



**ADDITION TO CORRECTIVE ACTION PLAN  
CAPA1-012822019  
SUBMITTED PURSUANT TO 4 CCR 723-7-7347(b)(VII)**

**January 28, 2019 Light Rail Derailment  
Response to Public Utilities Commission Request for  
Additional Information  
REGIONAL TRANSPORTATION DISTRICT-DENVER**

**September 16, 2019**

**Colorado PUC E-Filings System**

The Regional Transportation District (“RTD”) filed its Corrective Action Plan (“CAP”) and associated hazard analysis in this proceeding on July 18, 2019. The CAP contains all of the information required by Rule 7347 of the Commission’s Rules Regulating Railroads, Rail Fixed Guideways, Transportation by Rail, and Rail Crossings, 4 Code of Colorado Regulations (CCR) 723-7.

**UNDER COMMISSION RULE 4 CCR 723-7-7347(B)(VII), A CAP MAY INCLUDE SPECIFIC ACTIONS REQUIRED BY THE COMMISSION.**

For this CAP, the Public Utilities Commission of the State of Colorado (“PUC” or “Commission”) has added additional specific actions and requirements before it approves corrective action for this accident. The PUC requires RTD to file the following additional information with this CAP including:

- a) An analysis of the light rail alignment for locations where radar based speed violator strobe signs would be effective and will be installed;
- b) A report of the analysis performed by RTD of the LRV door design and what, if anything, can be done to mitigate the door failure that occurred during the January 28, 2019 derailment from occurring again under a similar set of circumstances in the future should such circumstances occur;
- c) Additional information from RTD on any additional information obtained and an analysis performed by RTD on anything else learned from this incident that can be used by RTD going forward to better prepare future operators or analyze operator awareness while they are operating light rail vehicles;
- d) Additional information from RTD on any issues they are having with obtaining and retaining operators and/or how the limited numbers of operators may be creating or leading to issues that may have led to or contributed to the derailment.

**Regional Transportation District’s Response to Commission’s request for Additional information:**

**a) An analysis of the light rail alignment for locations where radar based speed violator strobe signs would be effective and will be installed.**

RTD has added additional permitted speed signs in multiple locations in Downtown Denver and on the R-Line in Aurora. In addition, RTD’s analysis of speeding incidents identified throughout the system over the past 12 months determined the need for installation of radar based speed monitoring strobe signs. RTD placed orders for eight radar based speed monitoring units in April, 2019. One of the signs has been received and the additional seven signs ordered should arrive by the end of September, 2019. The use of such signs will alert operators if they are speeding as they are approaching critical points in the alignment

where a speed related incident could occur and will give operators a visual notification that they need to slow down. RTD has identified those critical points as curves of 10mph, and areas/curves where the posted speed limit is low and the preceding track speed limit is 2-3 times faster. RTD has also considered other potentially dangerous locations such as bridges/flyovers, and may determine that it needs to buy more strobe signs. The initial placement of the ordered signs will be at the following locations:

Sable and Exposition (R-Line, Lincoln Bound)  
Aurora Metro Center horseshoe curves (R-Line)  
Mile High Station curve (CPV Extension, Outbound,)  
Iliff Flyover (R-Line, Lincoln Bound)  
Colfax and 13<sup>th</sup> Avenue (R-Line near I-225)  
Curves Entering and exiting Federal Center (W-Line)

RTD Maintenance of Way ("MOW") will begin installing the signs as an immediate mitigation to the speed related concerns upon approval by the RTD Change Management Committee, and will complete installation at all identified sites (and any identified future sites) upon the commission's approval of this CAP response.

**b) A report of the analysis performed by RTD of the LRV door design and What, if anything, can be done to mitigate the door failure that occurred during the January 28, 2019 derailment from occurring again under a similar set of circumstances in the future should such circumstances occur?**

The light rail vehicle manufacturer Siemens Mobility, Inc., ("Siemens") has provided a draft report to RTD that is incomplete as it did not consider any structural deformation of the car shell due to the step thresholds contacting the street surface. RTD has requested the following additional analysis and clarification from Siemens:

1. The LRV car shell designed force tolerance during derailments of this type.
2. Did the car shell's performance contribute to the opening of the door allowing the passenger to be ejected and how?
3. What were the estimated abnormal forces the car shell experienced?
4. How did the car shell perform as far as structural deformation as the step thresholds contacted the street?
5. How can the car shell be modified to prevent the door from opening if the car shell deformation contributed to the ejection of the passenger?

Siemens requested copies of the videos in the accident report submitted to the Commission that depict the actual derailment of the train, to assist it in answering the requests. RTD filed a motion with the PUC to get permission to share the videos with Siemens provided that Siemens execute and return a Non-Disclosure Agreement prior to receipt of the video. The Commission determined to grant the motion in its September 11, 2019 meeting, and the written decision is pending. Siemens has indicated that the timeframe to provide RTD with the requested information will be 4-6 weeks after receipt of the video. RTD expects to have an NDA signed by Siemens within 2 weeks of this submission, and will provide the

video to Siemens immediately after receipt of the NDA. Therefore, RTD expects to have the final Siemen's report no later than November 30, 2019.

RTD has attached an initial report from the Door Manufacturer Innovations For Entrance Systems ("IFE"). IFE performed an analysis of the damage to the door to determine if there was any manufacturing defect that may have contributed to the door movement that allowed the passenger to be ejected from the train. The analysis shows that the door was properly manufactured and performed per manufacture and design specifications. The forces acting on the train during the derailment far exceeded the design specifications and contributed to the door movements. IFE and Siemens are in contact with one another to determine if there are any design changes that could be made to the door and/or vehicle body that would help to avoid similar accidents without introducing additional hazards to operations and evacuation scenarios. The results of these conversations/evaluations are expected with the response from Siemens.

The desired additional findings from IFE are;

1. The LRV door designed force tolerance during derailments of this type.
2. Did the car shell's contact with the pole and street contribute to the opening of the door allowing the passenger to be ejected and how?
3. How the person getting thrown against the door contributed to the opening of the door, allowing the passenger to be ejected.
4. What were the estimated abnormal forces the door experienced?
5. How did the door perform as far as structural resistance to coming open during the accident?
6. How can the door be modified to prevent the door from opening if the roller and roller track system contributed to the ejection of a passenger?

**c) Additional information from RTD on any additional information obtained and an analysis performed by RTD on anything else learned from this incident that can be used by RTD going forward to better prepare future operators or analyze operator awareness while they are operating light rail vehicles;**

RTD performed a full review of its training curriculum to determine if any deficiency in the curriculum could have contributed to this accident. Although no direct causation could be attributed to gaps in the training curriculum, RTD believes that the following training enhancements and additional oversight by supervisors will better prepare operators for revenue service and raise operator awareness of potentially hazardous behaviors while operating light rail vehicles. The following is a description of the changes we are instituting as immediate mitigations, and actions we will continue to take regarding our training and monitoring of our staff upon PUC approval of this CAP.

1. We have increased our testing of the new operators to 13 exams while in training, where they were previously given 4 exams. This should increase comprehension and familiarity. Operators are also tested and given a practical test on all portions of

our alignment and these results are documented and placed in their training files. This is in addition to the additional week of revenue instruction operators will be required to complete before they are released for solo revenue service. Any deficiencies, detected during any of the training, are addressed and corrected before operators are released to the next phase of training. They are now given a check ride on all areas of the alignment (all lines) prior to being released for revenue service, which indicates completion of their initial training.

2. We have scheduled a monthly campaign for our street supervisors to complete throughout the rest of this year, these elements are in addition to the required speed, station, policy and safety checks that street supervisors make on a daily basis.

August: Speed in Curves

September: Radio Procedures

October: 20 second Gated Crossing checks

November: Speed in Stations

December: Cell Phones

3. RTD is fast approaching its pilot of its efficiency testing of its Operators and hopes to have that started by the last week in September. We are developing efficiency check forms and will create an automated electronic tracking process to identify hotspots on the alignment, concerning operators and any other trends in the data.
4. RTD has also created the following program for re-training operators after a prolonged absence. If the operator is out:
  - a. 31 to 40 days: Conduct a full round trip ride check, and a refresh of any training they may request
  - b. 41 to 60 days: Classroom training of procedures and policies, two certification tests, and ride checks on the Main Line, ABS and Surface Street
  - c. 61 to 90 days: Classroom training on procedures and policies, two certification tests, Revenue assignment (1 day), ride checks on the mainline, ABS and Surface Street.
  - d. 91 to 180 days: Classroom training on procedures and policies, Two Certification tests, Simulator Training, Revenue Assignment (3 days), Ride checks on the Mainline, ABS and Surface street.
  - e. 181 to 364 days: Classroom training on procedures and policies, Two Certification tests, Simulator training, Revenue Assignment (5 days), Ride checks on the mainline, ABS and surface street.

All of these times may be adjusted based upon the operator's performance during re-training and their requests for additional training.

In addition to the training listed above, RTD is exploring technology that could be installed in our light rail vehicles to either enhance operator awareness, provide better oversight of operations or even actively prevent speeding in light rail vehicles. These technologies include:

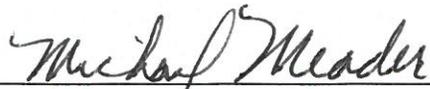
1. Upgraded cameras, to include In cab and forward facing cameras – RTD has these cameras in the 29 new Denver 8 trains that are being placed into service but all other 172 trains do not have in cab or forward facing cameras. These cameras would help RTD better understand operator behaviors that may be contributing to speeding and other potentially hazardous events to better address and mitigate. The approximate cost of upgrading all light rail vehicles is \$4M. There is no budget identified/appropriated for this technology in the short or long term.
2. Enhanced ATC/Metrom – Enhanced Automatic Train Control essentially provides a means to establish vehicle to wayside to control connectivity, that automatically monitors vehicle position/proximity and speed to provide signal enforcement and civil speed control of all trains at all times. This would eliminate red signal violations and govern the speed of trains in all locations to eliminate speeding and collisions. The approximate cost of upgrading to E-ATC is approximately \$12-15M. There is \$7M in the current short term budget (\$2M in 2020 and \$1M per year 2021-2025) for some type of E-ATC, but this budget is insufficient to acquire any type of system that is currently available for a fleet of RTD's size.
3. Communications based Train Control (CBTC) /Ultra wide band (UWB) communications- this is a high end train control system that could provide very sophisticated control of our train position, speed, braking distance, and signal system, etc. The approximate cost of a CBTC/UWB system would likely be in the \$100M+ range. Cost prohibitive.

RTD is evaluating grant funding opportunities, alternatives and budget adjustments, however, all of these technology enhancements are cost prohibitive in the short term and long term under current budgeting.

**d) Additional information from RTD on any issues they are having with obtaining and retaining operators and/or how the limited numbers of operators may be creating or leading to issues that may have led to or contributed to the derailment.**

RTD is currently experiencing a significant shortage in train operators. RTD currently has 216 train operator positions approved to effectively deliver the level of service that currently exists. We currently have 163 full time operators on staff. However, due to On the Job Injury (“OJI”) absence, Family and Medical Leave Act absences, scheduled PTO and call in absences, the operators available on any given day are typically 12-15 less than that number. RTD is seeing its attrition rate increase as well due to the workload and cannot hire and train enough operators to maintain current levels ongoing. This is creating the need to mandate existing operators to work a 6<sup>th</sup> day on a regular basis to fill scheduled work, and the mandating has increased with the opening of the Southeast Rail Extension. This has contributed to the increase in attrition. A large percentage of exit interviews confirm this to be the case. RTD monitors and ensures that operators do not exceed DOT hours, but in the current environment we do have some operators near the DOT limit on a regular basis. Fatigue was not determined to be a direct causal factor in the January 28, 2019 derailment, as the operator had just returned from an extended time off. Anecdotally, the mandating

/increased workload could be contributing to fatigue, inattention and potentially some distraction due to the stress this workload and lack of work life balance puts on operators. RTD is working on an analysis of the mandating history, hiring, retention, absences, OJI, etc. and will share this information with the commission NLT October 30, 2019.



Michael Meader

Chief Safety and Security Officer / AGM – Safety, Security, and Asset Management

September 16, 2019

**REFERENCES AND RESOURCES**

Speed Sign Estimate /Order

IFE Report



**Estimate**

AM Signal, Inc.  
 8100 Southpark Way, Unit A-10  
 Littleton CO 80120  
 Ph: 720-348-6925 Fx: 720-348-6950

Date	Estimate #
4/16/2019	4158

Bill To
Accounts Payable Department - DOM3 1660 Blake Street Denver CO 80202-1399

Ship To
RTD-Denver 1350 Rio Court Denver CO 80204

SO Type	Contract #	Terms	FOB	Expires	Primary Sales
Standard		Net 30	Origin	5/16/2019	Gale Nation

Notes  
 Prices based off of cooperative contract with the City and County of Denver 28820G

Item #	Quantity	Units	Item	Description	Rate	Amount
1	8	Each	RAD TC-1000S (S)	SOLAR POWERED RADAR SPEED SIGN-17" DISPLAY W/17" LED DISPLAY, 65 WATT SOLAR PANEL WITH POLE MOUNTING BRACKET, TWO 12V AGM BATTERIES, 36"W X 44"H "YOUR SPEED" FACEPLATE, SS MOUNTING PIPE CLAMP SET. BASHPLATE, BLUETOOTH WIRELESS TRANSMITTER. "SLOW DOWN"	3,869.00	30,952.00
2	8		Estimated Freight	Estimated Freight	95.00	760.00

<b>Total</b>	<b>\$31,712.00</b>
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Quote valid for 30 days. Restock fees may apply for returned materials.  
 Seller reserves the right to make an equitable adjustment by providing Buyer with new unit pricing if the Buyer's Purchase Order includes a variation in the quantity of any item from the time it was quoted on the Seller's Estimate.



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# Analysis Report

SCI Denver

## Denver VII

Project-No.	40004F1A
Customer	SIEMENS NA
Project-Part	Doors
System	RLC-E2

Created:	05.03.2019	Checked:	07.03.2019
	Date		Date

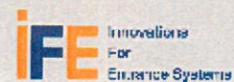
Wagner Thomas/Steinauer Hubert	Jones Brent/Almer Christian
Name	Name

BU-LM/BU-RS	BU-LM
Department	Department
Signature	Signature

Released:	Translated:
Date	Date

Gold	
Name	Name

BU-LM	
Department	Department
Signature	Signature



## Contact Address

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Fax: + 43 7448 9000 65110  
[www.ife-doors.com](http://www.ife-doors.com)

## Revision History

Rev	Date	Name	Para	Description of change
00	05.03.2019	Wagner T. Steinauer H.		

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## 1 Reference Documents

Doc. ID	Doc.No.	Äl (Index,..)	Title
01	T003565R03	2	Installation drawing
02	TREXLRV18r5aJun24	June 24, 2002	Transportation Expansion ProjectLight Rail Vehicles – Section 18 (Doors and Bridge Plates)

## 2 Definition

### 2.1 Abbreviations

RTD	Regional Transportation District
RLC	Reverse Locking - Classic system
MST	Mountain Standard Time
RH	Right hand
LH	Left hand
DL	Door leaf
PD	Production Date
S/N	Serial Number

### 3 Project description

#### 3.1 Train Operator

RTD has 10 lines with 53 stations serviced by ~ 135 Siemens trains.  
<http://www.rtd-denver.com/who-we-are.shtml>

- A** Union Station to Denver Airport Station
- B** Union Station to Westminster
- C** Union Station to Littleton - Mineral Station
- D** 18th & California Station to Littleton - Mineral Station
- E** Union Station to Lincoln Station
- F** 18th & California to Lincoln Station
- H** 18th & California to Florida Station
- L** 30th & Downing to 16th & Stout
- R** Lincoln Station to Peoria Station
- W** Union Station to JeffCo - Golden Station

#### Combined schedules

- C D** Southwest Line
- E F H** Southeast Line

Image 1: RTD Lines

#### 3.2 Train

The trains are Siemens SD-160 trains. Each train consists of two cars, an A-car and a B-car and has three bogies (one on each end and one in the center between the two cars). A car diagram is included in Image 4.

#### 3.3 Door system

The door system is a RLC system with a free width of 1200mm and a portal height of 2778mm.

Door 1 production:

LH DL	3T002930R28:	S/N D730238	PD: 10/2009
RH DL	3T002930R19:	S/N D720238	PD: 10/2009
LH Door leaf carrier	3T104329R20:	S/N 64/045	PD: 04/2010
Drive Unit	3T002741R76:	S/N 10100004	PD: 10/2010

### 3.3.1 RLC Components

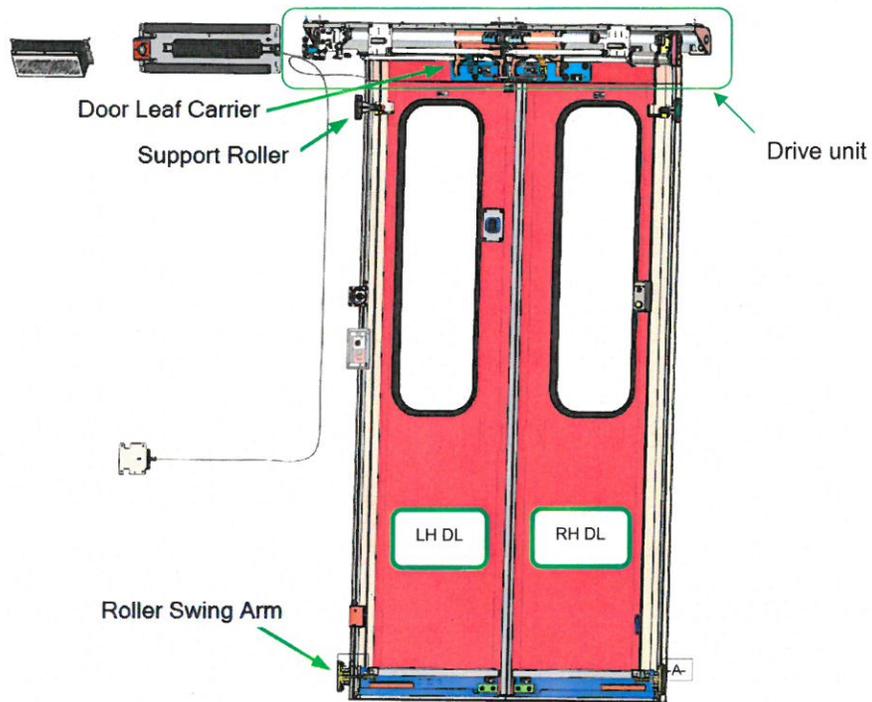


Image 2: RLC Components (symbolic image)

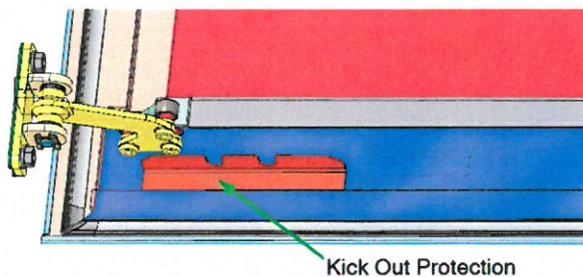


Image 3: RLC Components (Kick Out Protection)

### 3.3.2 Specification

The system was designed to withstand the requirements according to the project specification TREXLRV18r5aJun24 (890N single load on 930cm<sup>2</sup> per door panel located 50mm from the leading edge and centred within the door height).

## 4 Introduction

### 4.1 Investigation reason

On 28.01.2019 at 7:15am MST a train on the R-Line derailed. During the accident a female passenger was ejected from the LRV and suffered serious injuries. Because an IFE door system was involved in the accident an IFE team went to Denver to investigate.

### 4.2 Weather condition

Light snow. Ice fog. -7°C. 19km/h NE wind. Source: www.timeanddate.com/weather

### 4.3 Accident description

Train 316 from the R-Line was travelling from Peoria to Lincoln, at junction Sable Boulevard and Exposition Avenue East, the complete train (2 car train) derailed and was sliding towards the rails of the counter direction in the curve. The primary cause of the derailment was that the LRV entered the curve at excessive speed according to RTD (max. allowed speed and speed records are not available for IFE at the moment).

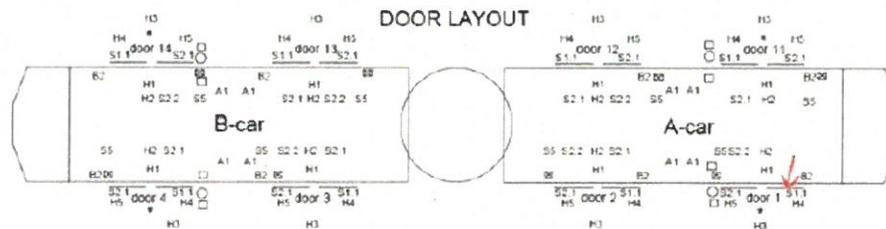
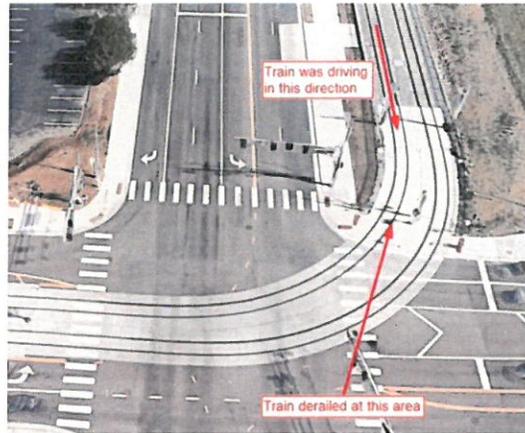


Image 4: Car Diagramm

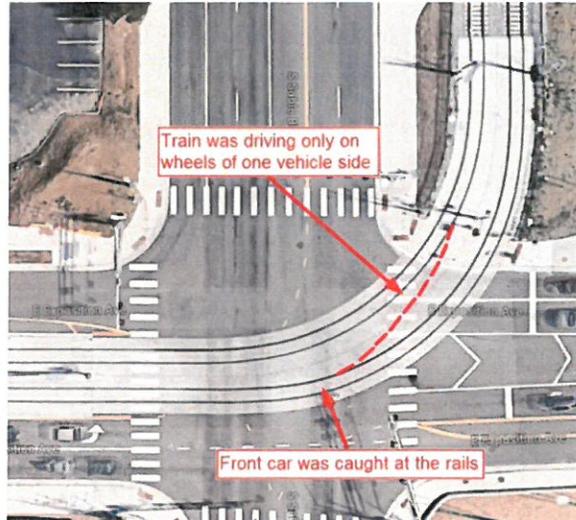
The front car (B car) was caught in the rails of the counter direction; the end car (A car) was sliding over the rails. During the derailment the train tipped on an angle and was sliding only on its outer wheels (train side of Door 1) and the door thresholds.



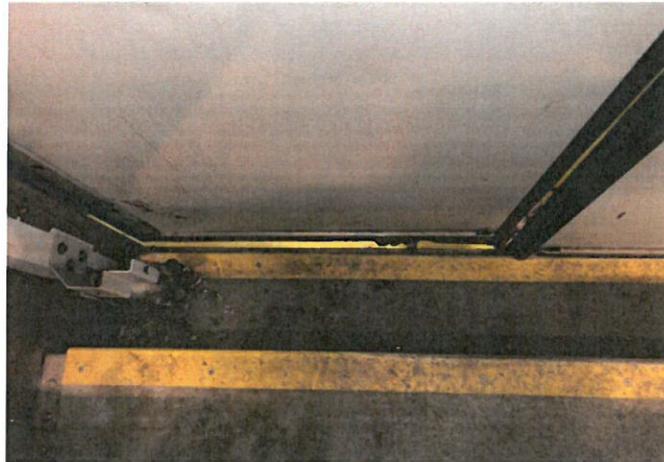
**Image 5: Accident location**

Pictures and videos (security camera) of the accident exist, but are not able to be shared with IFE at this time. RTD has not confirmed if IFE will be given access to this material.

It can be assumed that there were two significant impacts to Door 1. The first impact was the collision of the door leaf with the threshold (see Image 18: Threshold with mark of door leaf) caused by the derailment of the train. Due to the derailment and tilting of the train a woman fell down the stairs to the door.

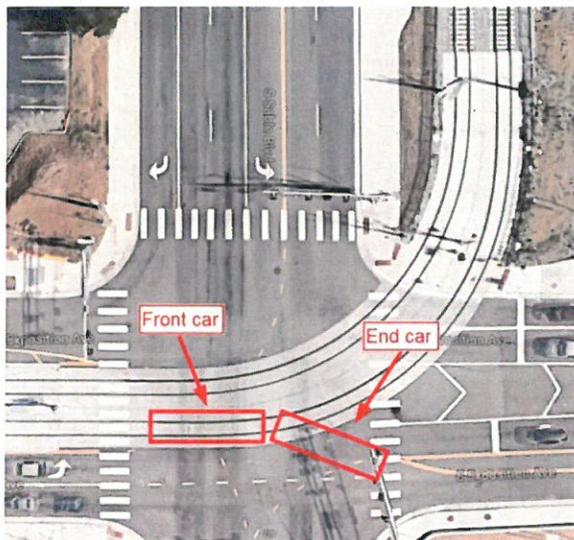


**Image 6: Sliding traces during first impact**



**Image 7: Stairs at door 1**

There was a second impact on Door 1 which is assumed to happen when the end car was sliding over the rails. According to RTD the threshold was bent to the inside of the vehicle during this impact so that the lower part of the left door leaf had direct contact with the street.



**Image 8: A-CAR sliding over rails**

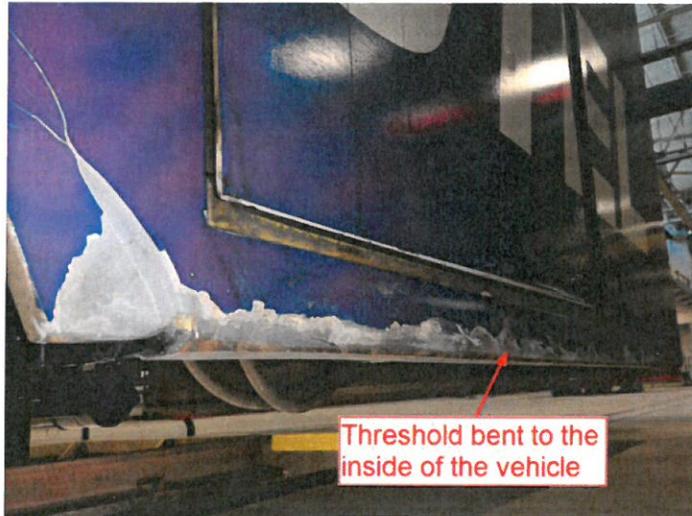


Image 9: Threshold of door 1

## 5 Consequences of the accident

- The right door leaf of Door 1 rotated counter clockwise (view from outside) and pushed the support roller to the end of the elongated holes



Image 10: Threshold - Lower door leaf

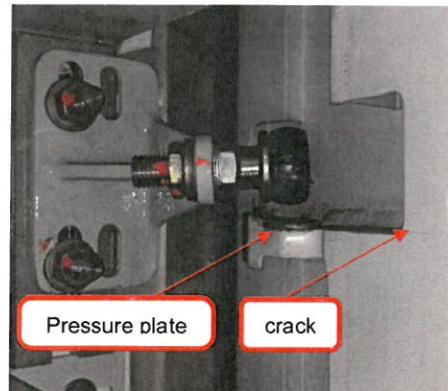


Image 11: Support roller with elongated holes

- Door leaf and door leaf carrier were twisted and collided with the upper sealing frame



**Image 12: Scratches on door leaf and carrier**



**Image 13: Bending on sealing frame**

- Lower bracket (kick out protection which is installed to prevent vandalism by passengers) was ripped off by the roller swing arm



**Image 14: kick out protection**



**Image 15: Bonding area of kick out protection on door leaf**

- The door leaf was lifted out from the roller swing arm and therefore had no guiding in the lower area anymore.



**Image 16: Door1 lifted out roller swing arm**

Due to the above described consequences of the accident a part of the woman's leg was exposed outside of the train, got trapped between threshold and street and was severed. When the leg was trapped between threshold and street the woman was pulled out of the train through the gap between threshold and the left door leaf (view from inside; see also)

## 6 Additional findings on Door 1

- No plastic deformation of the portal could be measured. (height, diagonal measurement)
- All mounting bolts of the drive unit were still in position (screw marking not cracked), only the marking of the left door leaf mounting bolts was cracked.
- Bolt markings on the trolley carrier were not cracked
- Door leaf guiding rail did not show any indication of movement due to the accident
- Even though the paint of the door leaf was cracked under the left door leaf carrier and at the pressure plate (see image 11) there was no deformations visible (flexible bending)
- The lower left door leaf area showed plastic deformation because of the collision with street



Image 17: Plastic deformation on left door leaf

- Door leaves were in contact with the threshold during the first impact of derailment

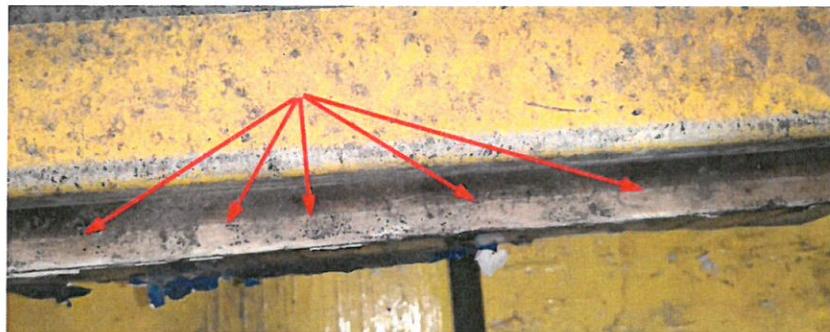


Image 18: Threshold with mark of door leaf

- The grounding wire of the left door leaf was cut-off when door leaf carrier and sealing frame were in contact.

- Diagnostic codes of door control unit were downloaded. No findings related to the accident.

## 7 Other findings on train 316

- All thresholds on the left side of the train made contact with the street and rails, most of the weld seams on the lower side of the thresholds were broken.



Image 19: Threshold Door 1



Image 20: Right portal side of threshold - broken welding seams

- The second wheel on the front bogie has a flat spot due to sliding over the street



**Image 21: Flat spot on wheel**

- Damage on the top of the end car due to collision with the light pole



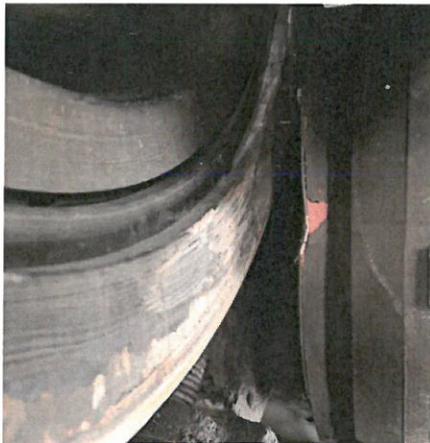
**Image 22: Top of end car**

- Damage of the car body and rain water gutter above Door 1



**Image 23: Scratch above Door 1**

- Collision of end bogie with air compression tank



**Image 24: Damage on tank**



**Image 25: Measurement to tank**

- Support rollers on all other doors were found in an incorrect position which could be a result of the accident or according to RTD also due to improper adjustment by their service people. It was not possible to evaluate if the parts moved due to the accident because the marking of the bolts and parts was insufficient. Only the left door leaf of Door 3 has a cracked bolt marking which was sufficient to conclude that the movement was due to the accident. The support roller on Door 3 has no contact with the pressure plate anymore.
- Generally, it could be observed that on all left door leaves of the left train side (in driving direction) and all right door leaves of the right train side there was no contact anymore between pressure plate and support roller.

## 8 Conclusion

The used door system was designed according to the project specification TREXLRV18r5aJun24 (applied specification for Denver VII).

According to RTD the accident happened due to too excessive speed. The observed damages on the train and on the door system caused by the accident lead to the conclusion that the resulting forces of the accident were far over the door system limits and are not included in any specified load case.

## 9 Next steps/ open points

Investigations on the train are still ongoing. Siemens will get in contact with IFE NA (Brent Jones) as soon as any update is available. Siemens requested IFE to investigate if there are any design improvements possible to avoid similar accidents (IFE will review the request and come back with a statement until end of April 2019).