running rail tie plate fastener assembly at the derailment site.

Figure 19 - Typical Track Fastener Assembly at Accident Site

4. Visually, the track geometry appeared in good condition. The track gauge at the location where car 3001 was displaced to the track wayside was approximately 1,444 mm, which is compliant with TTC's track maintenance standards (maximum allowed for that section of track was 1,447 mm). TTC and its track consultant have verbally confirmed the track geometry was measured at the location of the accident and found to be within the acceptable limits, although only measurement records for track gauge and superelevation have been submitted to Hatch (alignment and track warp results not available). Therefore, truck performance, such as

steering and equalization, would not appear to have been compromised in some way by track conditions.

5. Superficial markings were found on the top/gauge corner of the west side running rail at the location where accident occurred. Some of these markings were apart by approximately 1,700 mm, which corresponds to the vehicle's truck wheelbase. However, it is worth noting that the site inspection occurred after car 3001 was already removed from the site. TTC has indicated the recovery crews on site faced difficulties when removing the trailing truck from the carbody, due to the extensive damage of the truck-to-carbody connections, and "bouncing" of the car had occurred a few times, which may have caused some of the markings. In addition, the surveillance footage of the accident shows the trailing truck of car 3001 being completely lifted from the rails as a result of the primary collision. Hence, the markings found on the rails are not indications of a conventional "derailment", but rather consequences of the truck lifting.

Figure 20 - Rail Markings

6. Hatch did not find any evidence of conventional mechanisms associated with wheel/rail interaction that typically lead to derailments: no flanging marks on the rails due to truck hunting, no rail rollover, no track panel shift, no severe wheel flanging marks on the rails. Therefore, the primary event was a collision with a track infrastructure obstruction that subsequently led to the truck being lifted from the rails and displaced to the wayside (secondary event). In other words, the accident was not a conventional derailment but rather a collision. This observation aligns with the video evidence, from Ellesmere Stations' surveillance footage, which shows the moment the vehicle undercarriage collided with a guideway obstruction.

7. The 600V contact rail assembly consists of two contact rails (a positive and negative rail), a contact rail support, non-conductive contact rail chair, and a non-conductive protective cover board that spans adjacent supports. The 600V contact rail assembly was found to be in good condition at the train accident site with only minor contact damage to the corner of one protective cover board. Figure 21 below shows the 600V contact rail directly adjacent to the derailment location.

Figure 21 - 600V Contact Rail Assembly at Accident Site

8. Significant damage was observed to the reaction rail at the location of the SRT train accident. The reaction rail assembly consists of three primary components: an aluminum top, iron LIM rail, and a linear induction loop. The reaction rail is fastened to the concrete invert by a series of anchor blots. The following items detail the condition of the reaction rail observed during the site visits.

    a) Figure 22 depicts the SRT southbound track, approximately 60 metres south of Ellesmere Station, looking south as it was observed during site investigation. Section A corresponds to the reaction rail section immediately before the accident location, while Section B represents the reaction rail at the accident location (unseated) and Section C is the damaged section of reaction rail immediately after the accident location. Section B appears to have been struck by the incident train. This collision unseated the reaction rail section from its anchored location pushing it under subsequent reaction rail Section C.

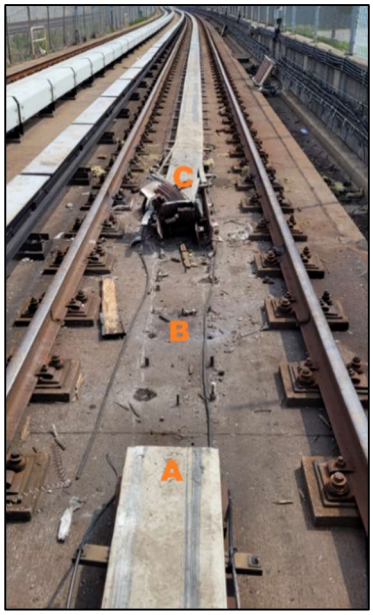


Figure 22 - Reaction Rail at the Accident Site

b) Reaction rail Section B anchor bolt fastener locations are identified by red circles in Figure 23 – numbered #0 through #9.

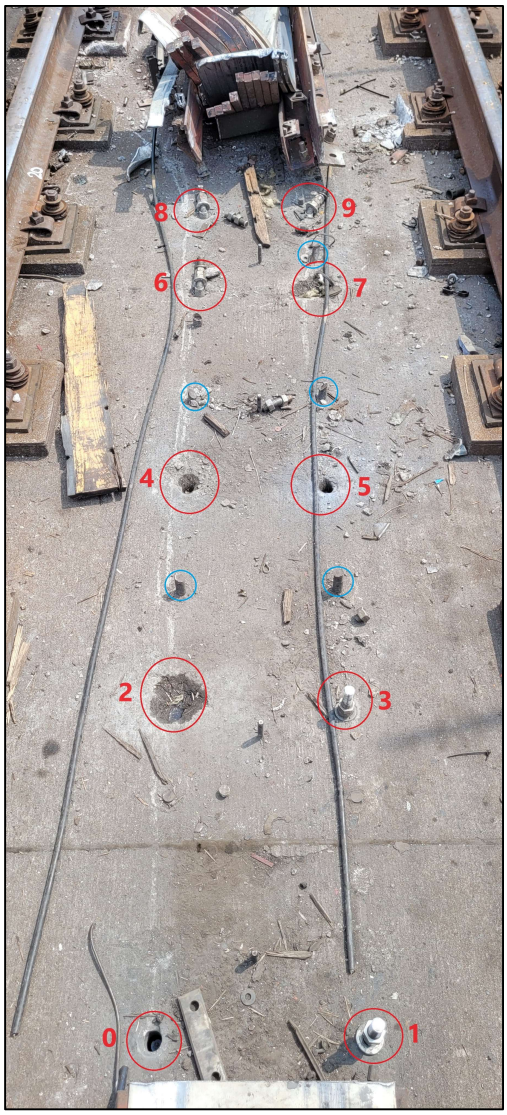


Figure 23 - Reaction Rail Section B Anchor Bolts

c) Anchor bolts #1, #3, #6, #8, and #9 were found in situ by TTC personnel immediately after the derailment. Anchor bolts #6, #8 and #9 were observed to be bent in the direction of train travel and the top portion of the anchor bolts were observed to be missing. Anchor bolts #1 and #3 were missing the top portion of bolt but were observed to be unbent below the shear face.

d) Anchor bolts #0, #2, #4, #5, and #7 were observed to have been pulled out of their cored holes and remained fastened to the reaction rail section that was pushed under reaction rail Section C.

e) Reaction rail anchor bolts #0 through #9 were observed to be mechanical set type fasteners. Anchor bolts #1 and #3 appeared to be stainless steel bolts. Anchor bolts #6, #8, and #9 appeared to be carbon steel bolts.

f) Anchor bolts #0, #2, #4, #5, and #7 were observed not to be in the core holes and were presumed to be still fastened to the underside of the unseated reaction rail, hidden from view. As these anchor bolts were not visible to the Track Specialist, their material composition could not be ascertained.

g) Blue circles in Figure 23 identify anchor bolts that were observed to have been saw cut and abandoned prior to the incident.

h) The flat failure face of the lower portion of anchor bolts #1 and #3 were observed to be polished, and the edge of the failure face was hammered flat by cyclical contact with the upper portion of the bolt, as shown in Figure 24. The top portion of anchor bolts #1 and #3 were observed to be still fastened to the unseated reaction rail.

Figure 24 - Anchor Bolts #1 and #3

i) Reaction rail Section B was observed to have been struck and unseated during the derailment. Reaction rail Section B was observed pushed under reaction rail Section C. The top cap of reaction rail Section B was dissimilar to other top cap sections in the immediate area as it was observed to be polished. Red outlined area in Figure 25 identifies the polished top cap of reaction rail Section B.

Figure 25 - Reaction Rail Section B

j) The aluminum top cap of reaction rail Section A was observed to have damage to the trailing edge of the T-bolt channel on both edges of the top cap as identified by the red circles in Figure 26. Close up of damaged T-bolt channel on top cap section of reaction rail Section A is shown in Figure 27. Corresponding damage to top cap T-bolt channel on reaction rail Section B is depicted in Figure 28.

Figure 26 - Aluminum Top Cap of Reaction Rail Section A

Figure 27 - Damaged Aluminum Top Cap of Reaction Rail Section A

Figure 28 - Reaction Rail Top Cap of Reaction Rail Section B

k) Bent anchor bolt #8 with corresponding top section of bolt lying directly beside is shown in Figure 29. Evidence of ductile overload was observed resulting in the failure of bolt. The top portion of anchor bolt #8 with rounded bolt end is also shown.

Figure 29 - Anchor Bolt #8

5. Inspection of the "63 Run" Train (Accident Train)

As part of the investigation process, Hatch has inspected the trucks of the four cars on the consist involved in the accident ("63 Run"). After the initial assessment of the damage on the trucks of car 3001, and considering the evidence found at the accident site/surveillance video, the vehicle inspections focused primarily on the LIMs, to determine if there was any indication these components may have been improperly adjusted, leading to a reduction of the air gap with the reaction rail. Thorough inspections of the LIM connections to the yoke assemblies were also performed.

For completeness, wheelset back-to-back inspections and wheel diameter measurements were also performed. However, due to the lack of evidence suggesting a conventional derailment occurred, wheel/track interaction characteristics were deemed not relevant. The inspection findings for each truck are documented in the next subsections.

Figure 30 shows the location of each inspected truck on "63 Run" Train.

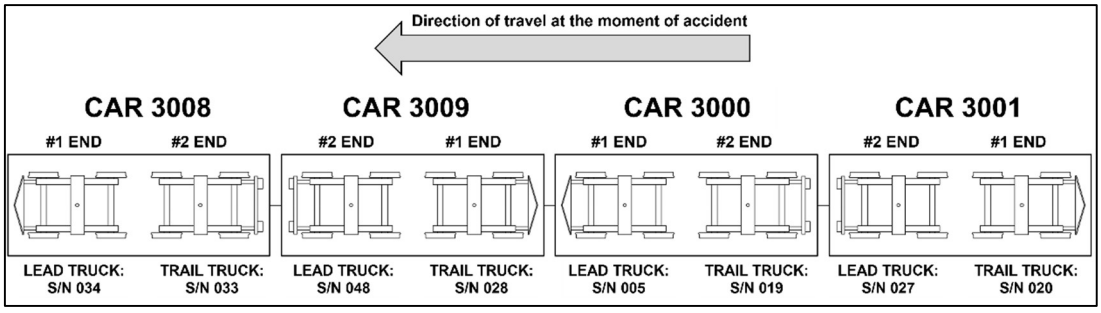


Figure 30 - Location of Trucks on "63 Run" Train

5.1 Car 3008

5.1.1 Leading Truck (Truck Serial Number 034)

Location of truck S/N 034 in the consist during the time of the accident is shown in Figure 31.

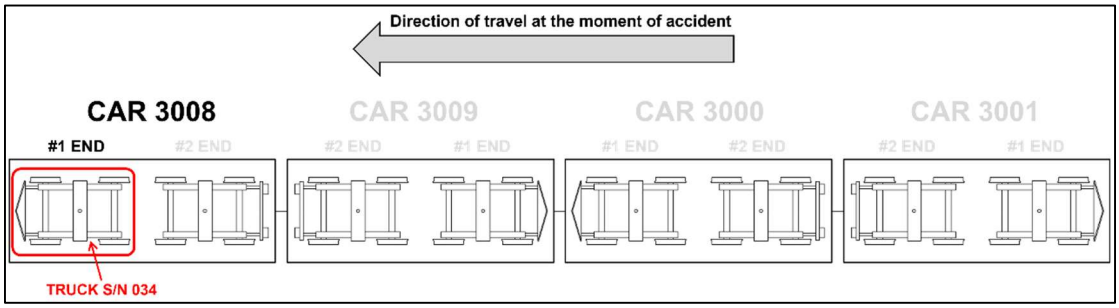
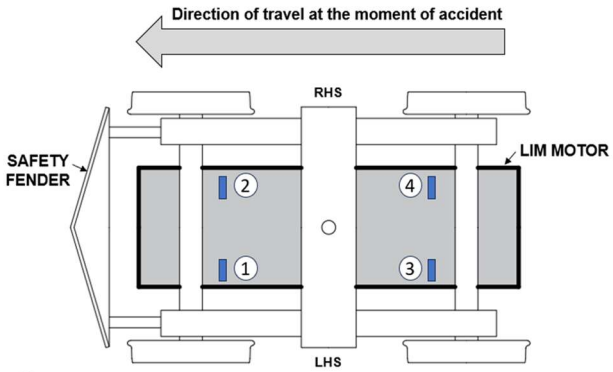


Figure 31 - Location of Truck S/N 034

The truck inspection occurred at McCowan Carhouse on July 26, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 32. The measurement results for truck S/N 034 were found to be within the acceptable limits, as shown in Figure 32.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	13
	2	12.5
	3	13.25
	4	13

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in red : smaller than minimum value required (12.5 mm).*
4) *Measurements in green: within tolerance range (12.5~13.5 mm).*
5) *Measurements in yellow: greater than maximum value required (13.5 mm).*

Figure 32 - LIM Height Measurement Results for Truck S/N 034

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 33.

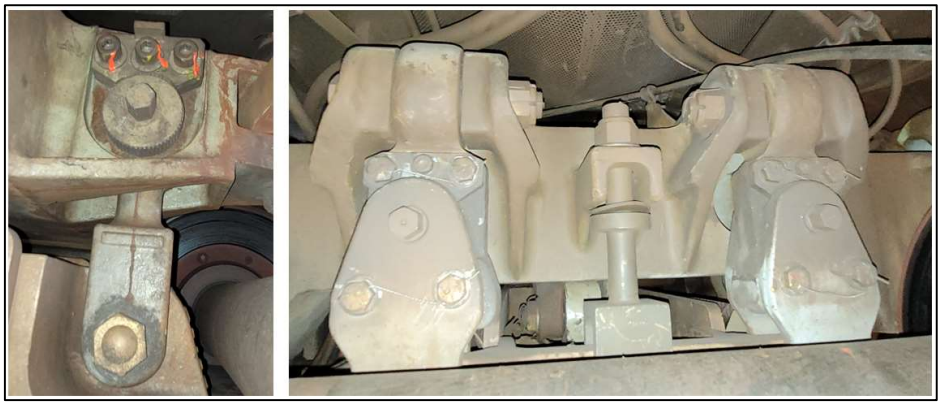


Figure 33 - Vertical Connection Links on Truck S/N 034

Uniform scratch marks were found along the entire length of the LIM bottom (Figure 34). These marks appeared to be aged due to their discoloration and dirt build-up presence. This proved to be a common finding for all inspected trucks/LIMs and suggests the bottom of the LIMs have been frequently rubbing against the reaction rail top aluminum cap at various locations in the system.

Figure 34 - Scratch Marks on Bottom of the LIM

No major damages were found on the safety fender, as shown in Figure 35.

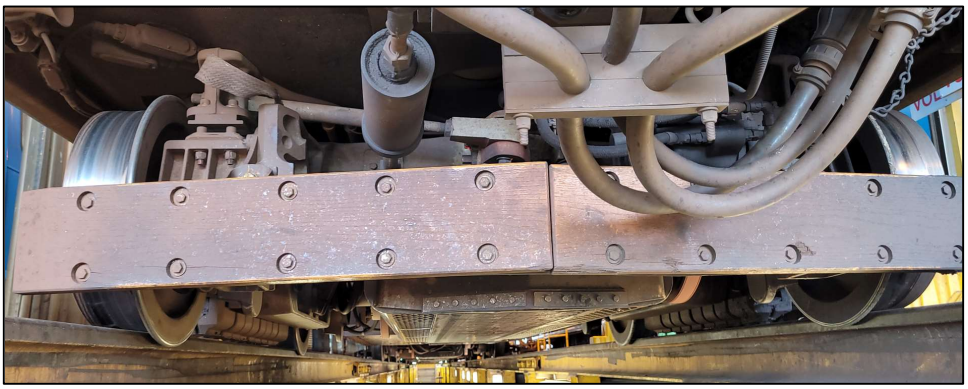


Figure 35 - Safety Fender on Truck S/N 034

A slight wearing of the scraper blade tip was also observed, as shown in Figure 36.

Figure 36 - Worn Scraper Blade

To rule out any abnormalities/non-conformities associated with wheel/rail interaction, the wheelset back-to-back dimensions were checked with the GO/NO-GO gauge illustrated in Figure 37 [10]. Both wheelsets on the truck were found to be compliant with the tolerances (back-to-back dimensions between 54.35” and 54.47”).

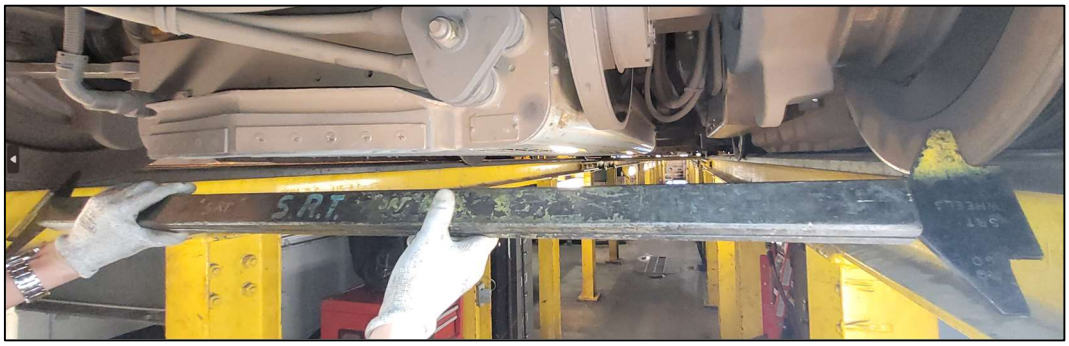
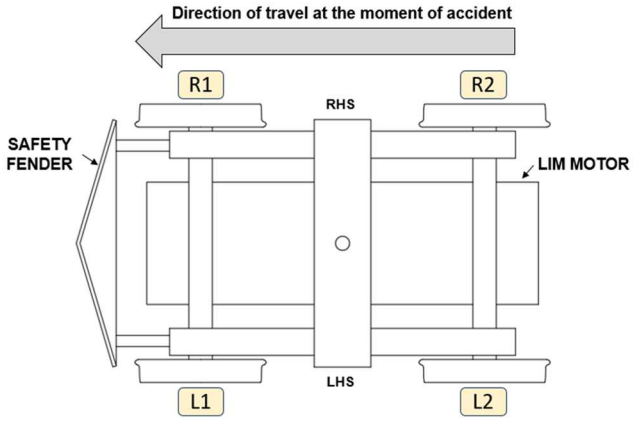


Figure 37 - Wheelset Back-to-Back Check

For completeness, wheel diameters were also measured and found to be above the minimum wheel diameter (> 440 mm). Results are shown in Figure 38.

MEASURING DIAGRAM	LOCATION	WHEEL DIAMETER (mm)
	R1	449
	R2	451
	L1	450
	L2	452

Notes:
1) *Image shows view from the top.*
2) *Nominal (new) wheel diameter: 467 mm*
3) *Minimum (worn) wheel diameter: 440 mm*

Figure 38 - Wheel Diameter Measurement Results on Truck S/N 034

5.1.2 Trailing Truck (Truck Serial Number 033)

Location of truck S/N 033 in the consist during the time of the accident is shown in Figure 39.

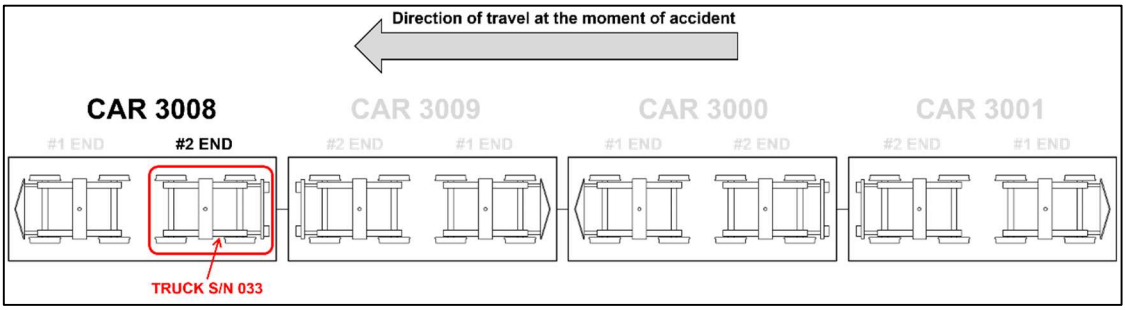
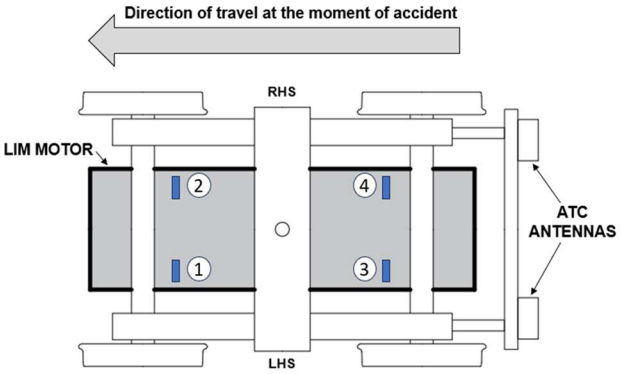


Figure 39 - Location of Truck S/N 033

The truck inspection occurred at McCowan Carhouse on July 26, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 40. Some of the measurement results were found to be outside of the specified range. However, all measurements outside of the tolerance were greater than the maximum allowed, hence increasing the air gap with the reaction rail.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	13.25
	2	14
	3	14
	4	14

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in **red**: smaller than minimum value required (12.5 mm).*
4) *Measurements in **green**: within tolerance range (12.5~13.5 mm).*
5) *Measurements in **yellow**: greater than maximum value required (13.5 mm).*

Figure 40 - LIM Height Measurement Results for Truck S/N 033

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 41.

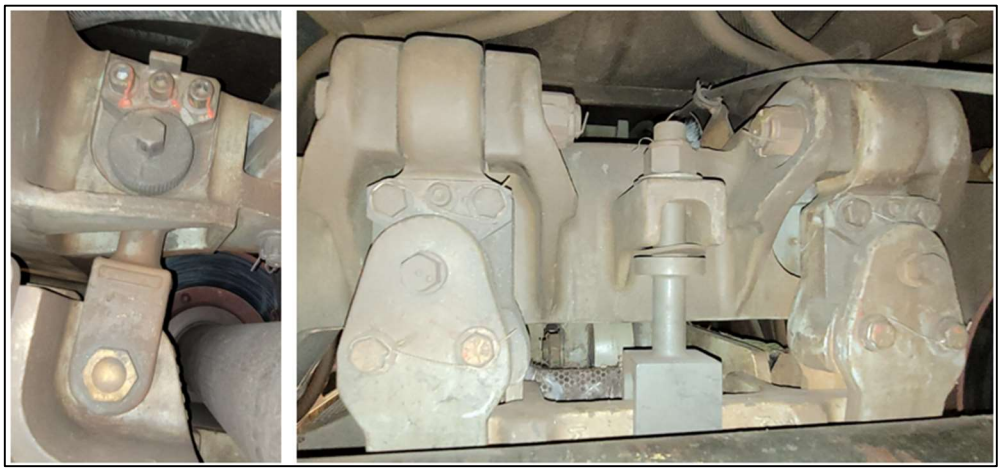


Figure 41 - Vertical Connection Links on Truck S/N 033

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 42, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

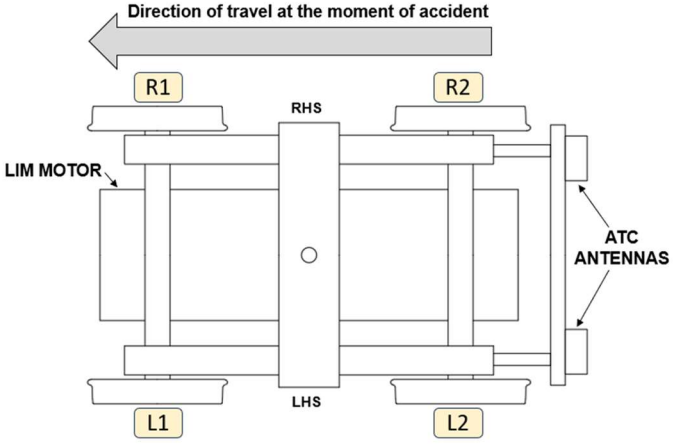
Figure 42 - Scratch Marks on Bottom of the LIM

No major damages were found on the ATC antennas, as shown in Figure 43.

Figure 43 - ATC Antennas on Truck S/N 033

The back-to-back dimensions on both wheelsets were checked with the GO/NO-GO gauge illustrated in Figure 37 [10] and found to be compliant.

For completeness, wheel diameters were also measured and found to be above the minimum wheel diameter (> 440 mm). Results are shown in Figure 44.

MEASURING DIAGRAM	LOCATION	WHEEL DIAMETER (mm)
	R1	452
	R2	452
	L1	453
	L2	452

Notes:
1) *Image shows view from the top.*
2) *Nominal (new) wheel diameter: 467 mm*
3) *Minimum (worn) wheel diameter: 440 mm*

Figure 44 - Wheel Diameter Measurement Results on Truck S/N 033

5.2 Car 3009

5.2.1 Leading Truck (Truck Serial Number 048)

Location of truck S/N 048 in the consist during the time of the accident is shown in Figure 45.

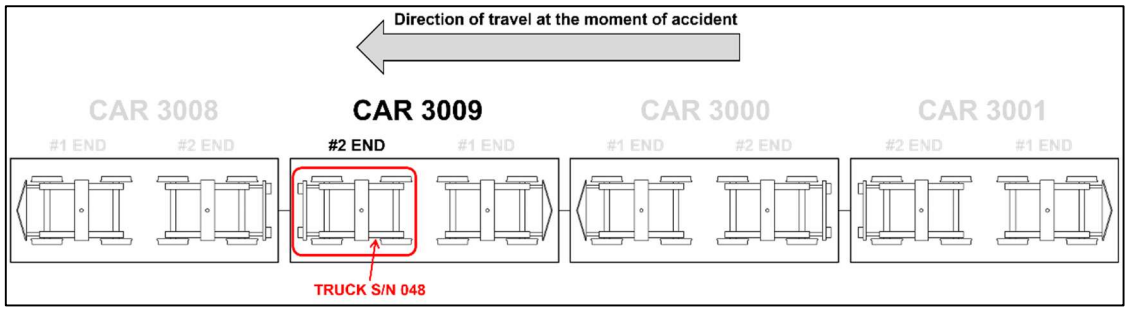


Figure 45 - Location of Truck S/N 048

The truck inspection occurred at McCowan Carhouse on July 26, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

Significant damage was found on the ATC antennas and its mounting structure, as shown in Figure 46, believed to be the result of a collision with a guideway obstruction.

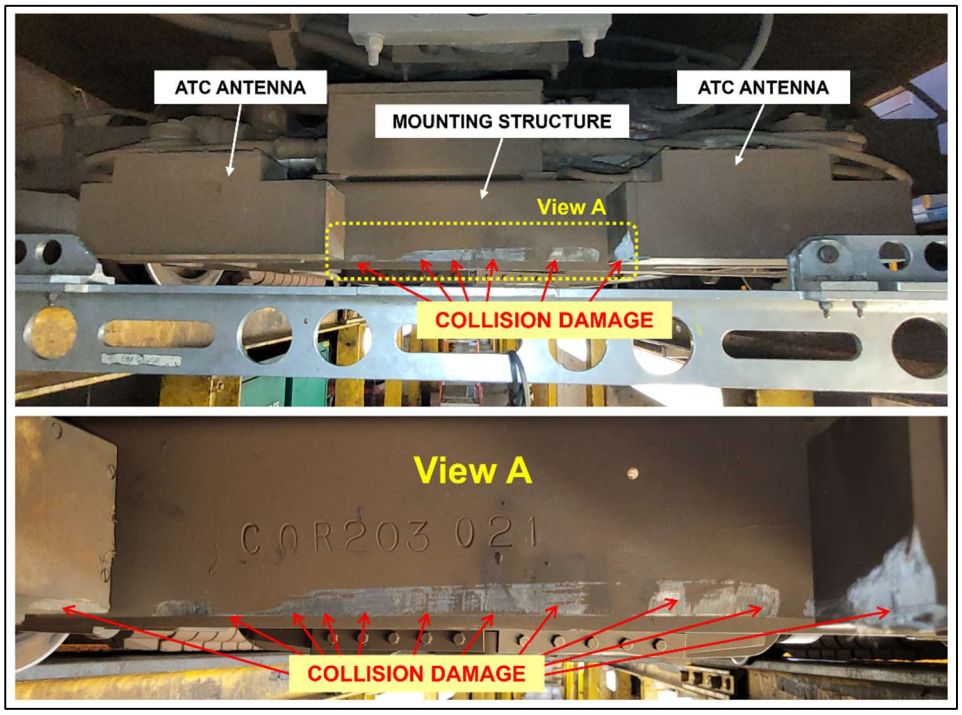


Figure 46 - ATC Antennas Damage on Truck S/N 048

The highest damage mark was observed approximately 70 mm above the top of the running rails, and was on the left side antenna, corresponding to the east side of the southbound track, based on the traveling direction at the time of the collision. The antennas are approximately 355 mm apart (14 inches), as shown in Figure 47. Since the marks were not wider than 14 inches, it is believed that the obstruction hitting the truck had a width of approximately 14 inches, which corresponds to the width of the reaction rail (13.75 inches, as measured on site).

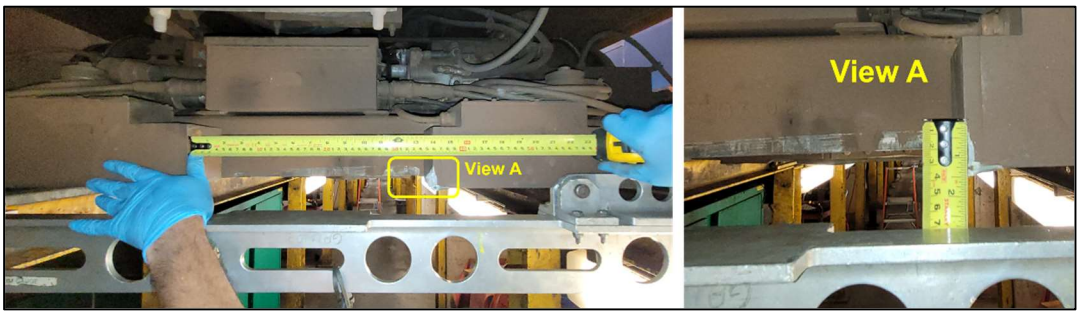


Figure 47 - ATC Antennas Damage Dimensions on Truck S/N 048

The aluminum structure where the ATC antennas are mounted, commonly known as ATC bridge, was also significantly damaged. It was found to be deformed inwards towards the LIM, as shown in Figure 48.

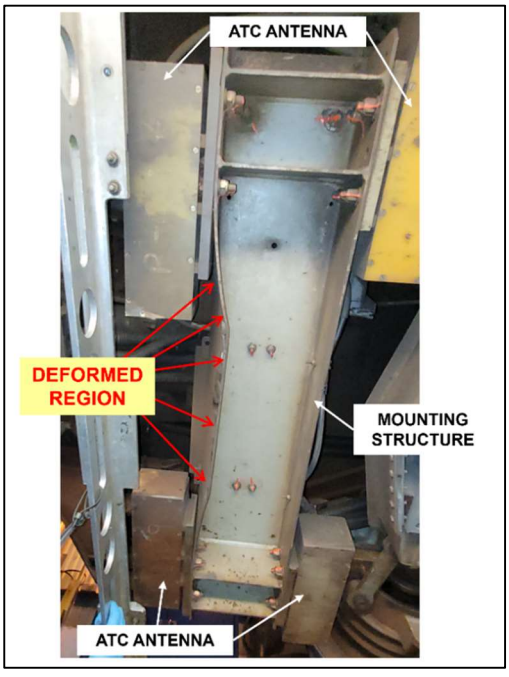


Figure 48 - ATC Antennas Mounting Structure Damage on Truck S/N 048

The LIM scraper blades brackets were also deformed inwards, as shown in Figure 49. Fresh scratch marks were also found on the skid at the bottom of the LIM.

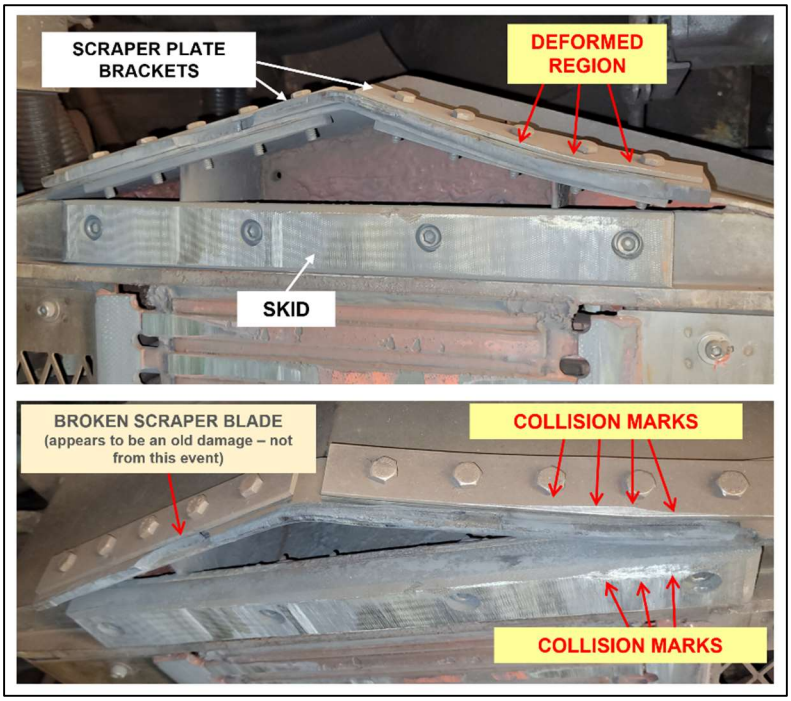
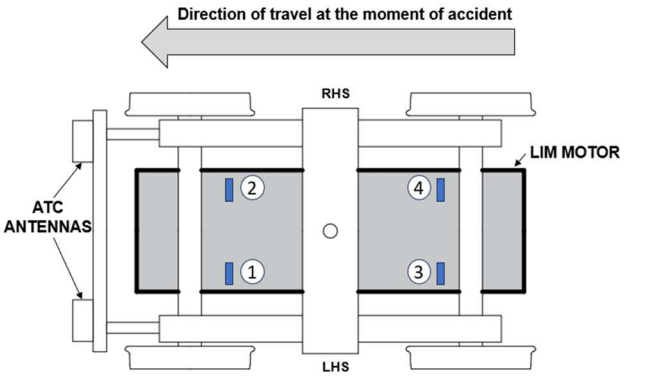


Figure 49 - Scraper Blades and Skid Damage on Truck S/N 048

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 50. One the measurements was found to be outside of the specified range (0.5 mm smaller than the lower specification limit). The measurement directly opposite to it was 13.5 mm. Given the considerable damage to the ATC antennas and its mounting bridge, as well as scraper blades brackets, and how high the guideway obstruction collided with the truck (approximately 70 mm), the 0.5 mm LIM height tolerance violation is not believed to have been a contributing factor to the accident.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	12
	2	13.25
	3	13.25
	4	13.25

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in **red** : smaller than minimum value required (12.5 mm).*
4) *Measurements in **green**: within tolerance range (12.5~13.5 mm).*
5) *Measurements in **yellow**: greater than maximum value required (13.5 mm).*

Figure 50 - LIM Height Measurement Results for Truck S/N 048

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 51.

Figure 51 - Vertical Connection Links on Truck S/N 048

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 52, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

Figure 52 - Scratch Marks on Bottom of the LIM

The back-to-back dimensions on both wheelsets were checked with the GO/NO-GO gauge illustrated in Figure 37 [10] and found to be compliant.

For completeness, wheel diameters were also measured and found to be above the minimum wheel diameter (> 440 mm). Results are shown in Figure 53.

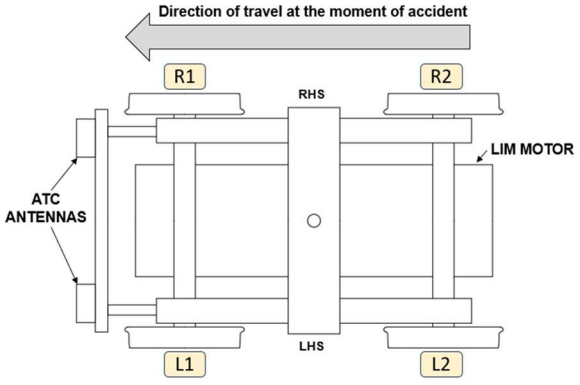
MEASURING DIAGRAM	LOCATION	WHEEL DIAMETER (mm)
	R1	455
	R2	455
	L1	456
	L2	455

Figure 53 - Wheel Diameter Measurement Results on Truck S/N 048

5.2.2 *Trailing Truck (Truck Serial Number 028)*

Location of truck S/N 028 in the consist during the time of the accident is shown in Figure 54.

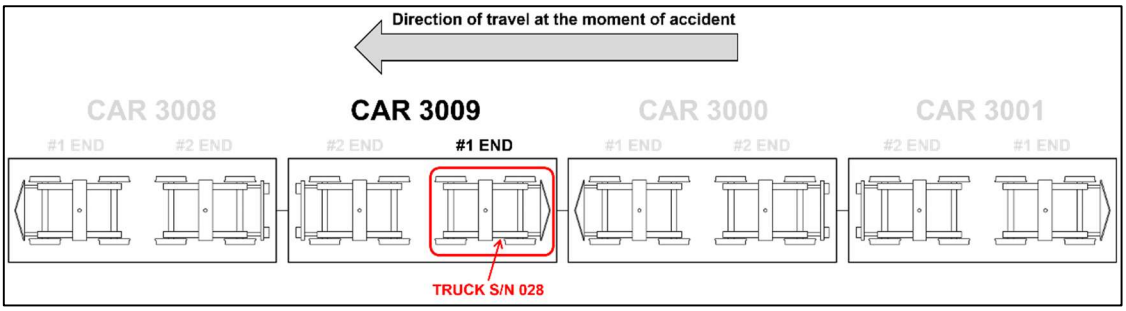
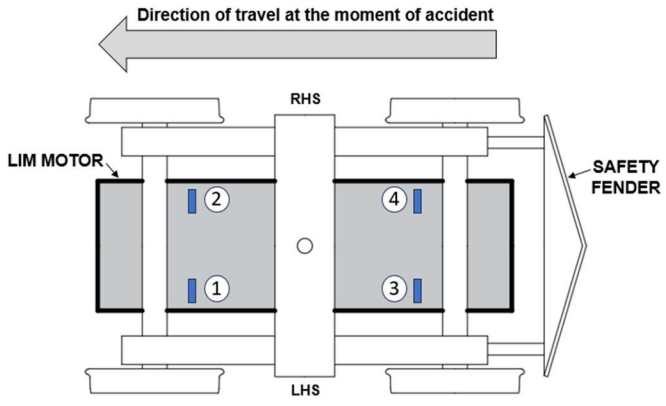


Figure 54 - Location of Truck S/N 028

The truck inspection occurred at McCowan Carhouse on July 26, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 55. One of the measurements was found to be outside of the specified range. However, it was greater than the maximum allowed, hence increasing the air gap with the reaction rail.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	13.5
	2	13.75
	3	13.5
	4	13.25

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in red: smaller than minimum value required (12.5 mm).*
4) *Measurements in green: within tolerance range (12.5~13.5 mm).*
5) *Measurements in yellow: greater than maximum value required (13.5 mm).*

Figure 55 - LIM Height Measurement Results for Truck S/N 028

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 56.

Figure 56 - Vertical Connection Links on Truck S/N 028

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 57, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

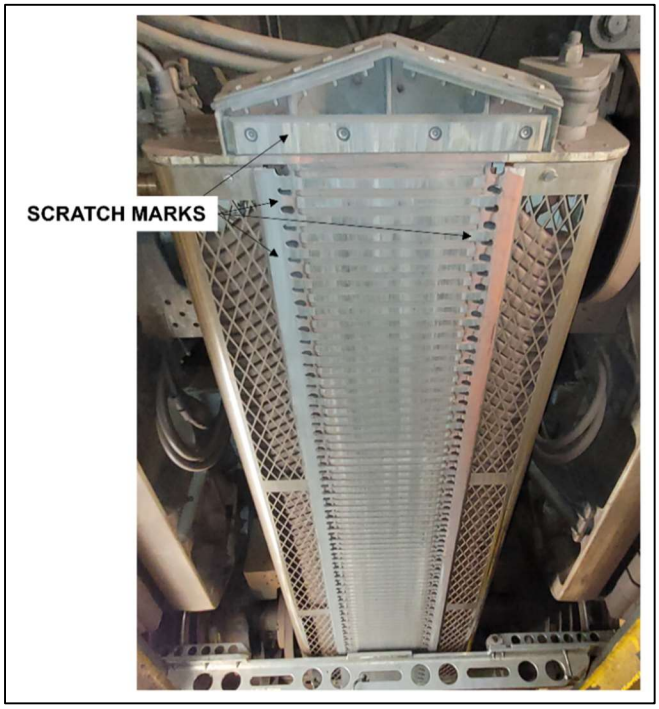


Figure 57 - Scratch Marks on Bottom of the LIM

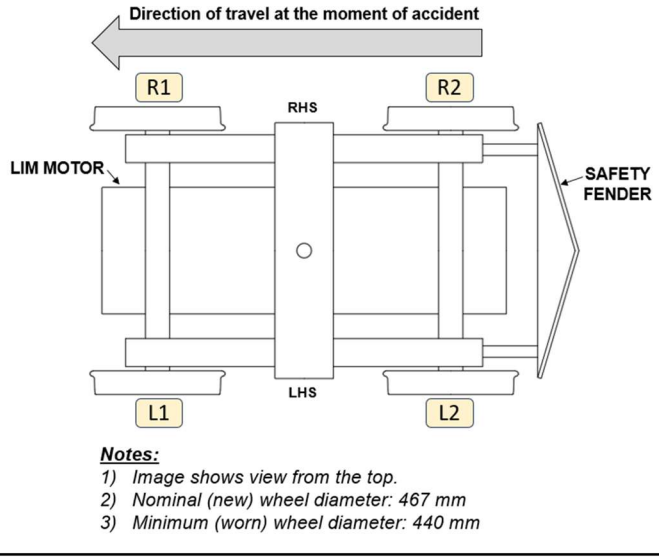
No major damages were found on the safety fender, as shown in Figure 58.

Figure 58 - Safety Fender on Truck S/N 028

A lack of contact damage on this truck compared to the leading truck (ATC antenna damage) suggests the obstruction somehow cleared momentarily as the vehicle passed chainage 135+10.

The back-to-back dimensions on both wheelsets were checked with the GO/NO-GO gauge illustrated in Figure 37 [10] and found to be compliant.

For completeness, wheel diameters were also measured and found to be above the minimum wheel diameter (> 440 mm). Results are shown in Figure 59.

MEASURING DIAGRAM	LOCATION	WHEEL DIAMETER (mm)
	R1	450
	R2	448
	L1	452
	L2	452

Notes:
1) *Image shows view from the top.*
2) *Nominal (new) wheel diameter: 467 mm*
3) *Minimum (worn) wheel diameter: 440 mm*

Figure 59 - Wheel Diameter Measurement Results on Truck S/N 028

5.3 Car 3000

5.3.1 Leading Truck (Truck Serial Number 005)

Location of truck S/N 005 in the consist during the time of the accident is shown in Figure 60.

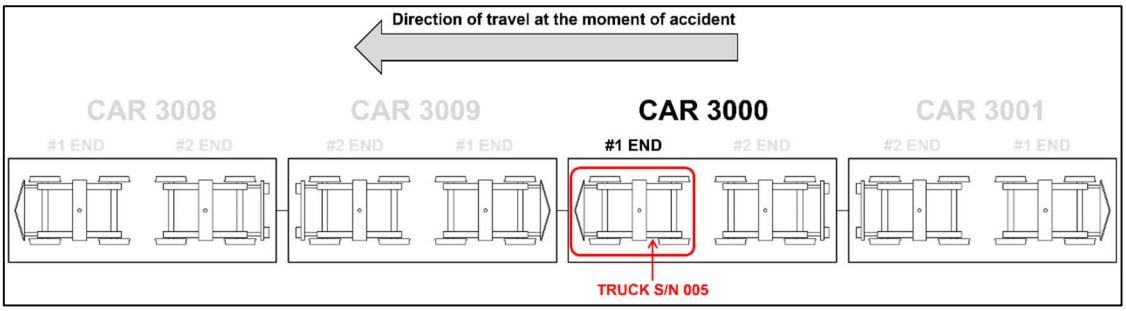
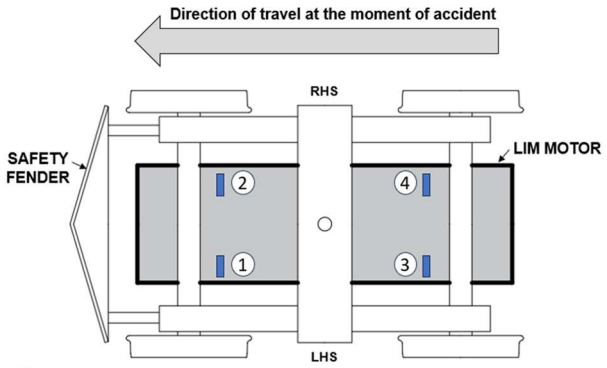


Figure 60 - Location of Truck S/N 005

The truck inspection occurred at McCowan Carhouse on July 26, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 61. All measurement results were found to be outside of the specified range. However, they were all greater than the maximum allowed, hence increasing the air gap with the reaction rail. Measurement results are shown in Figure 61.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	14.25
	2	14.25
	3	14.5
	4	14.25

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in red: smaller than minimum value required (12.5 mm).*
4) *Measurements in green: within tolerance range (12.5~13.5 mm).*
5) *Measurements in yellow: greater than maximum value required (13.5 mm).*

Figure 61 - LIM Height Measurement Results for Truck S/N 005

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 62.

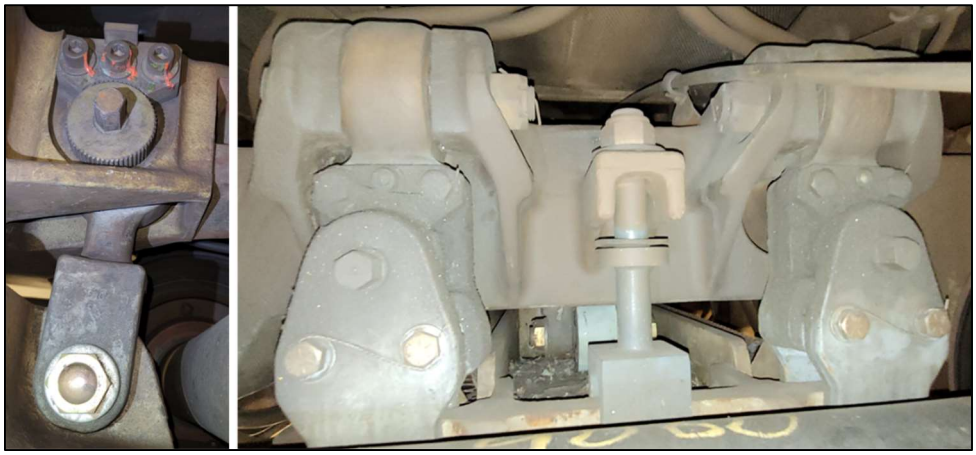


Figure 62 - Vertical Connection Links on Truck S/N 005

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 63, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

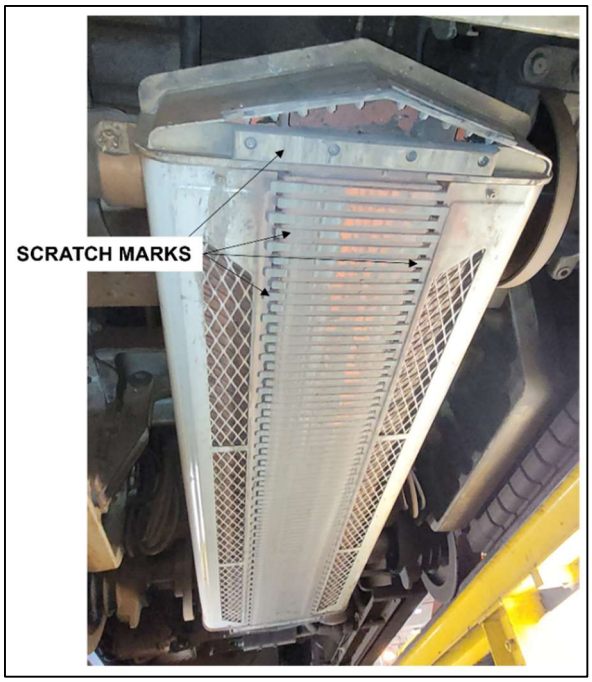


Figure 63 - Scratch Marks on Bottom of the LIM

No major damages were found on the safety fender, as shown in Figure 64.

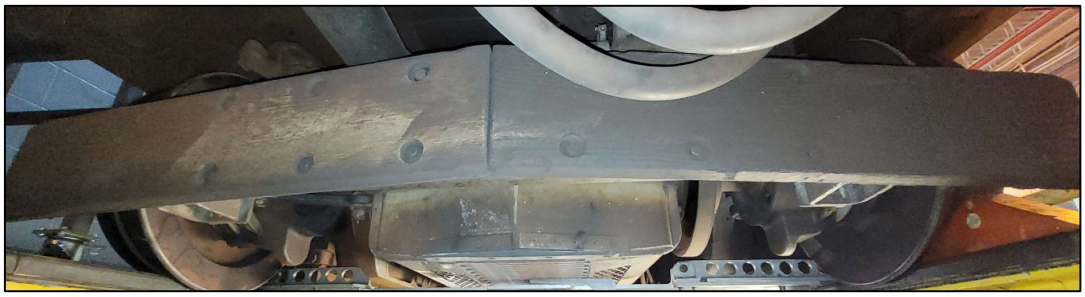
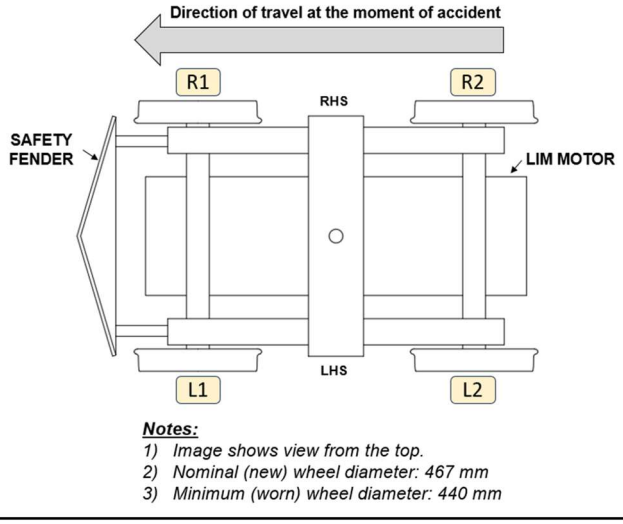


Figure 64 - Safety Fender on Truck S/N 005

A lack of contact damage on this truck compared to the ATC antenna damage on the leading truck of the previous car (3009) suggests the obstruction somehow cleared momentarily as car 3000 passed chainage 135+10.

The back-to-back dimensions on both wheelsets were checked with the GO/NO-GO gauge illustrated in Figure 37 [10] and found to be compliant.

For completeness, wheel diameters were also measured and found to be above the minimum wheel diameter (> 440 mm). Results are shown in Figure 65.

MEASURING DIAGRAM	LOCATION	WHEEL DIAMETER (mm)
	R1	462
	R2	463
	L1	464
	L2	464

Notes:
1) *Image shows view from the top.*
2) *Nominal (new) wheel diameter: 467 mm*
3) *Minimum (worn) wheel diameter: 440 mm*

Figure 65 - Wheel Diameter Measurement Results on Truck S/N 005

5.3.2 *Trailing Truck (Truck Serial Number 019)*

Location of truck S/N 019 in the consist during the time of the accident is shown in Figure 66.

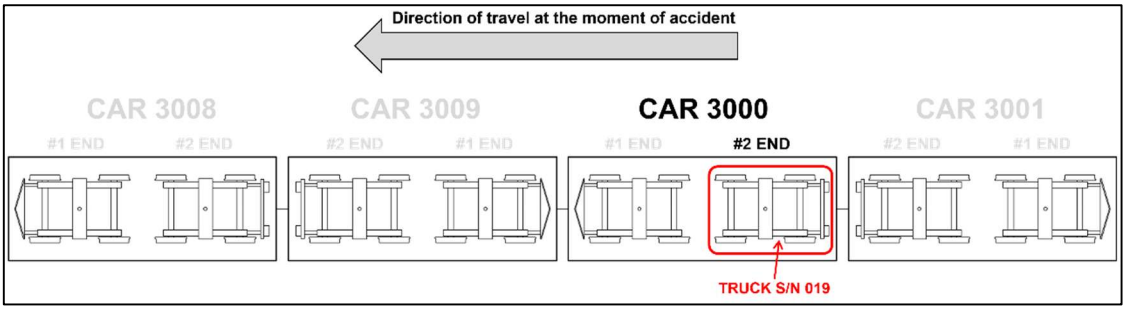
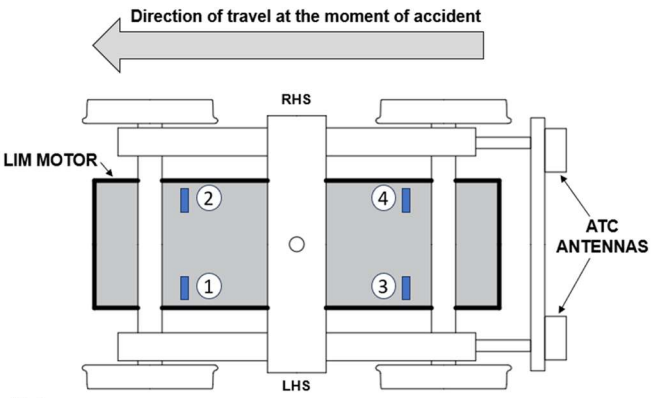


Figure 66 - Location of Truck S/N 019

The truck inspection occurred at McCowan Carhouse on July 26, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 67. Some of the measurement results were found to be outside of the specified range. However, all measurements outside of the tolerance were greater than the maximum allowed, hence increasing the air gap with the reaction rail.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	13.75
	2	14
	3	13.25
	4	13.25

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in red : smaller than minimum value required (12.5 mm).*
4) *Measurements in green: within tolerance range (12.5~13.5 mm).*
5) *Measurements in yellow: greater than maximum value required (13.5 mm).*

Figure 67 - LIM Height Measurement Results for Truck S/N 019

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 68.

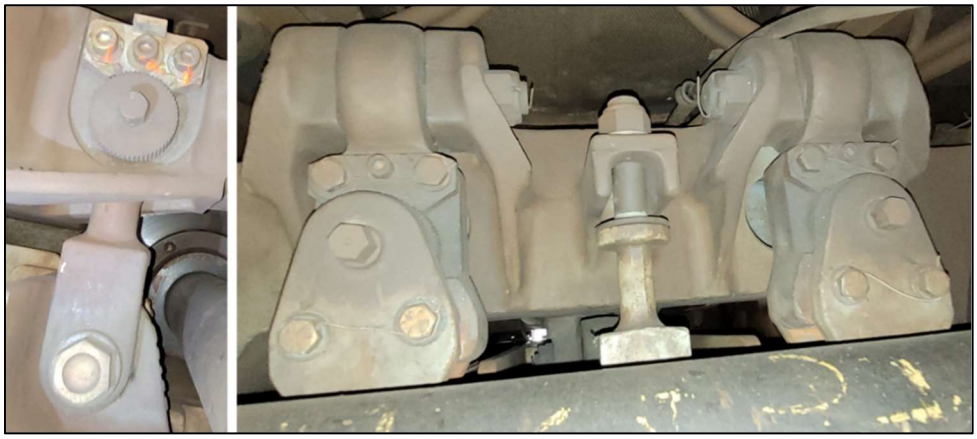


Figure 68 - Vertical Connection Links on Truck S/N 019

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 69, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

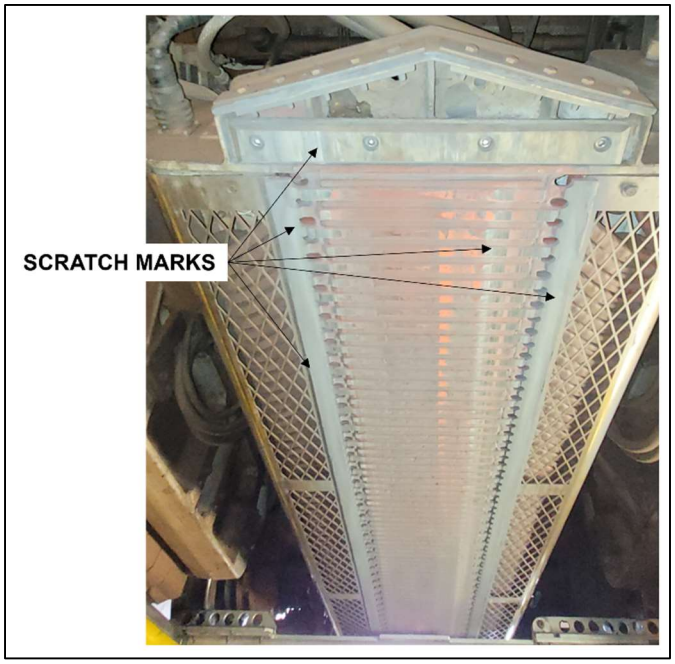


Figure 69 - Scratch Marks on Bottom of the LIM

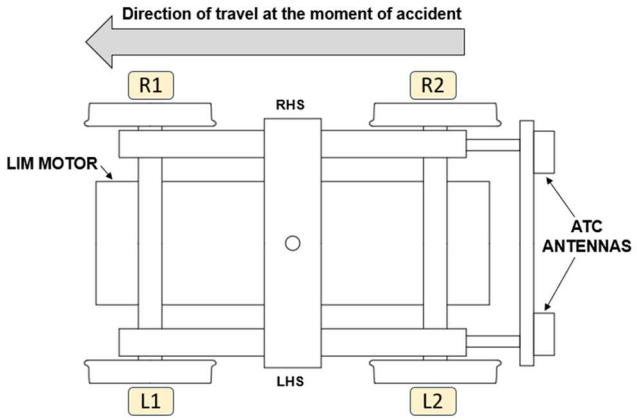
No major damages were found on the ATC antennas, as shown in Figure 70.

Figure 70 - ATC Antennas on Truck S/N 019

A lack of contact damage on this truck compared to the ATC antenna damage on the leading truck of the previous car (3009) suggests the obstruction somehow cleared momentarily as car 3000 passed chainage 135+10.

The back-to-back dimensions on both wheelsets were checked with the GO/NO-GO gauge illustrated in Figure 37 [10] and found to be compliant.

For completeness, wheel diameters were also measured and found to be above the minimum wheel diameter (> 440 mm). Results are shown in Figure 71.

MEASURING DIAGRAM	LOCATION	WHEEL DIAMETER (mm)
	R1	463
	R2	461
	L1	463
	L2	465

Notes:
1) *Image shows view from the top.*
2) *Nominal (new) wheel diameter: 467 mm*
3) *Minimum (worn) wheel diameter: 440 mm*

Figure 71 - Wheel Diameter Measurement Results on Truck S/N 019

5.4 Car 3001

5.4.1 Leading Truck (Truck Serial Number 027)

Location of truck S/N 027 in the consist during the time of the accident is shown in Figure 72. As a result of the accident, Car 3001 was displaced off the tracks.

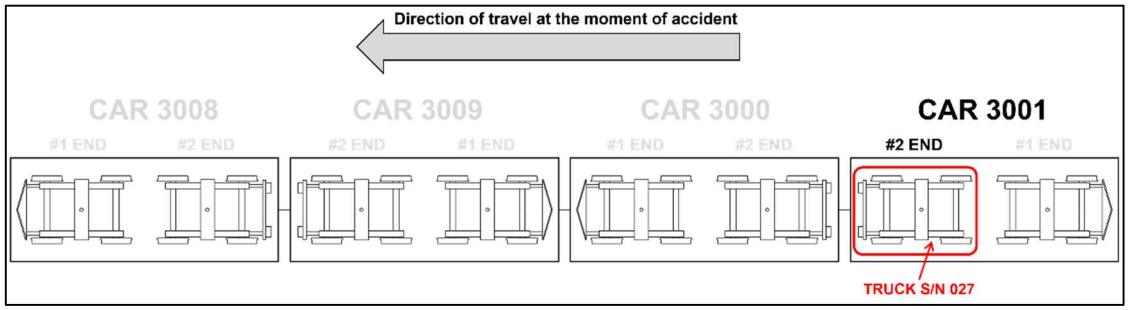


Figure 72 - Location of Truck S/N 027

After the accident, Car 3001 was taken to McCowan Carhouse with its leading truck (S/N 027) still attached (Figure 73). The trailing truck (S/N 020), which was detached from the carbody, was taken to Greenwood Carhouse. A preliminary inspection confirmed the collision damage to the ATC antennas, similar to Truck S/N 048 (Car 3009), as shown in Figure 74.

Figure 73 - Car 3001 at McCowan Carhouse

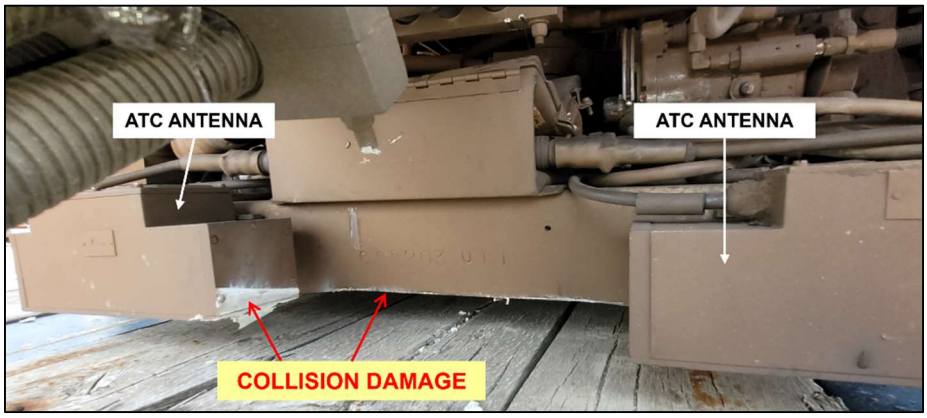


Figure 74 - Preliminary Damage Assessment on Truck S/N 027

On the days following the accident, TTC staff at McCowan Carhouse de-trucked Car 3001 for a thorough inspection of its leading truck (S/N 027). The inspection occurred at McCowan Carhouse on August 3, 2023. The truck was placed over the inspection pit to allow unobstructed access.

Significant damage was confirmed on the ATC antennas and its mounting structure, as shown in Figure 75, believed to be the result of a collision with a guideway obstruction.

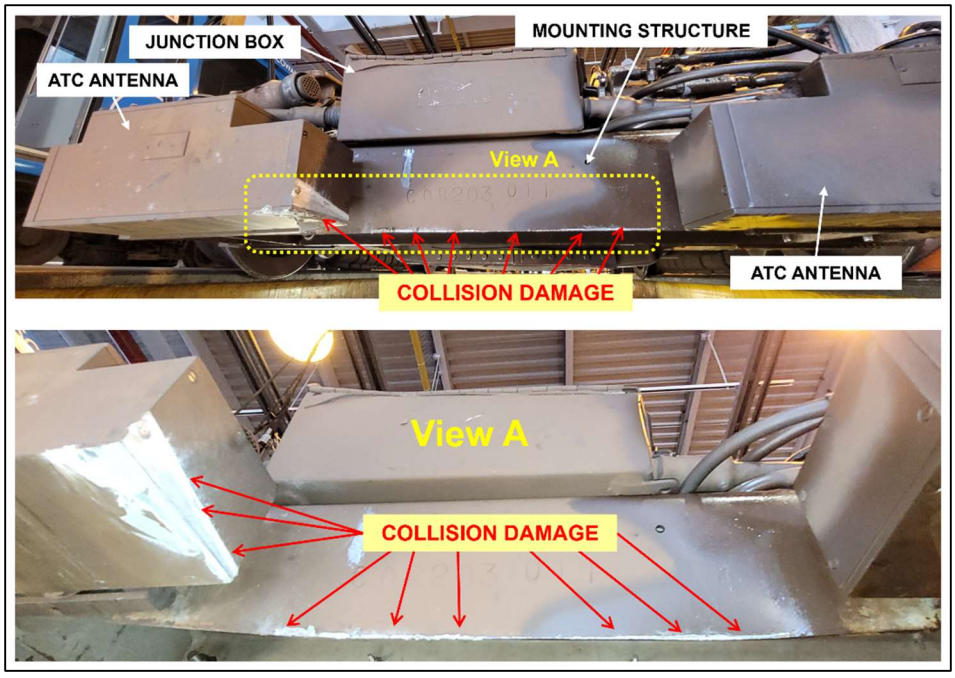


Figure 75 - ATC Antennas Damage on Truck S/N 027

The highest damage mark was observed approximately 70 mm above the top of the running rails. The damage was very similar to the one found on Truck S/N 048 (Car 3009). The more pronounced difference between the damage on these two trucks is that on Truck S/N 027 (Car 3001) the right-side (facing direction of travel) antenna experienced more severe damage, whereas the left-side (facing direction of travel) antenna was more significantly damaged on Truck S/N 048 (Car 3009). See Figure 76.

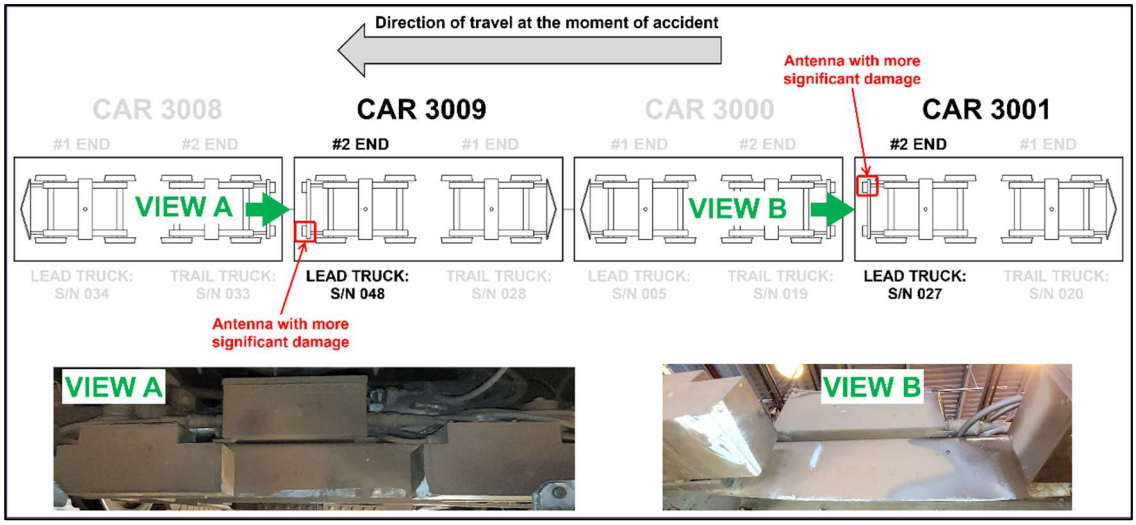


Figure 76 - ATC Antennas Damage: Truck S/N 048 vs Truck S/N 027

The aluminum structure where the ATC antennas are mounted (ATC bridge) was also significantly damaged. It was found to be deformed inwards towards the LIM, as shown in Figure 77. Once again, the damage was very similar to the one observed on Truck S/N 048 (see Figure 78). This similarity suggests both trucks have been struck by the same object violating the car clearance envelope.

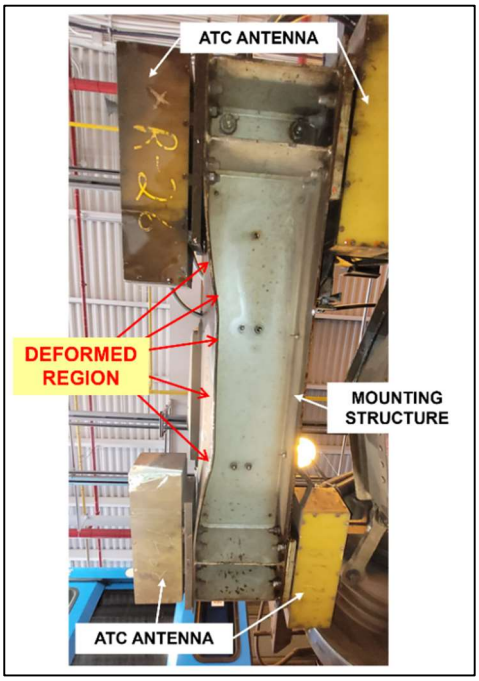


Figure 77 - ATC Antennas Mounting Structure Damage on Truck S/N 027

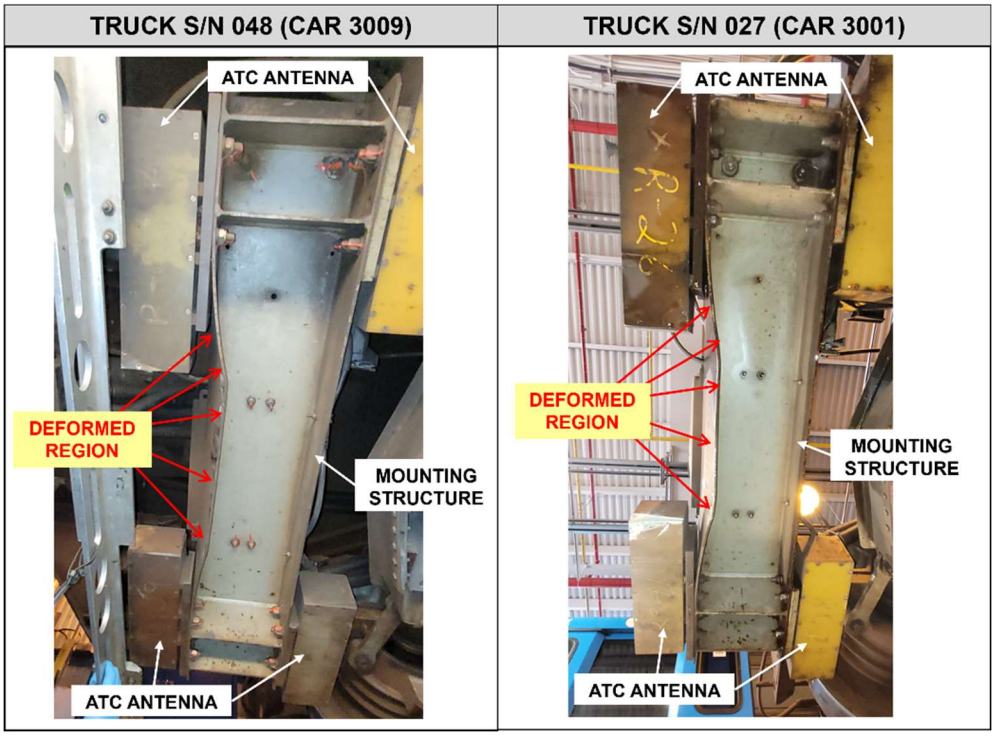


Figure 78 - ATC Antenna Bridge Damage: Truck S/N 048 vs Truck S/N 027

The junction box just above the ATC antennas was also found to be significantly deformed, suggesting it was crushed from the top (Figure 79). The shape and location of the deformation suggest an impact with the vehicle's coupler mounting bracket when the train struck the guideway obstruction and pitched forward.

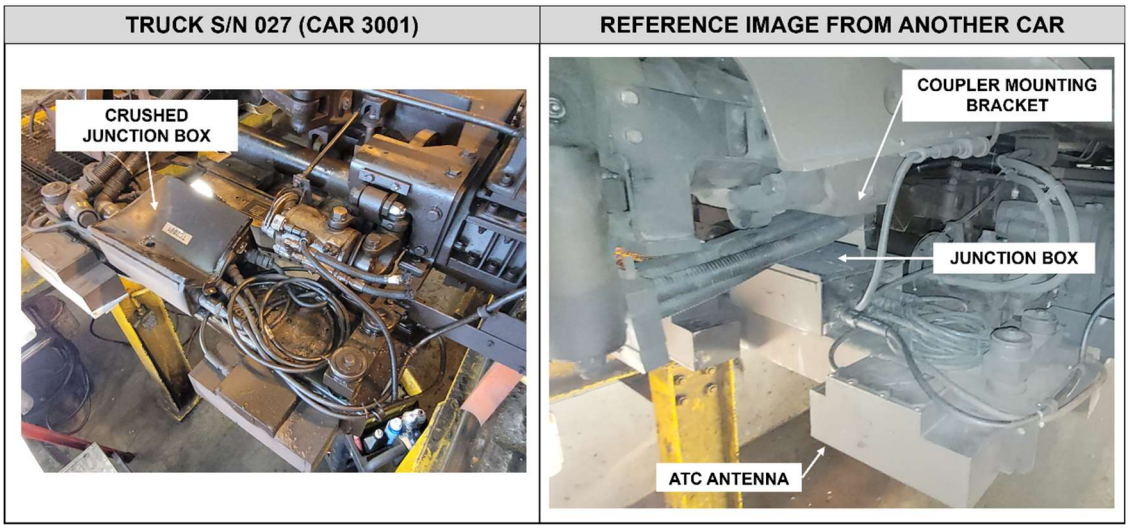


Figure 79 - Crushed ATC Junction Box on Truck S/N 027

Fractures were found on the LIM scraper blades, along with fresh scratch marks on the skid, as shown in Figure 80.

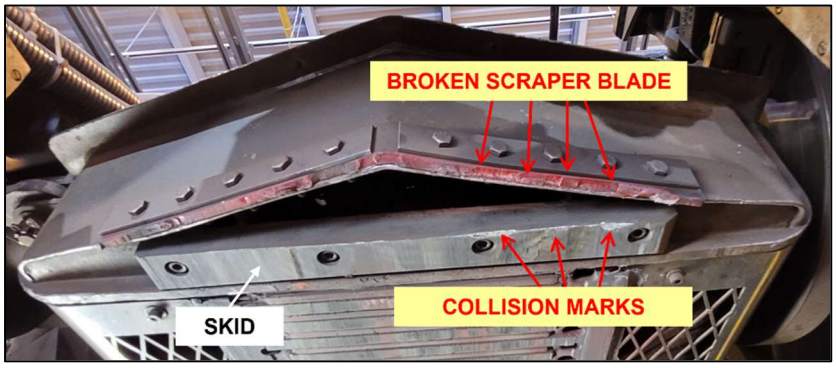


Figure 80 - Scraper Blades and Skid Damage on Truck S/N 027

In addition to the usual scratch marks commonly observed at the bottom of the LIM, deeper marks were also found, suggesting a more substantial scraping of the LIM bottom occurred (Figure 81).

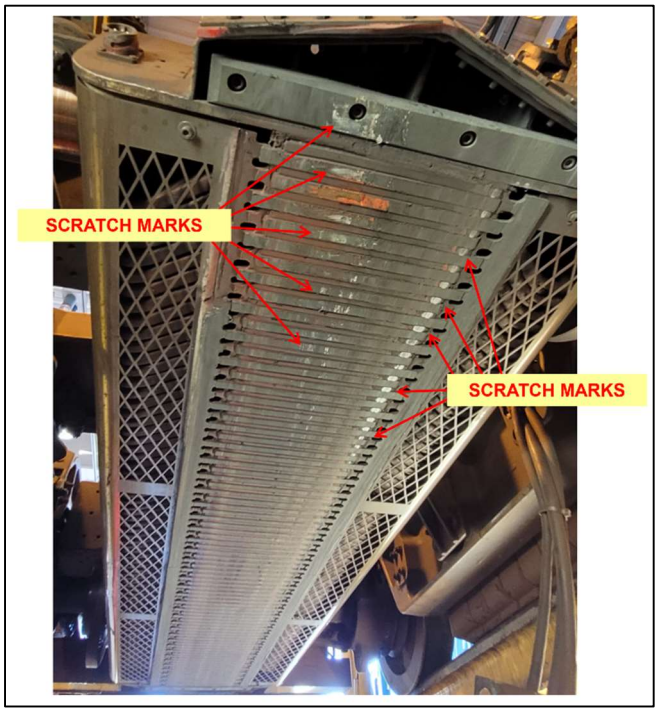
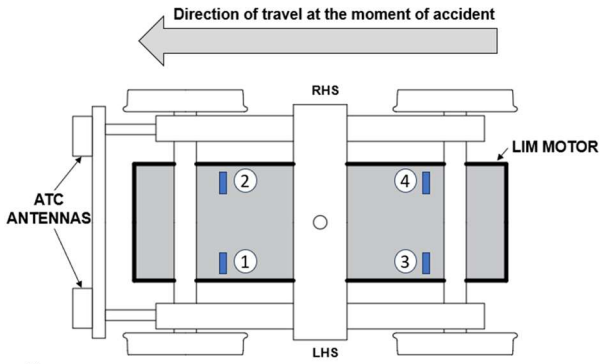


Figure 81 - LIM Bottom Damage on Truck S/N 027

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 82. One of the measurements was found to be outside of the specified range (0.5 mm smaller than the lower specification limit). The measurement directly opposite to it was 12.5 mm. Given the considerable damage to the ATC antennas and its mounting bridge and how high the guideway obstruction collided with the truck (approximately 70 mm), the 0.5 mm LIM height tolerance violation is not believed to have been a contributing factor to the accident.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	12
	2	12.5
	3	13
	4	12.5

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in **red**: smaller than minimum value required (12.5 mm).*
4) *Measurements in **green**: within tolerance range (12.5~13.5 mm).*
5) *Measurements in **yellow**: greater than maximum value required (13.5 mm).*

Figure 82 - LIM Height Measurement Results for Truck S/N 027

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 83.

Figure 83 - Vertical Connection Links on Truck S/N 027

The back-to-back dimensions on both wheelsets were checked with the GO/NO-GO gauge illustrated in Figure 37 [10] and found to be compliant.

For completeness, wheel diameters were also measured and found to be above the minimum wheel diameter (> 440 mm). Results are shown in Figure 84.

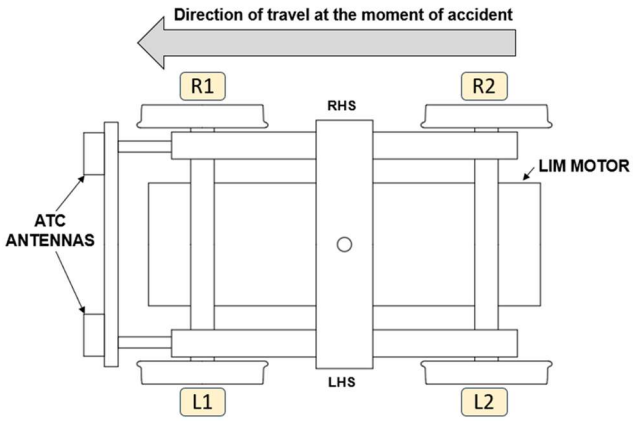
MEASURING DIAGRAM	LOCATION	WHEEL DIAMETER (mm)
 *Notes:* *1) Image shows view from the top.* *2) Nominal (new) wheel diameter: 467 mm* *3) Minimum (worn) wheel diameter: 440 mm*	R1	460
	R2	461
	L1	460
	L2	461

Figure 84 - Wheel Diameter Measurement Results on Truck S/N 027

5.4.2 Trailing Truck (Truck Serial Number 020)

Location of truck S/N 020 in the consist during the time of the accident is shown in Figure 85. As a result of the accident, Car 3001 was displaced off the tracks and its trailing truck (S/N 020) was completely detached from the carbody.

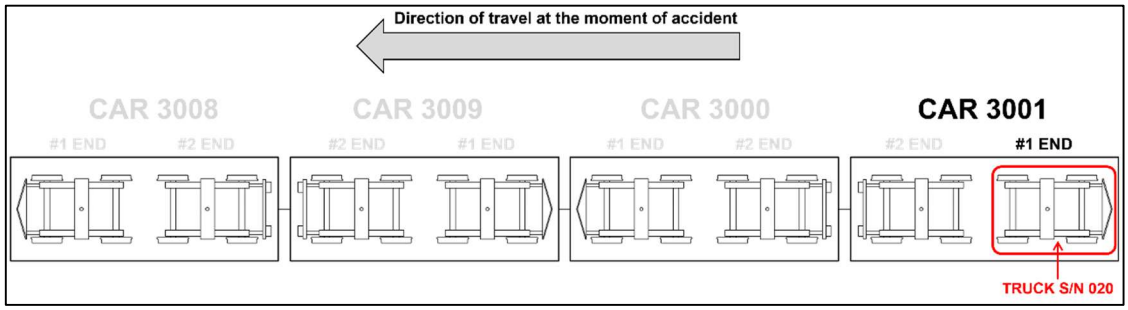


Figure 85 - Location of Truck S/N 020

The truck inspection occurred at Greenwood Carhouse on July 27, 2023. The truck was raised using inspection lifts to allow unobstructed access.

Extensive crushing damage was found on the front face of the LIM, as shown in Figure 86, confirming a front collision with a guideway obstruction occurred.

Figure 86 - LIM Damage on Truck S/N 020

As a result of the collision, the carbody bolster beam (where the traction rods are attached) fractured, completely separating the truck from the carbody (see Figure 87 and Figure 88). The traction rods did not break, although they were permanently deformed (buckled), and remained attached to the truck along with the carbody bolster beam (see Figure 89). All other mechanical truck-to-carbody connections (e.g., lifting chains, coupler rod, shock absorbers, etc.) were ruptured.

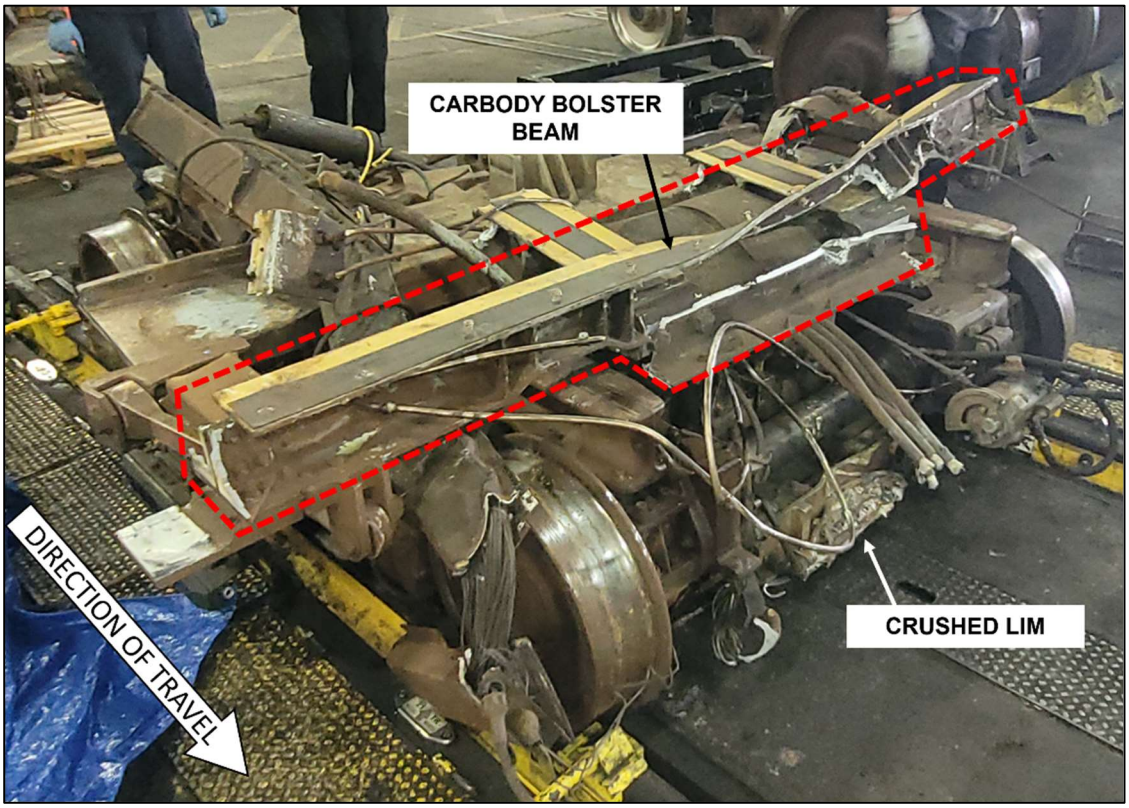


Figure 87 - Truck S/N 020 with Carbody Bolster Beam

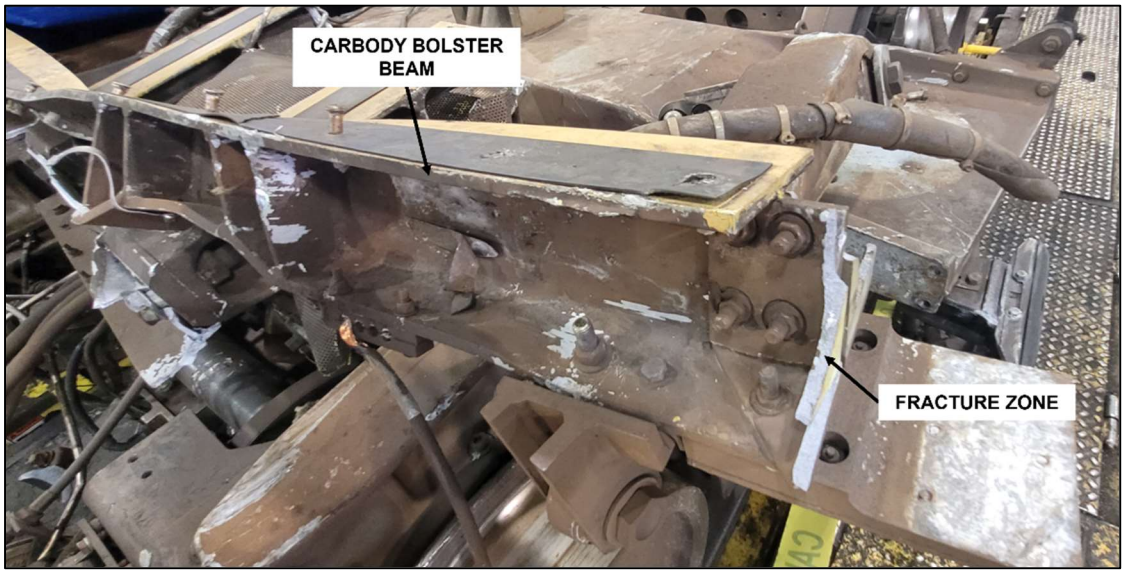


Figure 88 - Fractured Carbody Bolster Beam

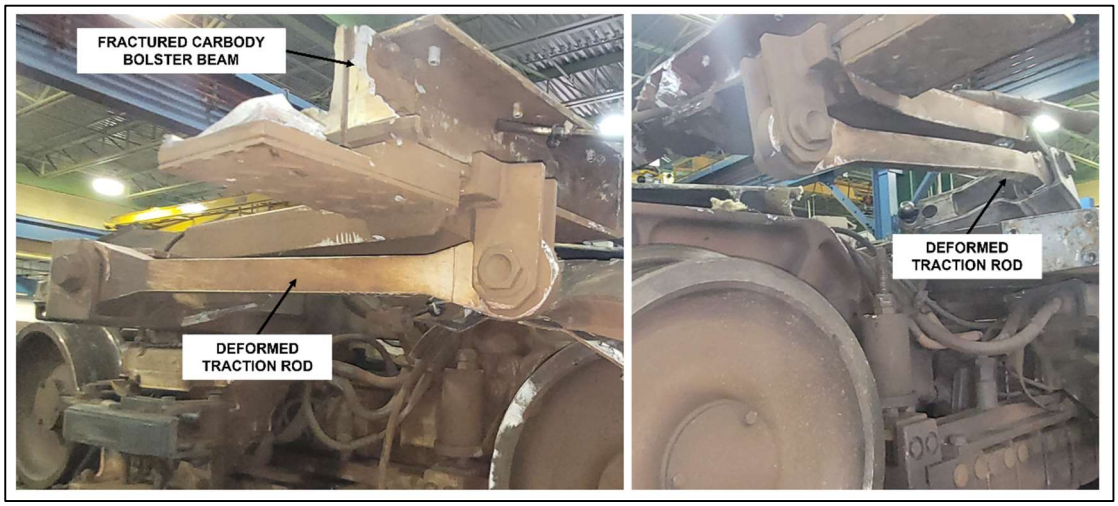


Figure 89 - Fractured Carbody Bolster Beam and Deformed Traction Rod

One of the LIM lateral link attachments to the journal box was fractured as a result of the collision, as shown in Figure 90. The LIM thrust link connections were also damaged (Figure 91).

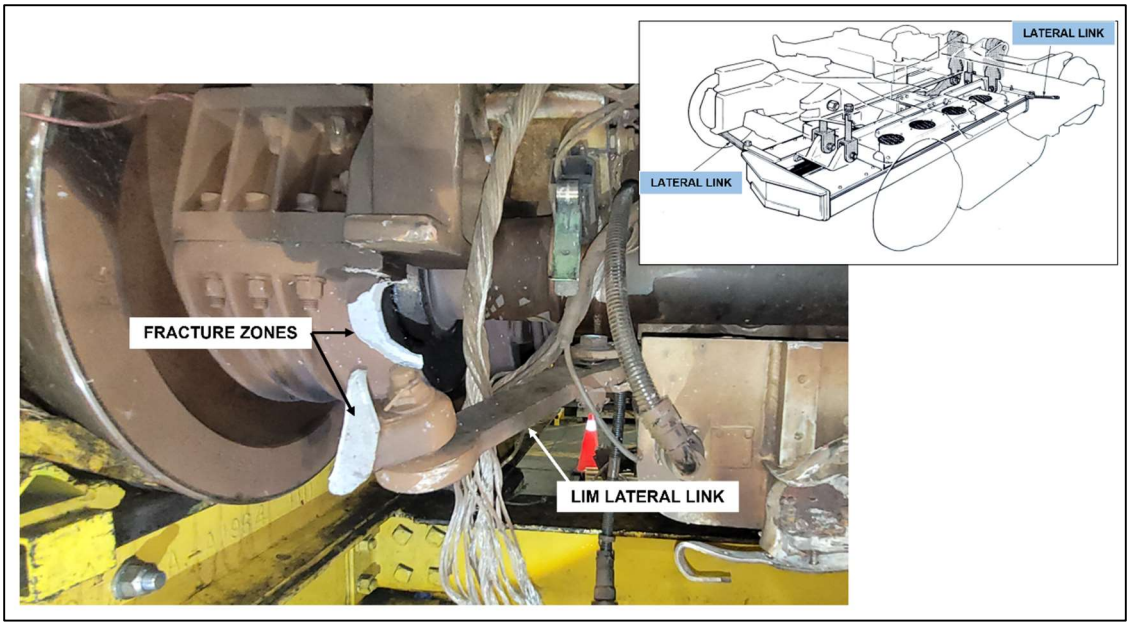


Figure 90 - Fractured Journal Box (LIM Lateral Link Attachment)

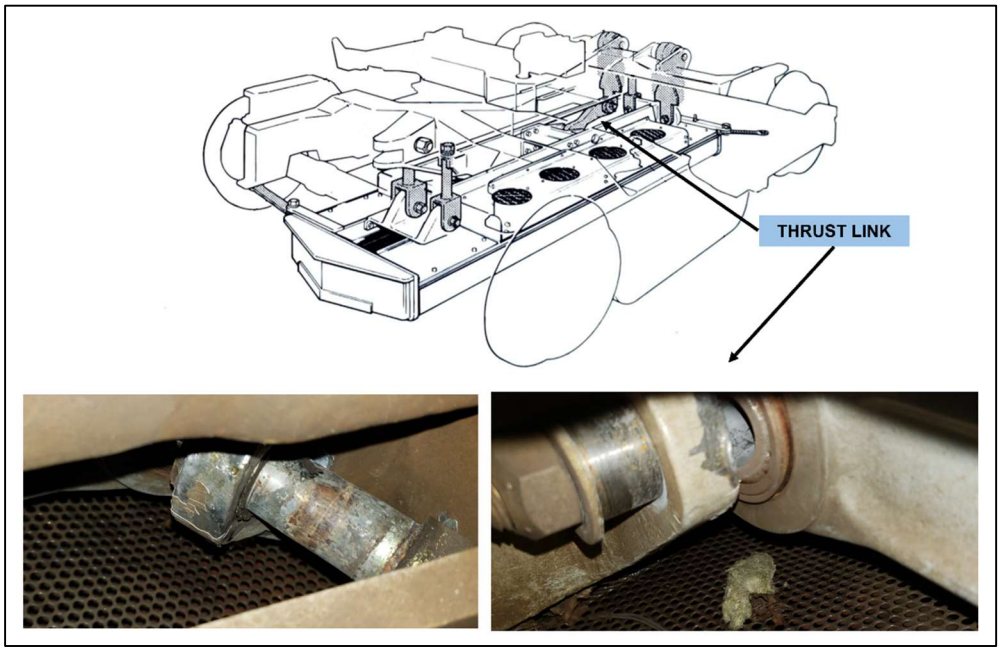


Figure 91 - Damaged LIM Thrust Link Connections

Substantial damage was also observed on the bottom of the LIM, although it is believed to be secondary (subsequent to the front collision). Some of the damage found is associated with the LIM landing on the rails after being lifted during the collision (Figure 92), while other areas were damaged when improper rigging was used to lift the truck during the vehicle's recovery (Figure 93).

Figure 92 - LIM bottom damage

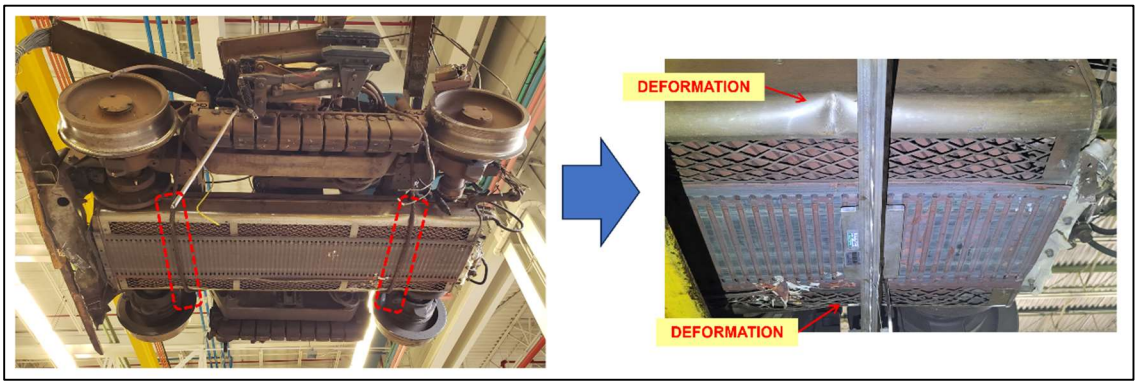


Figure 93 - LIM Bottom Damage Caused by Improper Lifting

The trailing axle was found to be significantly bent, as shown in Figure 94.

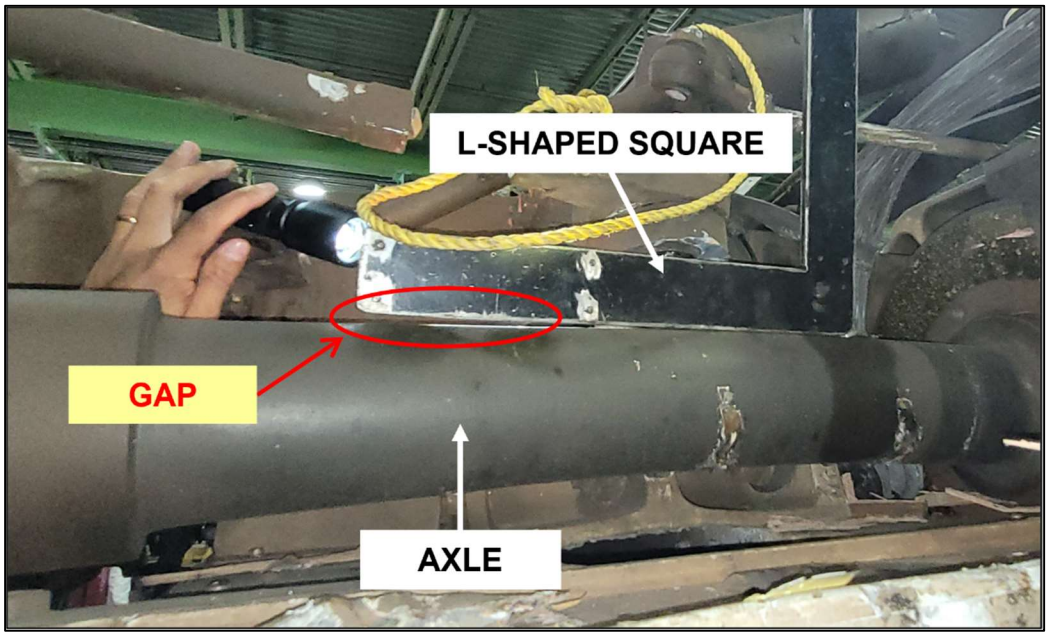


Figure 94 - Bent Trailing Axle

The safety fender on Truck S/N 020 was also significantly damaged, although the damage is believed to be secondary (after the front collision). The surveillance footage from Ellesmere Station shows the trailing end of the car being lifted and subsequently landing with high impact on its trailing truck (S/N 020). It is believed that the safety fender collided with the coupler mounting structure during the landing, causing the damage.

Figure 95 - Damaged Safety Fender

LIM height measurements with respect to the top of the running rails could not be reasonably taken due to the extensive damage. Nevertheless, Hatch considers the LIM height on this truck to be not relevant, given the clear evidence indicating a front collision between the LIM and a high guideway obstruction as shown in Figure 86 (LIM never passed over the obstruction). In addition, the height of the damage found at the front of the LIM was substantially higher than the LIM air gap.

Despite the large collision impact load, the vertical links attaching the LIM to the yoke assemblies and their connections were undamaged and found to be properly secured, as shown in Figure 96. Since these connections are designed not to be subjected to horizontal loads (which are resisted by the lateral and thrust links), they remained mostly intact.

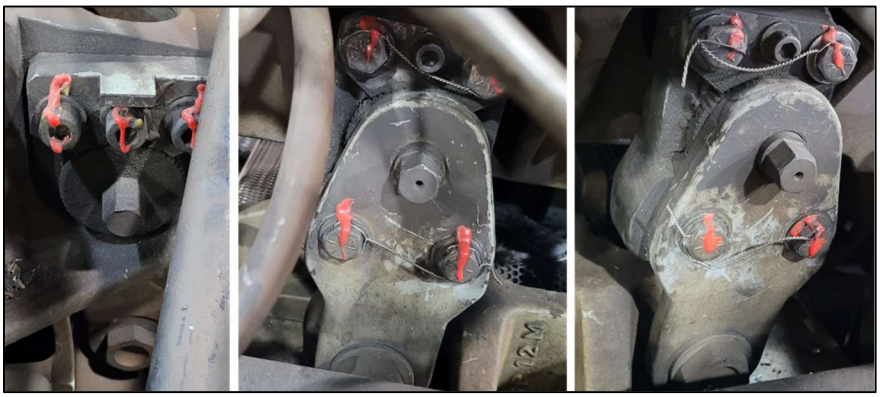


Figure 96 - Vertical Connection Links on Truck S/N 020

Due to the extensive damage (mainly the trailing axle bending), the wheelsets back-to-back dimensions could not be reasonably checked. Again, due to the evidence indicating a front collision with the LIM occurred, not a conventional derailment, this verification also is deemed not relevant.

For completeness, wheel diameters were also measured and found to be above the minimum wheel diameter (> 440 mm). Results are shown in Figure 97.

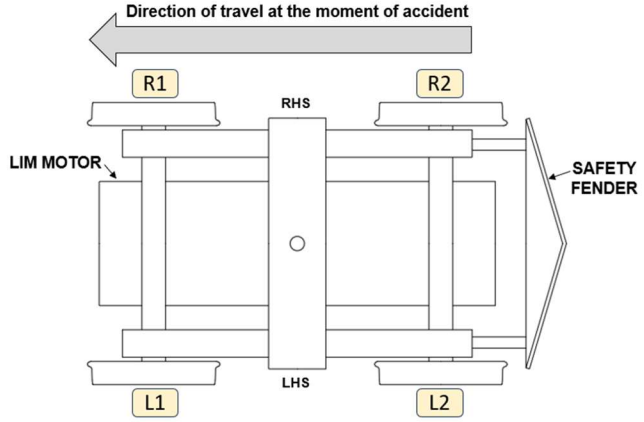
MEASURING DIAGRAM	LOCATION	WHEEL DIAMETER (mm)
	R1	460
	R2	461
	L1	460
	L2	461

Figure 97 - Wheel Diameter Measurement Results on Truck S/N 020

6. Inspection of “61 Run” Train (Ahead of the Accident Train)

To assist determining whether any abnormalities existed prior to the accident with “63 Run” train, the last train to pass the section of track where the event occurred without any incidents was also inspected by Hatch (“61 Run” train). Given the clear evidence indicating collisions between the trucks and a guideway obstruction, the inspection focused primarily on the LIM and its connections.

Figure 98 shows the location of each inspected truck on “61 Run” Train.

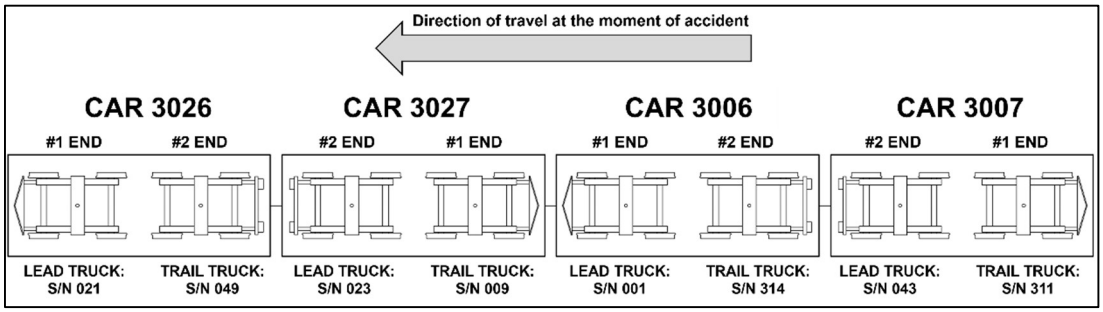


Figure 98 - Location of Trucks on "61 Run" Train

6.1 Car 3026

6.1.1 Leading Truck (Truck Serial Number 021)

Location of truck S/N 021 in the consist during the time of the accident is shown in Figure 99.

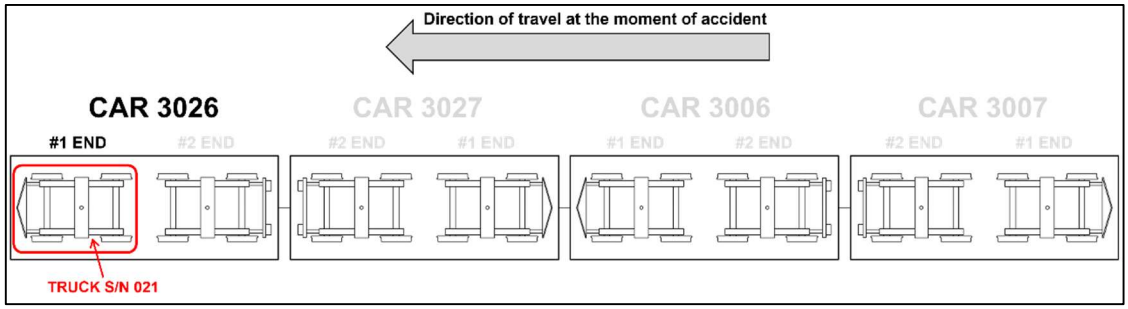
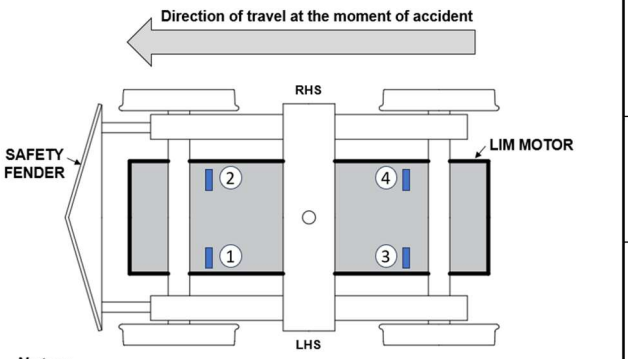


Figure 99 - Location of Truck S/N 021

The truck inspection occurred at McCowan Carhouse on July 31, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 100. One of the measurements was found to be outside of the specified range (0.5 mm smaller than the lower specification limit). The measurement directly opposite to it was 13.5 mm. Given how high the guideway obstruction collided with some of the trucks of the investigated cars (approximately 70 mm), the 0.5 mm LIM height tolerance violation is not believed to have been a contributing factor to the accident.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	13.25
	2	13.25
	3	13.5
	4	12

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in red : smaller than minimum value required (12.5 mm).*
4) *Measurements in green: within tolerance range (12.5~13.5 mm).*
5) *Measurements in yellow: greater than maximum value required (13.5 mm).*

Figure 100 - LIM Height Measurement Results for Truck S/N 021

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 101.

Figure 101 - Vertical Connection Links on Truck S/N 021

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 102, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

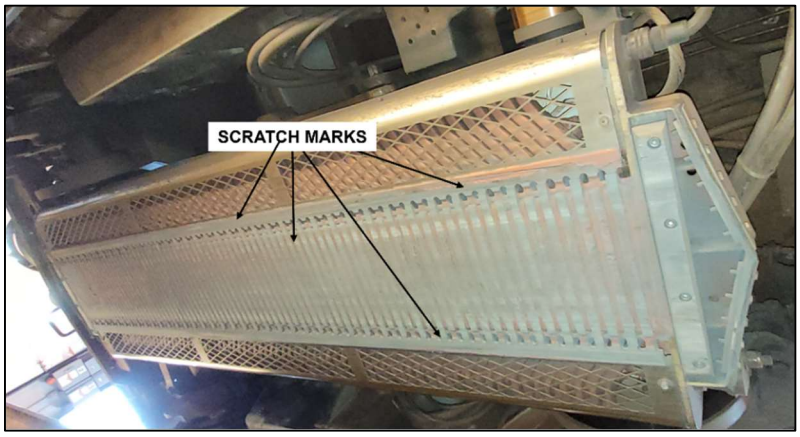


Figure 102 - Scratch Marks on Bottom of the LIM

No major damages were found on the safety fender, as shown in Figure 103.

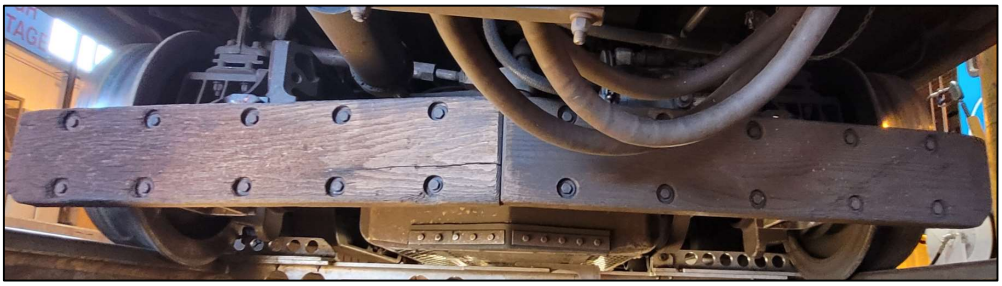


Figure 103 - Safety Fender on Truck S/N 021

Minor wearing/damage was found on the scraper blades, as shown in Figure 104. However, this is not believed to have been caused by the recent collision.

Figure 104 - Scraper Blades

6.1.2 *Trailing Truck (Truck Serial Number 049)*

Location of truck S/N 049 in the consist during the time of the accident is shown in Figure 105.

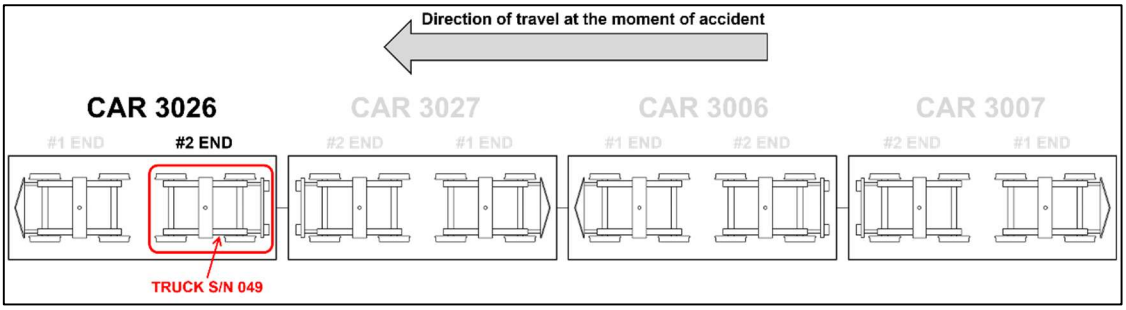
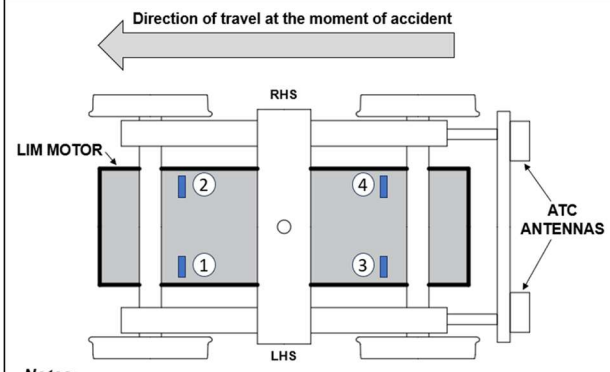


Figure 105 - Location of Truck S/N 049

The truck inspection occurred at McCowan Carhouse on July 31, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 106. One of the measurements was found to be outside of the specified range (0.25 mm smaller than the lower specification limit). The measurement directly opposite to it was 13.5 mm. Given how high the guideway obstruction collided with some of the trucks of the investigated cars (approximately 70 mm), the 0.25 mm LIM height tolerance violation is not believed to have been a contributing factor to the accident.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	13
	2	13.25
	3	13.5
	4	12.25

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in red : smaller than minimum value required (12.5 mm).*
4) *Measurements in green: within tolerance range (12.5~13.5 mm).*
5) *Measurements in yellow: greater than maximum value required (13.5 mm).*

Figure 106 - LIM Height Measurement Results for Truck S/N 049

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 107.

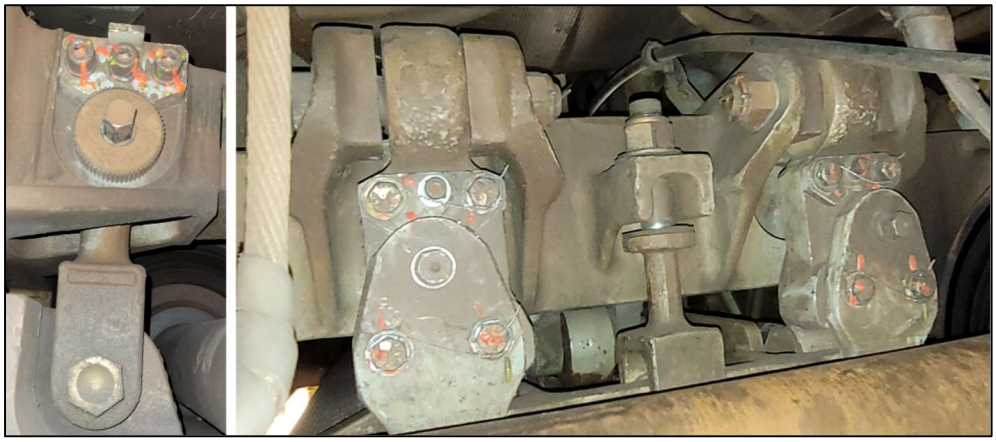


Figure 107 - Vertical Connection Links on Truck S/N 049

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 108, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

Figure 108 - Scratch Marks on Bottom of the LIM

No major damages were found on the ATC antennas, as shown in Figure 109.

Figure 109 - ATC Antennas on Truck S/N 049

6.2 Car 3027

6.2.1 Leading Truck (Truck Serial Number 023)

Location of truck S/N 023 in the consist during the time of the accident is shown in Figure 110.

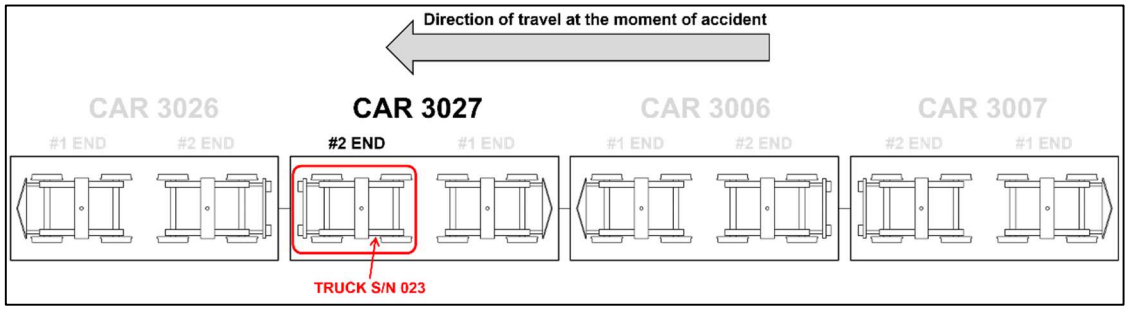
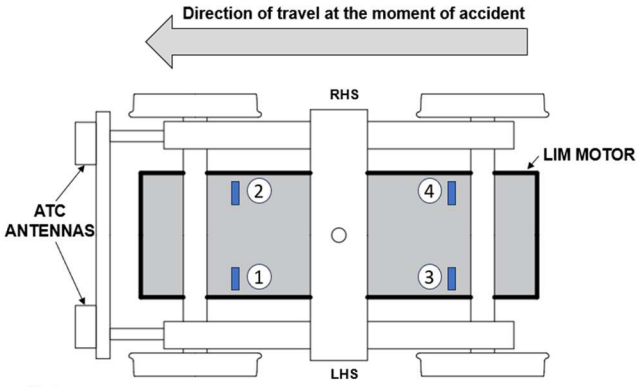


Figure 110 - Location of Truck S/N 023

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 111. All results were found to be within the acceptable limits.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	13
	2	13
	3	13
	4	13

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in red : smaller than minimum value required (12.5 mm).*
4) *Measurements in green: within tolerance range (12.5~13.5 mm).*
5) *Measurements in yellow: greater than maximum value required (13.5 mm).*

Figure 111 - LIM Height Measurement Results for Truck S/N 023

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 112.

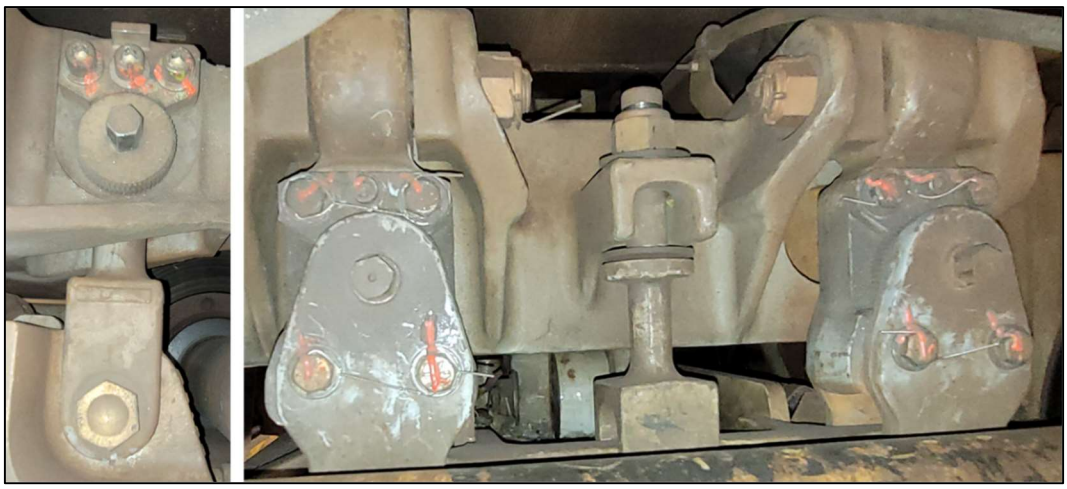


Figure 112 - Vertical Connection Links on Truck S/N 023

Uniform scratch marks were also found along the entire length of the LIM as shown in Figure 113, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

Figure 113 - Scratch Marks on Bottom of the LIM

No major damages were found on the ATC antennas, as shown in Figure 114.

Figure 114 - ATC Antennas on Truck S/N 023

6.2.2 Trailing Truck (Truck Serial Number 009)

Location of truck S/N 009 in the consist during the time of the accident is shown in Figure 115.

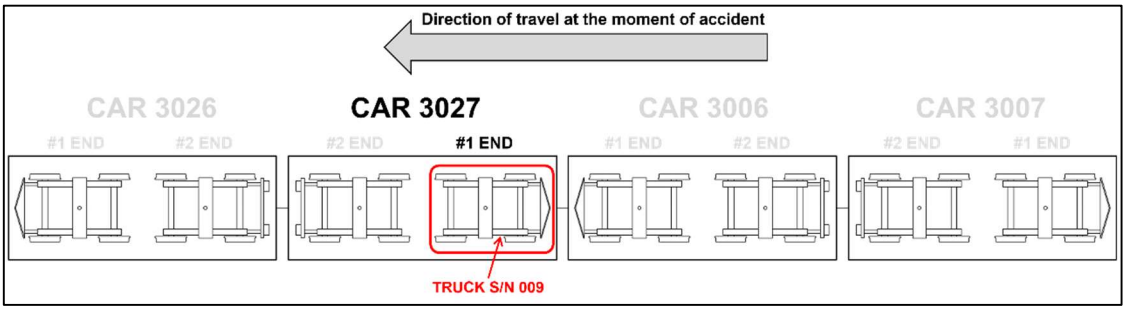
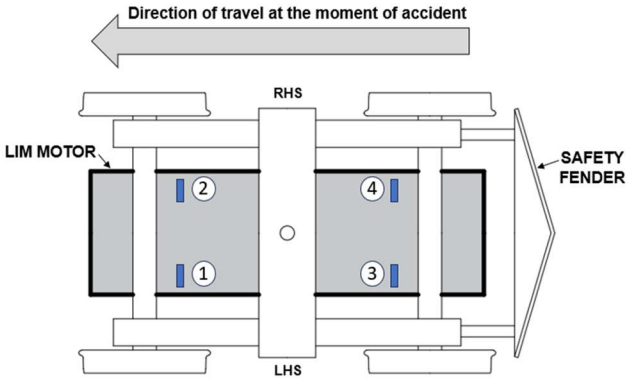


Figure 115 - Location of Truck S/N 009

The truck inspection occurred at McCowan Carhouse on July 31, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 116. All results were found to be within the acceptable limits.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	12.5
	2	12.5
	3	13
	4	13

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in red: smaller than minimum value required (12.5 mm).*
4) *Measurements in green: within tolerance range (12.5~13.5 mm).*
5) *Measurements in yellow: greater than maximum value required (13.5 mm).*

Figure 116 - LIM Height Measurement Results for Truck S/N 009

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 117.

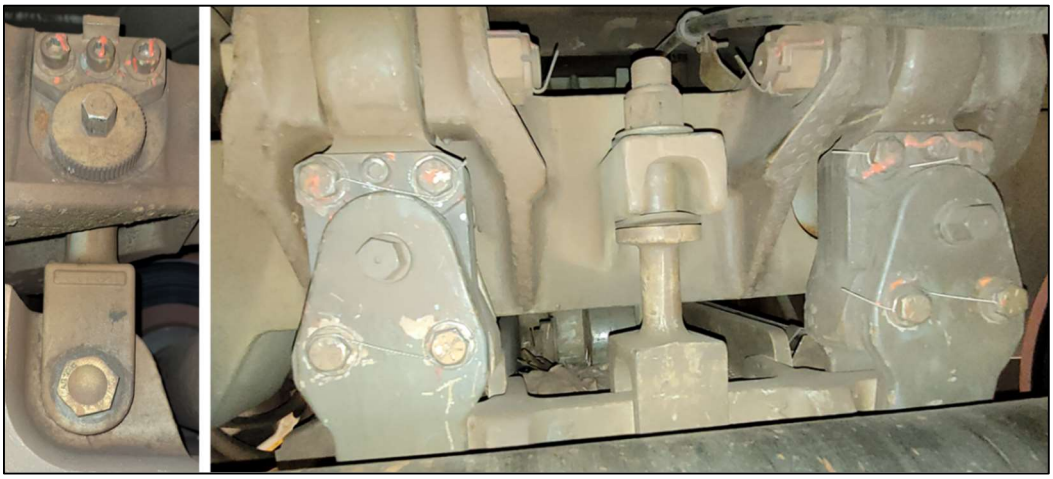


Figure 117 - Vertical Connection Links on Truck S/N 009

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 118, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

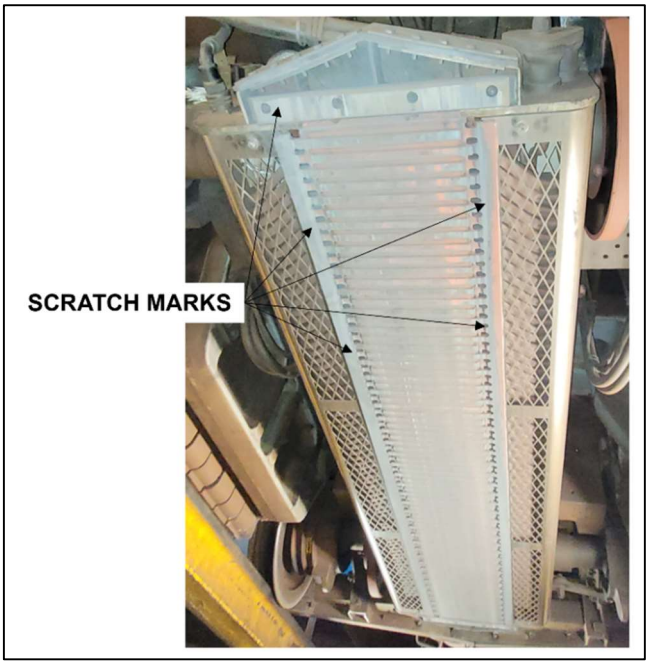


Figure 118 - Scratch Marks on Bottom of the LIM

No major damages were found on the safety fender, as shown in Figure 119.

Figure 119 - Safety Fender on Truck S/N 009

6.3 Car 3006

6.3.1 Leading Truck (Truck Serial Number 001)

Location of truck S/N 001 in the consist during the time of the accident is shown in Figure 120.

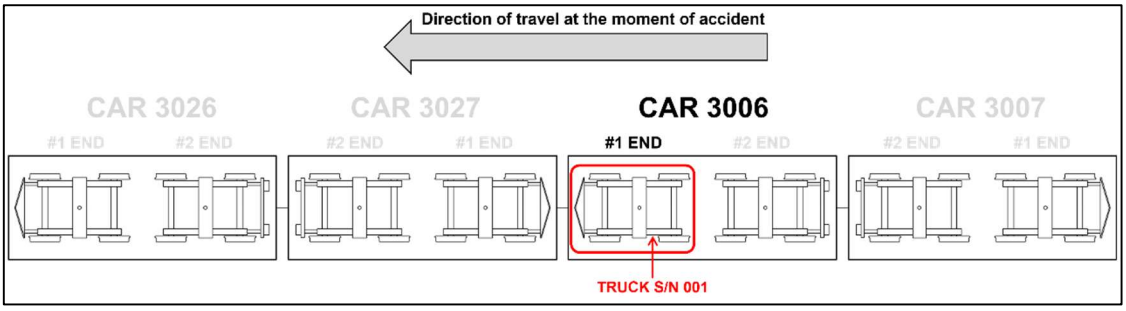


Figure 120 - Location of Truck S/N 001

The truck inspection occurred at McCowan Carhouse on July 31, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

Significant damage was found on the safety fender and its mounting structure, as shown in Figure 121, believed to be the result of a collision with a guideway obstruction.

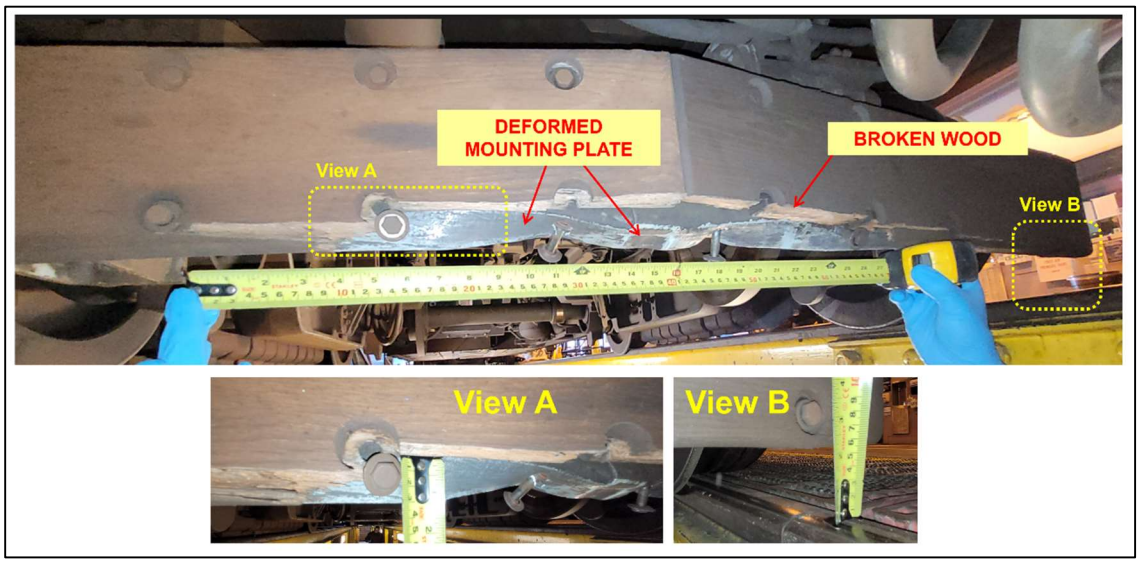


Figure 121 - Safety Fender Damage on Truck S/N 001

The fractured surfaces of the wooden fender appeared to have been broken recently (fresh fracture), with a non-aged appearance when compared with the other surfaces (see Figure 122).

Figure 122 - Broken Wooden Safety Fender on Truck S/N 001

The bottom of the safety fender sits at approximately 50 mm above the top of the running rails. The height of the damage was approximately 30 mm from the bottom of the safety fender, for a total height of the damage of approximately 80 mm from the top of the running rails (see Figure 121).

Car 3006 is used by TTC for de-icing purposes in the winter, and therefore Truck S/N 001 does not have a LIM.

6.3.2 *Trailing Truck (Truck Serial Number 314)*

Location of truck S/N 314 in the consist during the time of the accident is shown in Figure 123.

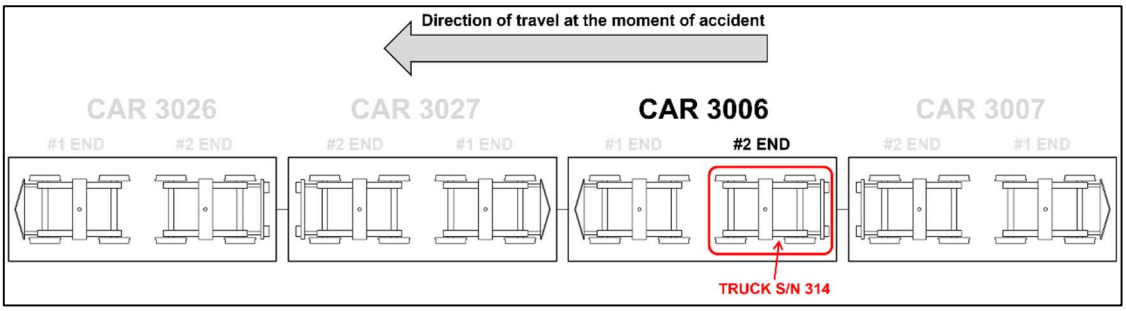
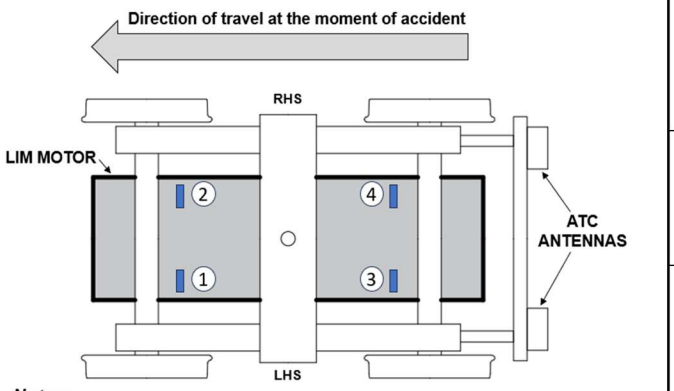


Figure 123 - Location of Truck S/N 314

The truck inspection occurred at McCowan Carhouse on July 31, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 124. One of the measurements was found to be outside of the specified range. However, it was greater than the maximum allowed, hence increasing the air gap with the reaction rail.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	13.5
	2	13.25
	3	14
	4	13.5

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in **red**: smaller than minimum value required (12.5 mm).*
4) *Measurements in **green**: within tolerance range (12.5~13.5 mm).*
5) *Measurements in **yellow**: greater than maximum value required (13.5 mm).*

Figure 124 - LIM Height Measurement Results for Truck S/N 314

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 125.

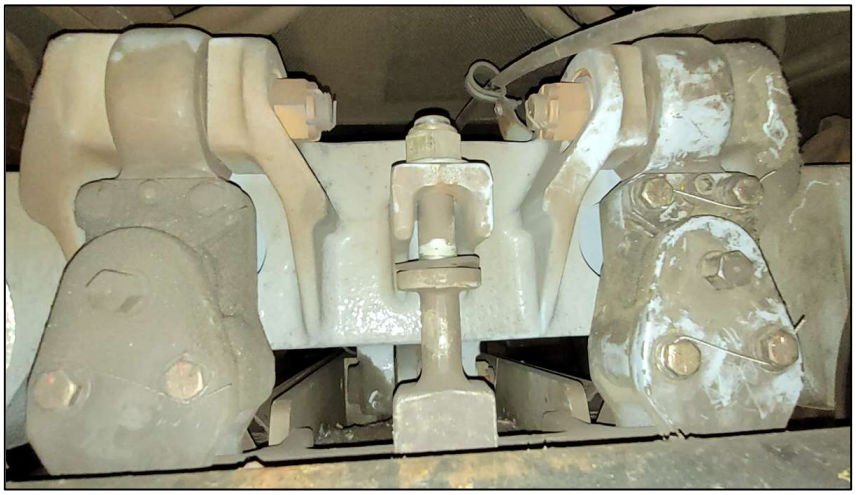


Figure 125 - Vertical Connection Links on Truck S/N 314

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 126, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

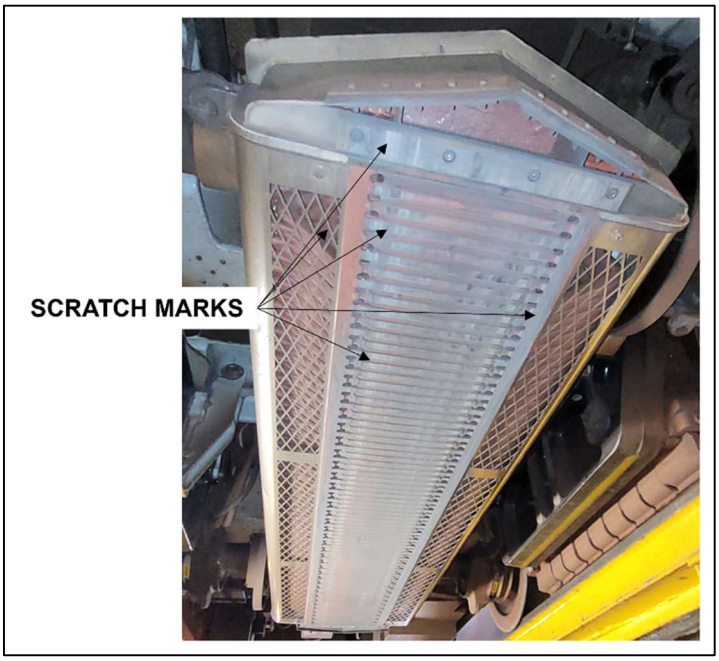


Figure 126 - Scratch Marks on Bottom of the LIM

No major damages were found on the ATC antennas, as shown in Figure 127.

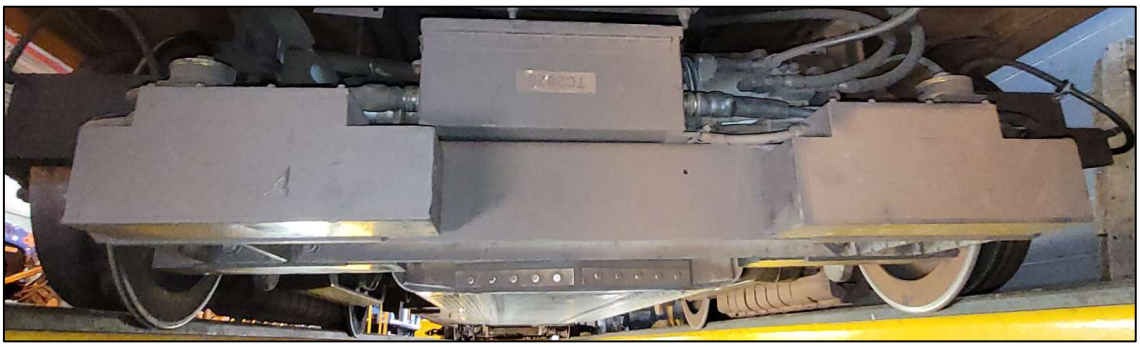


Figure 127 - ATC Antennas on Truck S/N 314

6.4 Car 3007

6.4.1 Leading Truck (Truck Serial Number 043)

Location of truck S/N 043 in the consist during the time of the accident is shown in Figure 128.

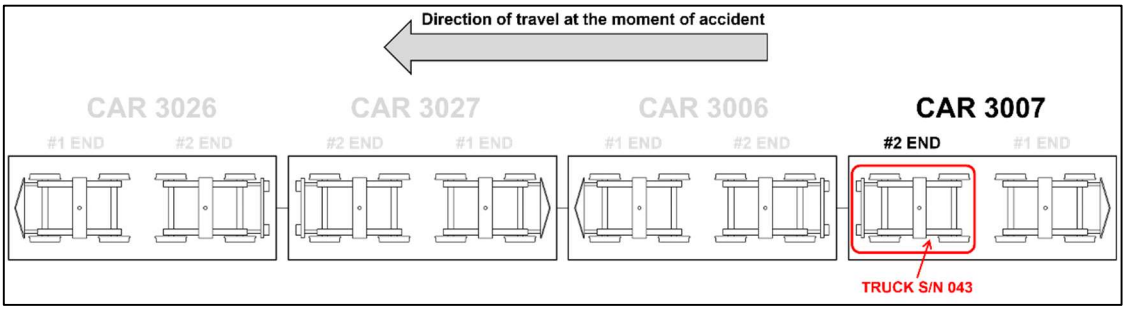
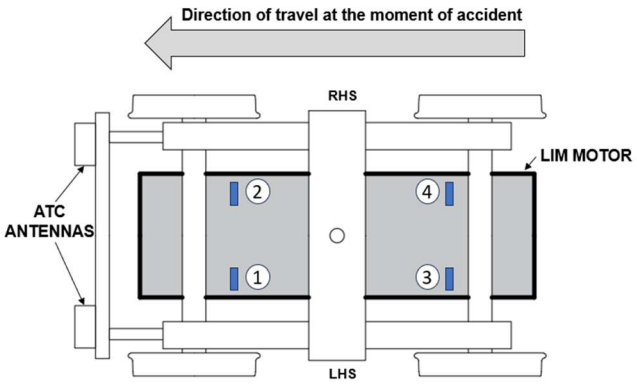


Figure 128 - Location of Truck S/N 043

The truck inspection occurred at McCowan Carhouse on July 31, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 129. Some of the measurements were found to be outside of the specified range (smaller than the lower specification limit). Given how high the guideway obstruction collided with some of the trucks of the investigated cars (approximately 70 mm), these small LIM height tolerance violations are not believed to have been contributing factors to the accident.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	12
	2	11.75
	3	13
	4	13.5

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in red: smaller than minimum value required (12.5 mm).*
4) *Measurements in green: within tolerance range (12.5~13.5 mm).*
5) *Measurements in yellow: greater than maximum value required (13.5 mm).*

Figure 129 - LIM Height Measurement Results for Truck S/N 043

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 130.

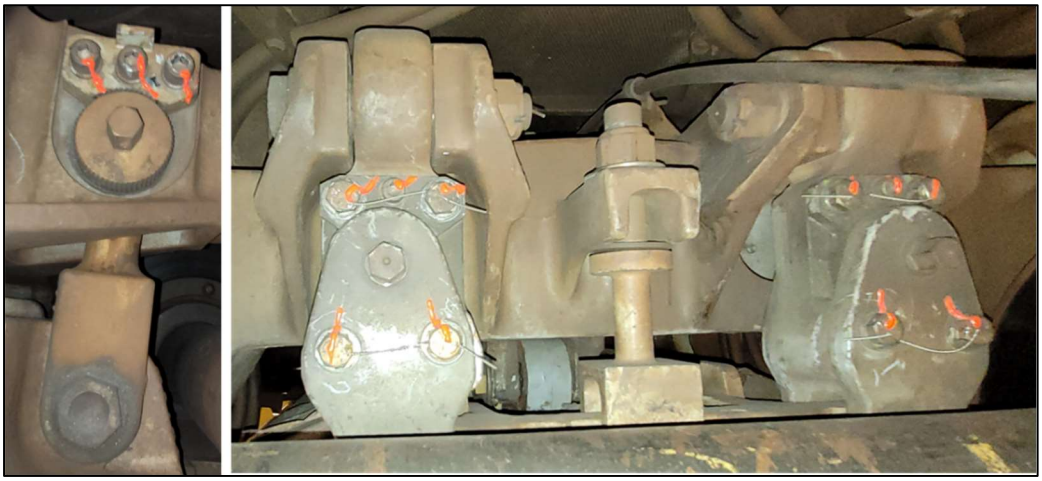


Figure 130 - Vertical Connection Links on Truck S/N 043

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 131, suggesting rubbing against the reaction rail top aluminum cap at various locations in the system. These marks appeared to be aged due to their discoloration and dirt build-up presence.

Figure 131 - Scratch Marks on Bottom of the LIM

No major damages were found on the ATC antennas, as shown in Figure 132.

Figure 132 - ATC Antennas on Truck S/N 043

6.4.2 Trailing Truck (Truck Serial Number 311)

Location of truck S/N 311 in the consist during the time of the accident is shown in Figure 133.

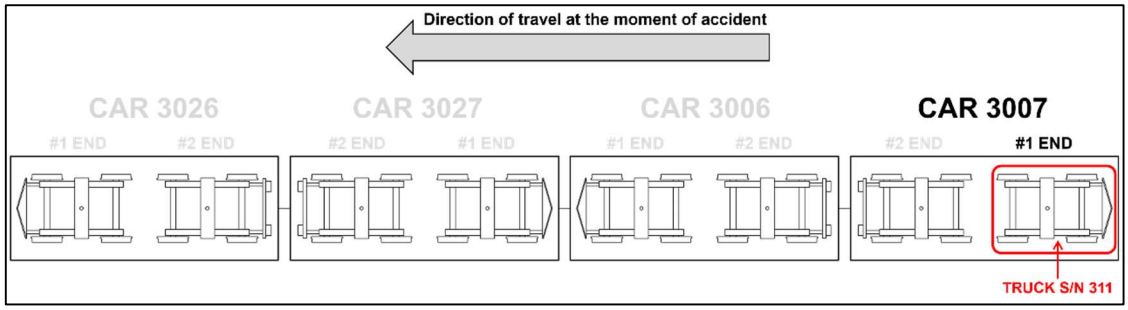
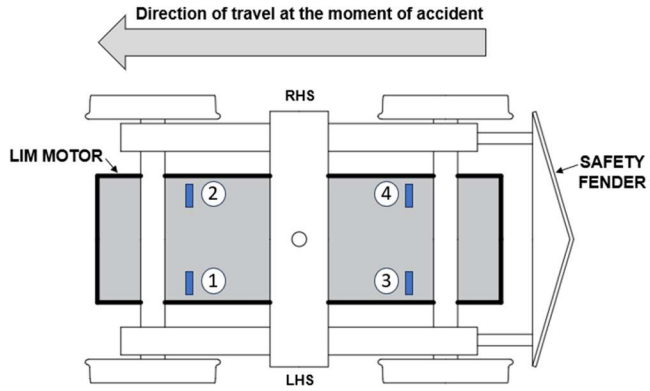


Figure 133 - Location of Truck S/N 311

The truck inspection occurred at McCowan Carhouse on July 31, 2023. The car was placed over the inspection pit to allow unobstructed access to the trucks.

The LIM height with respect to the top of the running rails was measured using gauge number 127E-610-005 [9], depicted in Figure 10, and verified with a caliper. Results are given in Figure 134. Some of the measurements were found to be outside of the specified range (smaller than the lower specification limit). Given how high the guideway obstruction collided with some of the trucks of the investigated cars (approximately 70 mm), these small LIM height tolerance violations are not believed to have been contributing factors to the accident.

MEASURING DIAGRAM	LOCATION	HEIGHT FROM TOR (mm)
	1	13
	2	12.75
	3	11.25
	4	11

Notes:
1) *Image shows view from the top.*
2) *Blue marks indicate locations where the measurements were taken.*
3) *Measurements in red : smaller than minimum value required (12.5 mm).*
4) *Measurements in green: within tolerance range (12.5~13.5 mm).*
5) *Measurements in yellow: greater than maximum value required (13.5 mm).*

Figure 134 - LIM Height Measurement Results for Truck S/N 311

The vertical links attaching the LIM to the yoke assemblies and their connections were also physically inspected and found to be properly secured, as shown in Figure 135.

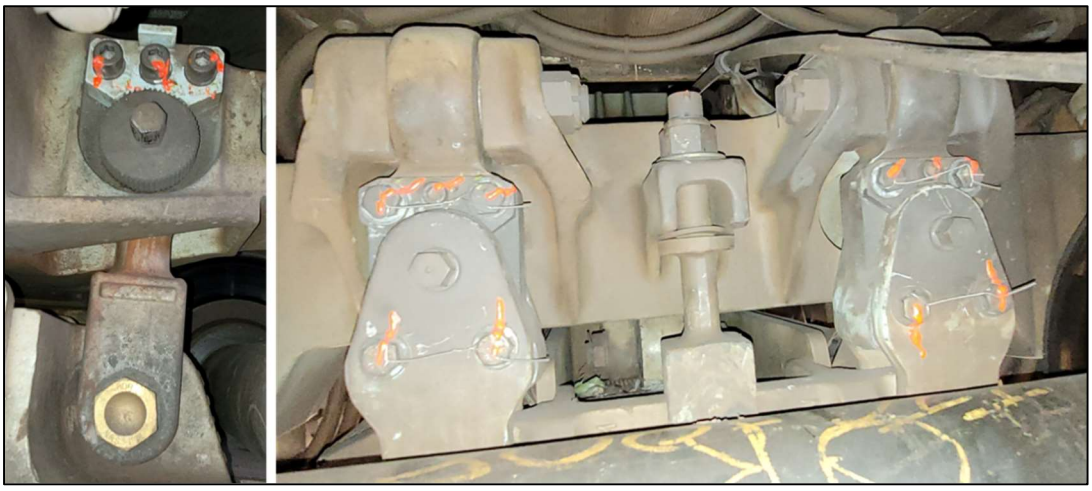


Figure 135 - Vertical Connection Links on Truck S/N 311

Uniform scratch marks were found along the entire length of the LIM bottom, as shown in Figure 136, suggesting rubbing against the reaction rail top aluminum cap. These marks appeared to be aged due to their discoloration and dirt build-up presence.

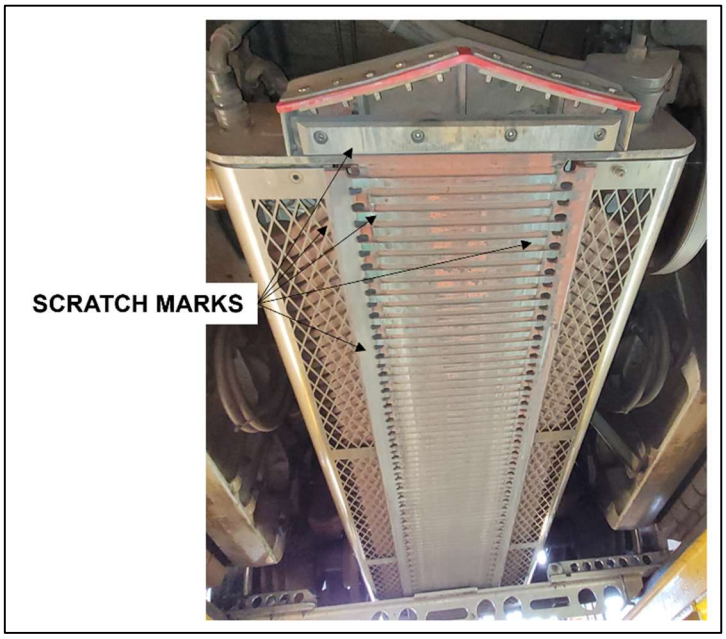


Figure 136 - Scratch Marks on Bottom of the LIM

No major damages were found on the safety fender, as shown in Figure 137.

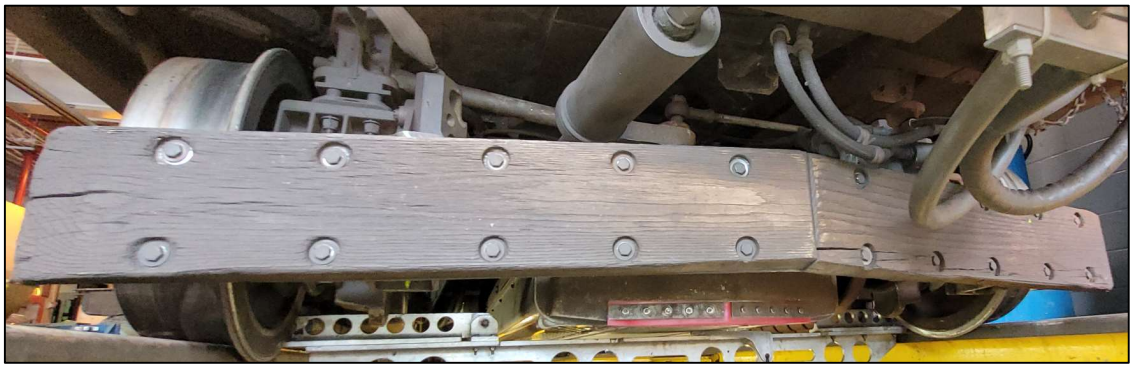


Figure 137 - Safety Fender on Truck S/N 311

7. Maintenance Records and Fleetwide Inspections

7.1 Review of Maintenance Records

Hatch reviewed the records for the last two inspections (either Safety or Standard Inspections) performed for each car, to identify whether TTC is consistently following the recommendation to verify the LIM height every 30 days. Table 2 shows a summary of the records. Hatch's findings based on the records are as follows:

1. The records demonstrate that TTC routinely inspects the LIM height of the fleet. The inspection intervals comply with the requirement to verify the LIM height every 30-36 days, as per TTC's SRT Vehicle Preventive Maintenance Scheduling [5].

2. There were four instances where the same LIM had to be adjusted on two consecutive inspections. On three of those (cars 3010, 3016 and 3026), wheel machining occurred after the second last inspection. As indicated on the maintenance records provided by TTC, the LIM heights were measured and adjusted (when required) immediately after wheel machining in these cases (per TTC's practice, LIM measurement/adjustments are done as part of the same intervention as wheel machining). However, the records show subsequent adjustments were still required a few days/weeks later, during the last recorded inspection. Due to the lack of actual measurements (values) in the maintenance records, Hatch cannot determine why the last adjustments were needed. Only car 3013 had to have its #2 LIM adjusted on two consecutive inspections without wheel machining happening between. The reasons for that second intervention are not clear in the inspection records. Nevertheless, given the low occurrence rate of consecutive interventions on the same LIM, Hatch believes the mechanisms preventing loosening of the vertical connection links and keeping the LIM height properly set are effective and the current inspection interval also appears adequate.

3. Although TTC's latest LIM height specification requires the LIM height to be set between 12.5 and 13.5 mm, as shown in Figure 9 [4], the Standard Inspection Check Sheet [11] used to record the measurements still references the OEM's original tolerances (11 +1/+0 mm). This inconsistency may lead to errors if the technicians performing the adjustment are not properly trained. In addition, the inspection sheets, as currently formatted, do not require the technician to record key elements associated with the LIM height, such as the measured height value found during the inspection as well as new height after adjustment (if required). TTC is recommended to revise the Standard Inspection Check Sheet [11] to correct the discrepancy described above and allow the inspected heights to be adequately recorded.

Table 2 - LIM Height Measurement Records

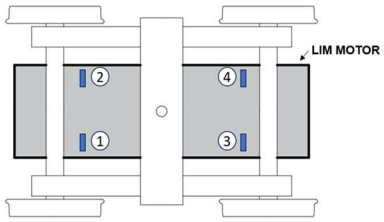
Car #	Second Last Inspection			Last Inspection			Insp. Interval	Consecutive Adjustment of Same LIM?	Comments
	Date	Insp. Type	LIM Height	Date	Insp. Type	LIM Height			
3000	29-May-23	Standard	Inspected. No work required.	29-Jun-23	Safety	Inspected. No work required.	31	No	
3001	29-May-23	Standard	Inspected. LIM #2 Adjusted	29-Jun-23	Safety	Inspected. No work required.	31	No	Wheels were machined on 05-Jun-23. LIM heights checked/adjusted on same intervention.
3002	31-May-23	Standard	Inspected. No work required.	02-Jul-23	Safety	Inspected. LIM #1 Adjusted	32	No	Wheels were machined on 09-Jul-23. LIM heights checked/adjusted on same intervention.
3003	31-May-23	Standard	Inspected. No work required.	02-Jul-23	Safety	Inspected. No work required.	32	No	
3004	06-Jun-23	Standard	Inspected. LIM #1 Adjusted	10-Jul-23	Safety	Inspected. No work required.	34	No	
3005	06-Jun-23	Standard	Inspected. No work required.	10-Jul-23	Safety	Inspected. No work required.	34	No	Wheels were machined on 23-Jul-23. LIM heights checked/adjusted on same intervention.
3006	16-May-23	Standard	Inspected. LIM #2 Adjusted	20-Jun-23	Safety	Inspected. No work required.	35	No	
3007	16-May-23	Standard	Inspected. No work required.	20-Jun-23	Safety	Inspected. No work required.	35	No	
3008	08-Jun-23	Safety	Inspected. No work required.	12-Jul-23	Standard	Inspected. LIM #1 Adjusted	34	No	
3009	08-Jun-23	Safety	Inspected. LIM #1 & #2 Adjusted	12-Jul-23	Standard	Inspected. No work required.	34	No	
3010	12-Jun-23	Standard	Inspected. LIM #2 Adjusted	16-Jul-23	Safety	Inspected. LIM #2 Adjusted	34	Yes	Wheels were machined on 14-Jun-23. LIM heights checked/adjusted on same intervention.
3011	12-Jun-23	Standard	Inspected. LIM #2 Adjusted	16-Jul-23	Safety	Inspected. No work required.	34	No	Wheels were machined on 13-Jun-23. LIM heights checked/adjusted on same intervention.
3012	04-Jun-23	Safety	Inspected. No work required.	09-Jul-23	Standard	Inspected. No work required.	35	No	
3013	04-Jun-23	Safety	Inspected. LIM #2 Adjusted	09-Jul-23	Standard	Inspected. LIM #2 Adjusted	35	Yes	This is the only occurrence where the same LIM had to be adjusted on consecutive inspections without the wheels being machined.
3014	18-May-23	Safety	Inspected. No work required.	22-Jun-23	Standard	Inspected. LIM #1 & #2 Adjusted	35	No	
3015	18-May-23	Safety	Inspected. No work required.	22-Jun-23	Standard	Inspected. LIM #1 & #2 Adjusted	35	No	
3016	22-May-23	Safety	Inspected. LIM #1 Adjusted	26-Jun-23	Standard	Inspected. LIM #1 & #2 Adjusted	35	Yes	Wheels were machined on 22-Jun-23. LIM heights checked/adjusted on same intervention.
3017	22-May-23	Safety	Inspected. No work required.	Record not provided by TTC					TTC informed this car is not in service (on hold), for reasons unrelated to the accident. Hence, the last inspection was actually on May 22, 2023.
3018	19-Jun-23	Standard	Inspected. LIM #1 Adjusted	23-Jul-23	Safety	Inspected. LIM Adjusted (# not specified)	34	Unknown	Wheels were machined on 25-Jun-23. LIM heights checked/adjusted on same intervention.
3019	19-Jun-23	Standard	Inspected. LIM #1 & #2 Adjusted	23-Jul-23	Safety	Inspected. No work required.	34	No	
3020	13-Jun-23	Safety	Inspected. LIM #1 & #2 Adjusted	18-Jul-23	Standard	Inspected. No work required.	35	No	
3021	13-Jun-23	Safety	Inspected. No work required.	18-Jul-23	Standard	Inspected. LIM #1 Adjusted	35	No	
3022	15-Jun-23	Standard	Inspected. LIM #2 Adjusted	19-Jul-23	Safety	Inspected. No work required.	34	No	
3023	15-Jun-23	Standard	Inspected. No work required.	19-Jul-23	Safety	Inspected. No work required.	34	No	
3024	Record not provided by TTC			Record not provided by TTC					
3025	25-May-23	Safety	Inspected. LIM #1 Adjusted	26-Jun-23	Standard	Inspected. No work required.	32	No	
3026	01-Jun-23	Safety	Inspected. LIM #2 Adjusted	04-Jul-23	Standard	Inspected. LIM #1 & #2 Adjusted	33	Yes	Wheels were machined on 19-Jun-23. LIM heights checked/adjusted on same intervention.
3027	01-Jun-23	Safety	Inspected. No work required.	04-Jul-23	Standard	Inspected. LIM #1 Adjusted	33	No	

7.2 Post-accident Fleetwide Inspections of LIM Height

After the accident, TTC has conducted a fleetwide verification of LIM height with respect to the top of the running rails. The measurement records were shared with Hatch and are summarized in Table 3 below.

Table 3 - Fleetwide LIM Height Measurement Results

MEASUREMENT LOCATIONS



Notes:

1) *Blue marks indicate locations where the measurements were taken.*
2) *Measurements in **red**: smaller than minimum value required (12.5 mm).*
3) *Measurements in **green**: within tolerance range (12.5~13.5 mm).*
4) *Measurements in **yellow**: greater than maximum value required (13.5 mm).*

Car Number	LIM #	LIM Height (mm)			
		Location #1	Location #2	Location #3	Location #4
3000	#1	"63 RUN" train: Height checked as part of Hatch's investigation			
	#2				
3001	#1	"63 RUN" train: Height checked as part of Hatch's investigation			
	#2				
3002	#1	13.0	13.0	13.5	13.5
	#2	13.0	13.0	12.0	12.5
3003	#1	13.0	13.0	13.0	13.5
	#2	13.0	13.0	13.0	13.5
3004	#1	13.5	Not provided	13.5	Not provided
	#2	13.5	Not provided	13.5	Not provided
3005	#1	13.0	Not provided	12.0	Not provided
	#2	12.5	Not provided	13.0	Not provided
3006	#1	"61 RUN" train: Height checked as part of Hatch's investigation			
	#2				
3007	#1	"61 RUN" train: Height checked as part of Hatch's investigation			
	#2				
3008	#1	"63 RUN" train: Height checked as part of Hatch's investigation			
	#2				
3009	#1	"63 RUN" train: Height checked as part of Hatch's investigation			
	#2				
3010	#1	13.3	13.3	13.5	13.5
	#2	13.5	13.5	13.5	13.5
3011	#1	12.0	12.0	12.0	12.0
	#2	13.0	13.0	13.0	13.0
3012	#1	13.0	13.0	14.0	13.5
	#2	12.5	13.0	13.0	13.0
3013	#1	13.0	13.0	12.5	13.0
	#2	13.5	13.0	13.0	13.0

Car Number	LIM #	LIM Height (mm)			
		Location #1	Location #2	Location #3	Location #4
3014	#1	12.0	13.0	13.0	12.5
	#2	13.5	13.0	13.0	13.0
3015	#1	13.5	13.5	13.5	13.0
	#2	13.0	14.0	13.0	13.0
3016	#1	12.5	12.5	13.0	13.0
	#2	13.0	13.0	13.5	13.0
3017	#1	Car out of service			
	#2				
3018	#1	12.5	12.0	13.0	13.0
	#2	12.0	13.0	13.0	13.0
3019	#1	13.0	13.5	13.0	13.0
	#2	13.0	13.0	13.5	13.0
3020	#1	11.5	Not provided	11.5	Not provided
	#2	11.0	Not provided	12.0	Not provided
3021	#1	No LIM on #1-end truck			
	#2	12.5	Not provided	13.5	Not provided
3022	#1	12.5	13.0	13.0	12.5
	#2	13.0	13.5	13.0	13.0
3023	#1	13.0	13.0	13.5	13.0
	#2	13.0	13.0	12.5	13.0
3024	#1	13.0	13.2	13.0	13.5
	#2	12.0	12.5	13.0	12.5
3025	#1	13.0	13.0	13.0	13.0
	#2	13.0	13.0	13.0	13.0
3026	#1	"61 RUN" train: Height checked as part of Hatch's investigation			
	#2				
3027	#1	"61 RUN" train: Height checked as part of Hatch's investigation			
	#2				

For the most part, all the LIM heights are within the acceptable tolerance range (between 12.5 and 13.5 mm), although there were few instances where the measured values were below the minimum allowed height. The minimum measured height was 11 mm (1.5 mm below the allowed minimum value) on car 3020. Nevertheless, given how high the guideway obstruction collided with some of the trucks of the investigated cars (approximately 70 mm), the 1.5 mm LIM height tolerance violation is not believed to have been a contributing factor to the accident.

8. Conclusions

Hatch has conducted a thorough investigation, from the vehicle's perspective, to determine whether the vehicles had any influence on the accident involving train "63 Run" on the evening of July 24, 2023, at the SRT southbound track, south of Ellesmere Station. The following conclusions were achieved:

1. Hatch did not find any evidence suggesting the existence of conventional mechanisms associated with wheel/rail interaction typically leading to derailments (i.e., no flanging marks on the rails due to truck hunting, no rail rollover, no track panel shift, no severe wheel flanging marks on the rails). Therefore, a collision with a track infrastructure obstruction was the primary event, which subsequently led to the truck being lifted from the rails and displaced to the wayside (secondary event). In other words, the accident was not a conventional derailment but rather a collision. This conclusion aligns with the video evidence, from Ellesmere Stations' surveillance footage, which shows the vehicle undercarriage colliding with a guideway obstruction.

2. Hatch found evidence of collision with a guideway obstruction on four trucks of the inspected cars ("63 Run" and "61 Run" trains), as shown Figure 138. The damage caused by the collision on all four trucks were very similar, indicating they were all struck by the same object. Since damage was also found on car 3006, the track obstruction was already present when "61 Run" train, ahead of train "63 Run", passed over the accident site.

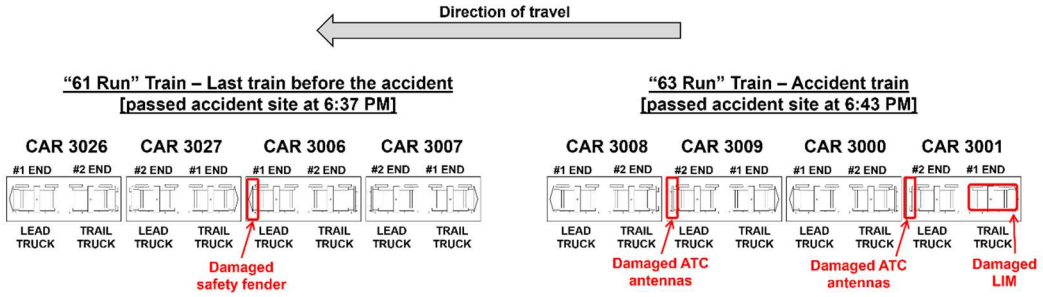


Figure 138 - Location of Damaged Trucks

3. Upon conclusion of all car inspections, Hatch did not find any clear evidence suggesting the vehicles had caused or contributed in any manner to the accident on July 24, 2023. No evidence was found of improper LIM height to an extent that could potentially have caused an interference with the reaction rail or to lift it in any way that would cause a collision. Although a few of the LIM height measurements taken were below the minimum allowed value, these violations are considered small compared with the height of the object colliding with the vehicles.

9. References

[1] TTC's website The future of TTC's Line 3 Scarborough (SRT) [https://www.ttc.ca/about-the-ttc/projects-and-plans/Future-of-Line-3-Scarborough]

[2] Section 3.6.3.2 of document "129E900-003 RMM SRT Propulsion. sections 2&3", provided by TTC.

[3] Document "pr24893-15-IR SRT LIM Reaction Rail Gap" (and its attachments), provided by TTC.

[4] Document "PR24893-13 SRT LIM Height Specification Updated 2021", provided by TTC.

[5] Document "RPM-ALVE-22-06 Preventive maintenance scheduling", provided by TTC.

[6] Document "RPM-RTVE-2-8_SRT Vehicle Safety Inspection", provided by TTC.

[7] Document "RPM-RTVE-5-3_Standard Inspection Procedure Propulsion", provided by TTC.

[8] Section 2.7.2.1 of document "129E900-003 RMM SRT Propulsion. sections 2&3", provided by TTC.

[9] Document "127E-610-005 rev C LIM Gauge", provided by TTC.

[10] Document "21107-01-rev 2", provided by TTC.

[11] Document "RPM-RTVE-33-3_SRT Standard Inspection Check Sheet", provided by TTC.

[12] Website https://climate.weather.gc.ca/historical_data/search_historic_data_e.html, data for Toronto Buttonville weather station, approximately 13 km away from TTC's Ellesmere Station.

[13] Document "SRT Pamphlet", provided by TTC.

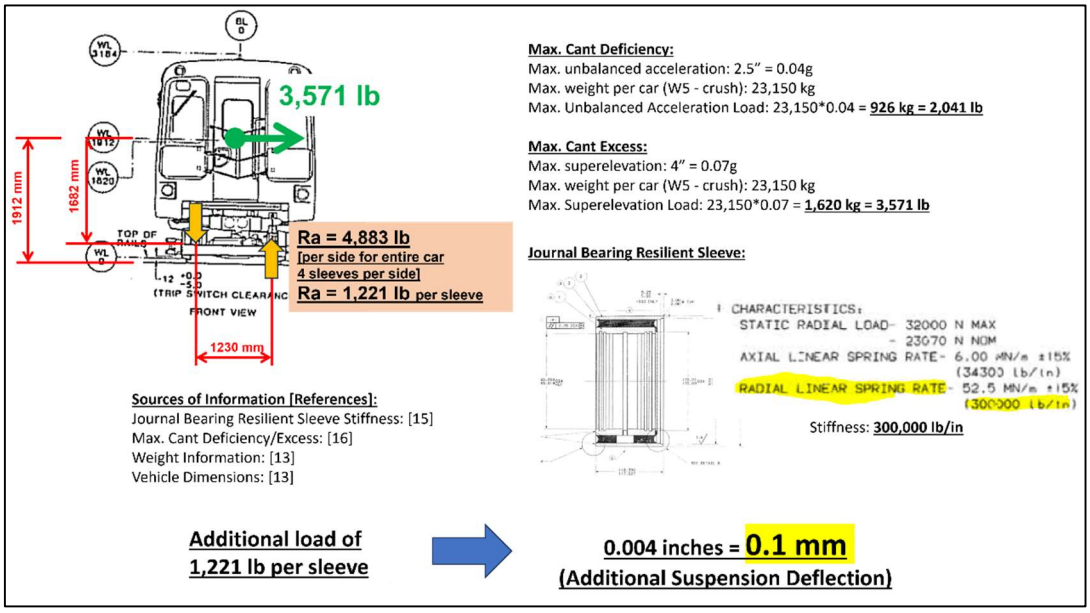
[14] Document "129E900-005 SRT Propulsion (LIM) Heavy Repair Manual", provided by TTC.

[15] Resilient Sleeve for Axle Bearing Drawing "121 624 024-rev B", provided by TTC.

[16] TTC's Track Maintenance Standards "TS-0603-04".

10. Appendix A: Primary Suspension Deflection Due to Additional Loads

10.1 Additional Journal Bearing Load Due to Cant Deficiency/Excess



10.2 Additional Journal Bearing Load Due Passenger Weight