



**Railway Accident
Investigation Unit
Ireland**



INVESTIGATION REPORT

**Passenger trap-and-drag occurrence on Luas tram
at Heuston Stop,**

26th March 2019

RAIU Report No: 2020 – R001

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Report publication

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Reader guide

All dimensions and speeds in this report are given using the International System of Units (SI Units). Where the normal railway practice, in some railway organisations, is to use imperial dimensions; imperial dimensions are used and the SI Unit is also given.

All abbreviations and technical terms (which appear in italics the first time they appear in the report) are explained in the glossary.

Descriptions and figures may be simplified in order to illustrate concepts to non-technical readers.

Report preface

The RAIU is an independent investigation unit within the Department of Transport, Tourism and Sport (DTTAS) which conducts investigations into accidents and incidents on the national railway network, the Dublin Area Rapid Transit (DART) network, the LUAS light rail system, heritage and industrial railways in Ireland. Investigations are carried out in accordance with the Railway Safety Directive 2004/49/EC enshrined in the European Union (Railway Safety) (Reporting and Investigation of Serious Accidents, Accidents and Incidents) Regulations 2014.

The RAIU investigate all serious accidents. A serious accident means any train collision or derailment of trains, resulting in the death of at least one person or serious injuries to five or more persons or extensive damage to rolling stock, the infrastructure or the environment, and any other similar accident with an obvious impact on railway or tramline safety regulation or the management of safety. During an investigation, if the RAIU make some early findings on safety issues that require immediate action, the RAIU will issue an Urgent Safety Advice Notice outlining the associated safety recommendation(s); other issues may require a Safety Advice Notice.

The RAIU may investigate and report on accidents and incidents which under slightly different conditions might have led to a serious accident.

The RAIU may also carry out trend investigations where the occurrence is part of a group of related occurrences that may or may not have warranted an investigation as individual occurrences, but the apparent trend warrants investigation.

The purpose of RAIU investigations is to make safety recommendations, based on the findings of investigations, in order to prevent accidents and incidents in the future and improve railway safety. It is not the purpose of an RAIU investigation to attribute blame or liability.

Report summary

On the 26th March 2019 at approximately 14:22 a male passenger attempted to board inbound Luas tram, Tram 3011, at Heuston Stop. The passenger placed his hand between the door leaf and the door pillar of the rear most entrance door as the door was closing. The passenger's hand became trapped in the door seals. The door *obstacle detection* system did not detect the presence of the hand as it was less than 10 millimetres (mm); the door operation mechanism allows 10 mm obstacle detection to facilitate door closing.

The tram departed Heuston Stop nineteen seconds after the doors were closed with the passenger's hand trapped in the door. Two security staff from Special Task Team (STT), STT 1 and STT 2, came to the passenger's assistance, with one of the security staff communicating with the driver by radio. The tram began to move, with the passenger's hand still trapped and the passenger walked along the platform with his hand trapped in the door seal for five seconds before the security staff assisted in freeing the passenger's hand from the door. The tram came to a stop four seconds after the passenger had freed his hand.

The immediate cause of the passenger hand being trapped in the door of Tram 3011 was the passenger placed his hand in the door opening, as he attempted to board the tram, during the door closing sequence.

Contributory factors (CF) associated with the incident were:

- CF-01 – The Driver did not conduct an adequate visual check, using rear view monitors and mirrors during or after the door closing sequence; this, in part, may be as a result of deficiencies in the mirrors (absent from Heuston Stop) and ineffective in-cab monitors (older black and white monitors);
- CF-02 – There were no labels warning the passenger of the risk of attempting to board or exit a tram while the doors are closing;
- CF-03 – STT1 did not follow the instructions in the Transdev Radio Protocol which requires emergency calls to commence by saying "This is an Emergency call" twice.

The underlying cause (UC) associated with the incident was:

- UC-01 – There appears to be an over-reliance on the part of the drivers in relation to the Traction Control Management System (TCMS) Console for confirmation of the doors being closed and locked; this is in part, as a result of drivers not fully understanding that obstacle detection is removed for the last 10 mm of door travel to allow the doors to close.

The root cause (RC) associated with the incident was:

- RC-01 – The Transdev Dublin Light Rail Ltd (Transdev) suite of documents (SM 017 Driver Training Plan, SM 018 Competency Assessment, SM 019 Competence Assessment, Tramway Safety Instruction (TSI) Manual, etc) do not sufficiently warn the driver against the over-reliance of the tram's doors closed and locked indications as an assurance that the door is free from obstacles. Therefore, a thorough final visual door check (using CCTV and mirrors) after obtaining doors closed and locked indications and before moving the tram to confirm that nothing is trapped in the doors is essential.

The RAIU made ten recommendations related to the incident and three related to additional observations, as follows:

- Safety Recommendation 2020001-01 – Transdev should update their suite of document for driver training (SM 017 Driver Training Plan), operations (TSI Manual) and competence assessment (SM 018 & SM 019 Competence Assessment) to include a requirement for drivers to conduct a thorough final visual check (using CCTV and mirrors) after obtaining doors closed and locked indications and before moving the tram to confirm that nothing is trapped in the doors;
- Safety Recommendation 2020001-02 – Transport Infrastructure Ireland (TII) should conduct a risk-based review on whether CCTV platform monitors should be installed at high-use tram stops;
- Safety Recommendation 2020001-03 – TII should conduct a risk-based review on whether the tram fleet operating on the Red Line should be upgraded with coloured rear view monitors;
- Safety Recommendation 2020001-04 – Transdev and TII should develop new labels, for the application on tram doors, which warn passengers of the dangers of closing doors;
- Safety Recommendation 2020001-05 – Transdev, as part of the update to the SMS 018 Competence Assessment, should formally include the assessments that should be conducted every quarter;
- Safety Recommendation 2020001-06 – Transdev should brief drivers on the operation of the door mechanism, and specifically explain the removal of obstacle detection for the final 10 mm of door travel; this briefing should then be incorporated into their suite of training and competence management documents;
- Safety Recommendation 2020001-07 – Transdev should develop and implement an induction training and competency assessment program for security staff, which should include training and assessment in the use of safety critical communications;
- Safety Recommendation 2020001-08 – Transdev should update their Work Instructions (WIs) to ensure that appropriate testing is conducted for sensitivity of obstacle detection, door impact for closing forces and obstacle removal forces; the requirements set out in Irish Standard (I.S.) EN 14752 should be used, as appropriate;

- Safety Recommendation 2020001-09 – Transdev should update their drugs and alcohol policy to include explicit requirements that testing is conducted post incident/accident where the actions of a driver may have contributed to the incident/accident. Transdev should also develop a system whereby a decision not to test an individual is documented with clear justification for the decision provided;
- Safety Recommendation 2020001-10 – Transdev should update their Chain of Care Procedure mandating that drivers are subject to appropriate developmental supports (such as assessment, monitoring and supervision) post incident/accident. Depending on the type of incident/accident, and whether the actions of the driver contributed to the incident/accident, specified periods of time of continuing developmental supports should be set.

As the RAIU were preparing the publication of this investigation report, another similar occurrence was reported to the RAIU which occurred on the 22nd January 2020 at 18:08, whereby a female, pushing a buggy, got her hand trapped in the tram doors at Jervis Stop and was dragged along beside the tram.

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The incident

Parties & roles involved in this incident

Parties involved in the incident

- 1 Transdev Dublin Light Rail Ltd (to be referred to as Transdev for the remainder of this report) operates the Luas light rail tram system in Dublin. As of the 1st December 2019, Transdev are now also the Vehicle Maintenance Contractor (VMC) and Infrastructure Maintenance Contractor (IMC); and they provide the security staff.
- 2 At the time of the incident Alstom Ireland Limited (to be referred to as Alstom for the remainder of this report) were both the VMC and the IMC. Alstom are also the original manufacturers and suppliers of the Citadis trams in operation on the LUAS network.
- 3 At the time of the incident STT were contracted, by Transdev, to provide security staff on Luas trams and infrastructure.

Roles involved in the incident

- 4 The Luas Driver (to be referred to as the Driver for the remainder of this report) is employed by Transdev. The Driver has been trained and is deemed competent to drive Luas trams and has approximately four years' experience. The Driver passed his last assessment on the 31st January 2019 (with no restrictions).
- 5 There were two STT staff on duty at Heuston Stop at the time of the incident (they will be referred to as STT 1 and STT 2 for the remainder of this report). STT 1 had four years' experience working in general security with eight months specific to Luas security. STT 2 had eleven and a half years' experience working in general security with fifteen months specific to the Luas security. There is no competency assessment for STT security staff.

Parties & roles not directly involved in the incident

- 6 TII was established through a merger of the National Roads Authority and the Railway Procurement Agency under the Roads Act 2015. The TII's primary function is to provide an integrated approach to the future development and operation of the national roads network and light rail infrastructure throughout Ireland.
- 7 TII is the Irish State body that provides the rolling stock and infrastructure required for the Luas light rail network.

Summary of the incident

- 8 On the 26th March 2019, Luas Tram 3011 was operating the 13:49 hrs Tallaght to Connolly service.
- 9 At 14:20:57 Tram 3011 came to a stop at Heuston Stop and the Driver pressed the left side selection button followed by the door authorisation button (this allowed passengers to exit and enter the tram by pressing the local door open button).
- 10 At 14:21:24 the Driver checked that the platform was clear by viewing the Left and Right Rear view monitors on the driver's console before deselecting the authorisation button (this function commences the passenger closing door sequence) and then pressing the left side selection button.
- 11 At 14:21:26 a passenger ran towards Tram 3011 placing his hand between seals of the door and the door pillar on the rear door, as the door was closing. The passenger's hand became trapped between the rear door and the door pillar one second later.
- 12 The Driver viewed the door open indicator lamp had extinguished on the Driver's console and the Traction Control Management System (TCMS) Console showed all passenger doors were closed and locked.
- 13 The Driver checked the signal at the end of the platform and sent a Ready To Start (RTS) command.
- 14 With a proceed signal in front of the tram the Driver commenced his departure from Heuston Stop 14:21:46 (nineteen seconds after the passenger first got his hand trapped).
- 15 STT 1 and STT 2 saw the passenger with his hand trapped in the door and came to his assistance.
- 16 The passenger and STT staff walked along the platform keeping pace with the tram as it moved along the platform.
- 17 STT 1 made a general call using the Tetra radio system requesting "Heuston inbound will you open up there" a similar message was repeated after the Driver had answered "The signal has just changed".
- 18 At approximately 14:21:51 the STT staff succeeded in freeing the passenger's hand from the door; the passenger did not report any injuries (twenty-four seconds after getting his hand trapped in the doors).
- 19 A jogger who was passing by and saw the incident, ran to the front of the tram and advised the Driver.
- 20 The Driver brought the tram to a stop at 14:21:54.

General description of the tramway

Infrastructure

- 21 The Dublin Luas tram network consists of two lines the Red line serving Saggart and Tallaght to the West and the Point to the East with a spur off to Connolly Railway Stop. The Green Line serves Broombridge to the North and Brides Glen to the South.
- 22 Trams operate on a combination of separated track, segregated track and shared running (where the trams share the road with other road users).
- 23 Heuston Stop is located on the Red Line, see Figure 1, which consist of 21 kilometres (km) of track and thirty-two Stops.
- 24 Trams are powered by an Overhead Conductor System (OCS) providing 750 volts (V) DC.
- 25 The infrastructure was not found to be contributory to the incident.

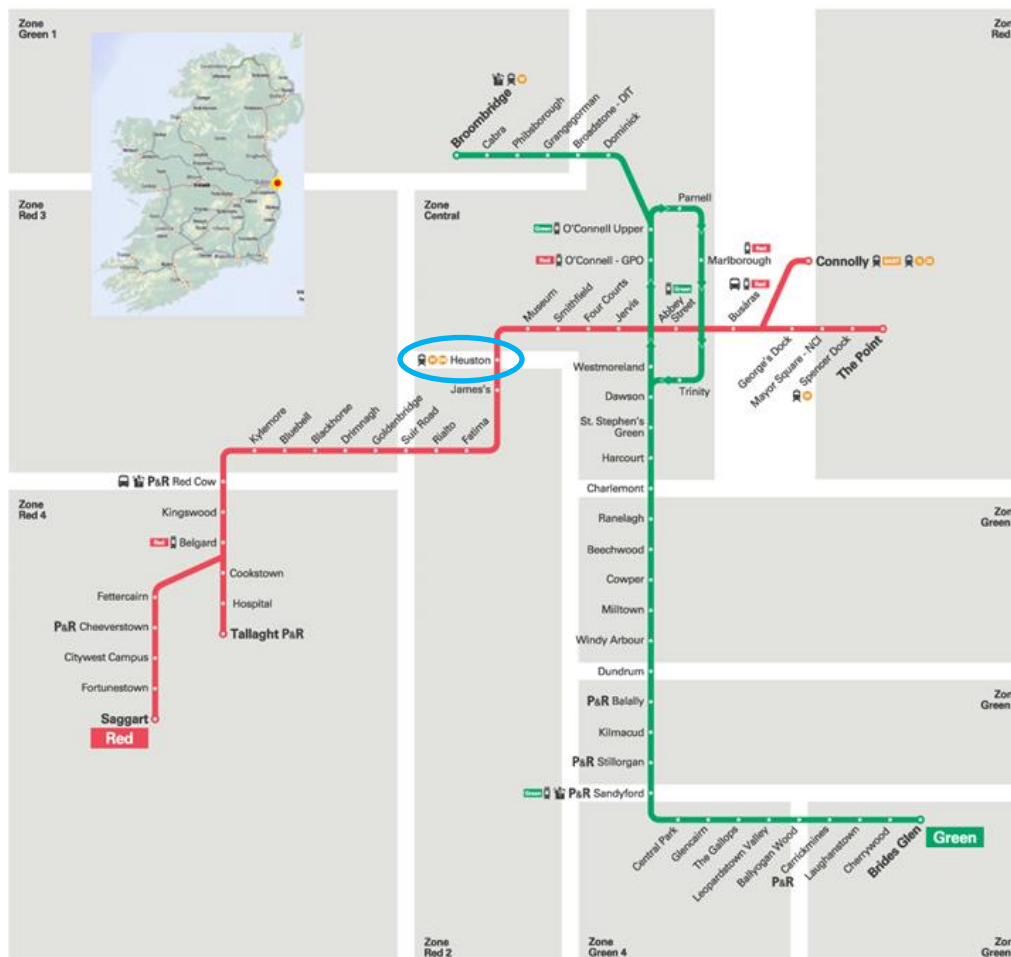


Figure 1 – LUAS network with Heuston Stop circled in blue

Rolling Stock

- 26 The tram involved in the incident, Tram 3011, is a Citadis 401 type tram manufactured by Alstom Transport in La-Rochelle in France; it has a mass of 49,616 kilograms (kg) and is 40.813 m long.
- 27 At the time of the production of trams (before their introduction in 2004) the relevant standard in relation to door operation checks and tests was a French Standard, NF F 31-054, issued by Association Francaise de Normalisation in December 1994, entitled "Railway rolling stock - "Passenger" access doors for vehicles intended for use on urban and suburban networks".
- 28 Later trams complied with EN 14752:2005, Railway Applications – Body Side Entrance Systems for Rolling Stock. It should be noted, that since the drafting of this RAIU report, newer versions EN 14752:2005 and EN 14752:2019 have been published. It should also be noted that the National Standards Authority of Ireland (NSAI) have converted these documents into Irish Standards e.g. I.S. EN 14752:2015, Railway Applications – Body Side Entrance Systems for Rolling Stock. For ease of reading, the RAIU will reference the standard as I.S. EN 14752, where recommendations are made, the party should consider the requirements set out in the latest standard publication.

Signalling and communications

- 29 Tram movements operate on a line of sight principle and are also controlled by line side signals normally positioned to the left of the leading driving cab on the kerb. The signals are provided by an array of *light emitting diodes* (LED) which are lit according to the type of signal to be displayed, horizontal (stop), vertical (proceed).
- 30 The means of communication between tram drivers and the Central Control Room (CCR) is by Tetra radio or the on-board cab phone.
- 31 Communication between STT security staff and the tram driver is by Tetra radio system.

Operations

- 32 Trams are regulated on track by "line of sight driving" where the driver is responsible for observing and maintaining a sufficient distance from trams ahead, motor vehicles, pedestrians, hazards or obstacles that are present or can be expected to be present on the track so the driver can stop the tram without causing a collision.

Fatalities, injuries & material damage

Fatalities & injuries

- 33 Although the passenger's hand was trapped in the door, the passenger left the scene when his hand was freed and did not report the incident.

Material damage

34 There was no material damage as a result of this incident.

External Circumstances

Weather

35 The weather on the 26th March 2019 ranged between a minimum temperature of 1.9°C and a maximum temperature of 12.7°C with no rainfall over the course of the day.

36 The weather was found not to be contributory to the incident.

RAIU Investigation

RAIU decision to investigate

- 37 In accordance with the Railway Safety Act 2005 and Statutory Instrument No. 258 of 2014 European Union (Railway Safety) (Reporting and investigation of Serious Accidents, Accidents and Incidents) Regulations 2014, the RAIU investigate all serious accidents, the RAIU may also investigate and report on accidents and incidents which under slightly different conditions might have led to a serious accident.
- 38 Under slightly different conditions, this incident may have led to a serious accident with the potential for a fatality or serious injuries due to the passenger's hand being trapped in a door and the tram commencing moving; therefore, a decision was made to investigate.

Scope of investigation

- 39 The RAIU must establish the scope of the investigation to ensure that only pertinent information is recovered and reviewed. Therefore, for this investigation, the RAIU have defined the following scope:
- Establish the sequence of events leading up to the incident;
 - Establish, where applicable, the immediate cause, contributory factors, underlying factors and root causes;
 - Examine the relevant elements of the door mechanism;
 - Examine the maintenance schedule and instructions for tram doors;
 - Examine the operational dispatch procedures at Luas stops;
 - Examine the procedures in place for carrying out safety critical communications;
 - Review the SMS documentation in relation to risk and hazard identification;
 - Review previous tram door incidents in Ireland;
 - How lessons learned from other tram operators are disseminated to the Luas network.

Investigation and evidence

- 40 During this investigation the RAIU collated and logged the following evidence:
- Heuston Stop CCTV;
 - Witness evidence from parties involved in the incident;
 - Transdev standards, procedures and other documentation;
 - Maintenance regime for passenger entrance doors;
 - European and Irish standards for passenger entrance doors.

Evidence

Passenger doors

Passenger door operation

41 The Citadis 401 type tram are formed of five modules. The driving cab modules at each end of the tram have a single sliding passenger door and two sets of double doors on each side, the centre module has one double door on each side, and the two intermediate modules have no doors, see Figure 2.

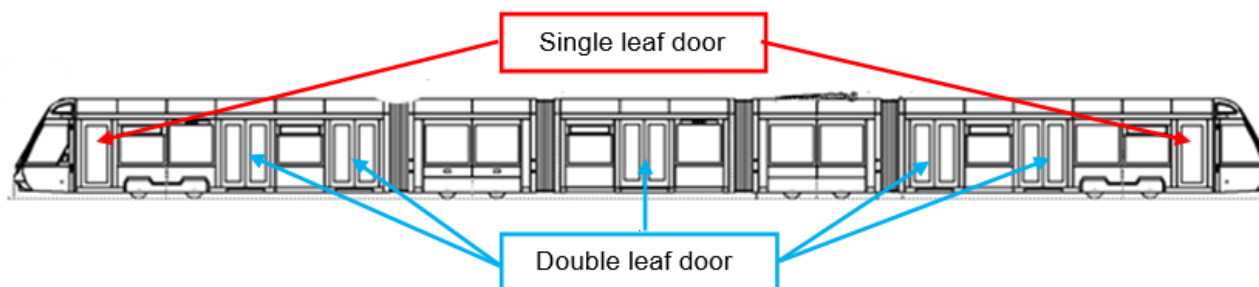


Figure 2 – Door arrangement on a Citadis 401 type tram

42 Doors are opened by the action of an electric motor. The passenger doors operate on the 'Driver Authorisation, Passenger Open' principle:

- Driver Authorisation – The tram must be stopped; and the driver must press the appropriate 'Side Selection' button followed by the 'Door Authorisation' button, see Figure 3;
- Passenger Open – The passenger must press the local 'Open Door' button for the desired door to open (it is noted that the driver can also open and close all doors from the cab).

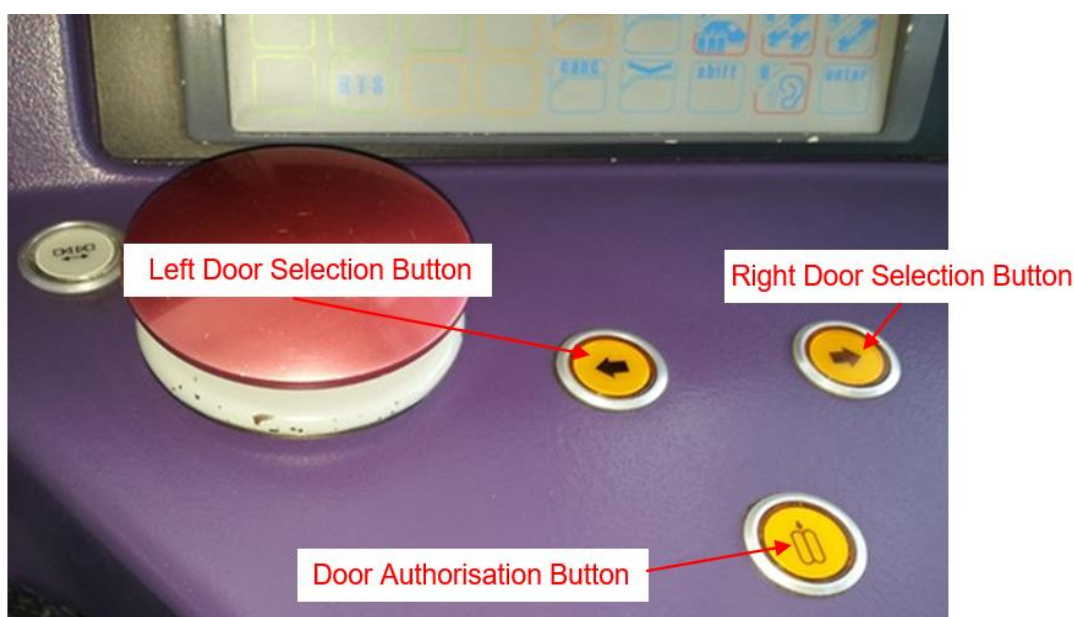


Figure 3 – 'Door Selection' & 'Door Authorisation' buttons on the Driver's Console

- 43 When a door is open the Door Indicator Light on the driver's console is illuminated and the internal amber lights above the door flash. The driver can view the platform side from the Left and Right Rear View Monitors on the driver's console; the image on the Rear View Monitors on the Red Line are black-and-white whereas the images on the newer fleets on the Green Line are full colour and give a clearer picture.

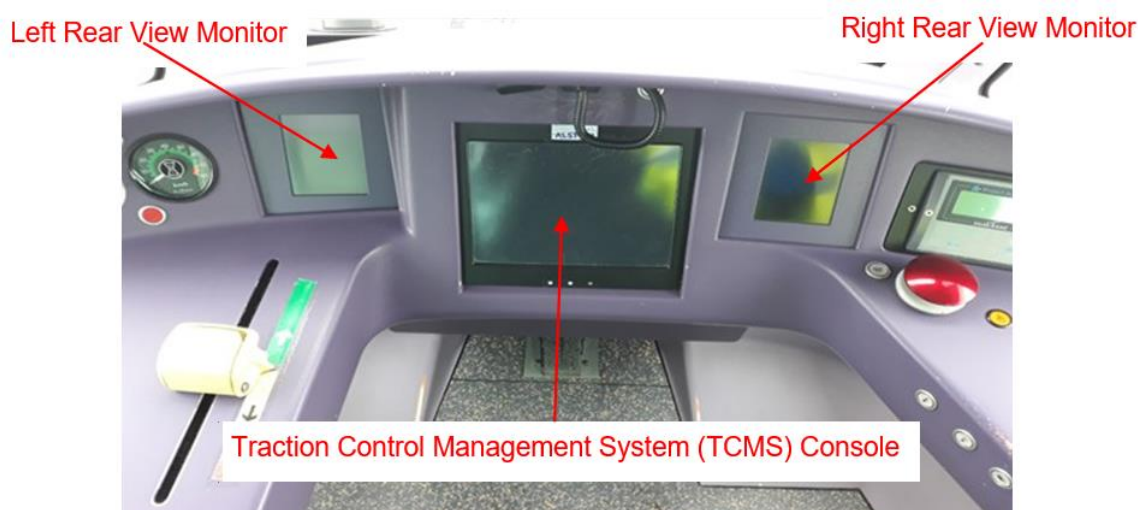


Figure 4 – Rear View Monitors & TCMS Console

- 44 To close the doors, the driver deselects the 'Door Authorisation' button, waits until all the doors are closed and then deselects the appropriate 'Door Selection' button. If the side 'Door Selection' button is deselected before the doors are closed, the door will continue to close but without the operation of obstacle detection. This anomaly is addressed in driver documentation, such as the TSI Manual (see last bullet of paragraph 65).
- 45 Doors are closed by the action of an electric motor and locked by means of spindle unlock brake; micro-switches fitted to each door confirm the door is closed and locked. When all doors are closed the Door Indicator Light on the driver's console and the internal amber lights situated above the door extinguish. The status of the doors can be viewed by the driver on the TCMS Console (see Figure 4).
- 46 Doors are fitted with obstacle detection to detect obstacles in the path of the door, which in turn reduces the possibility of injury in the event of a passenger being struck by a closing door. The system monitors the passenger door electric motor current values and compare the value to the stored normal current value. If the current value is higher than the stored value the door reopens during the closing sequence and the tram cannot take power. To prevent the doors reopening when a pair of double doors abut or when a single door touches the door pillar obstacle detection is removed from the door for the last 10 millimetres (mm) of travel. This has the effect of obstacles less than 10 mm not being detected even though the TCMS Console will show all doors closed and locked; and the tram can take power. The door operation does not differ from the passenger doors on heavy rail and tram systems around the world, in relation to the removal of obstacle detection for the final 10 mm of door travel.

Alstom Work Instructions related to passenger doors

- 47 At the time of the incident the maintenance and inspection of the passenger doors on Luas trams is carried out by Alstom (it should be noted that Transdev are now the VMC and IMC) and in accordance with periodic scheduled maintenance exams at intervals of 30,000 km, 60,000 km, and 120,000 km.
- 48 Specific tasks in the scheduled maintenance exams are called Work Instructions (WI). The door checks that are included in the scheduled maintenance are as follows:
- ATS-LUAS-WI-00588, Cleaning and greasing of door seals, to be undertaken every 30,000 km (Revision C published in September 2013);
 - ATS-LUAS-WI-00597, Door inspection and test, to be undertaken every 30,000 km (Revision D published in July 2015);
 - ATS-LUAS-WI-00903, Door test of the obstacle detection devices, to be undertaken every 30,000 km (Revision D published in July 2015);
 - ATS-LUAS-WI-02663, Door trolley inspection & crack management, to be undertaken every 60,000 km (Revision C published in January 2017);
 - ATS-LUAS-WI-02280 Door adjustment and set up, to be undertaken every 60,000 km (Revision B published in May 2015);
 - ATS-LUAS-WI-00722, Door lubrication of mechanism, to be undertaken every 60,000 km, (Revision C published in June 2012);
 - ATS-LUAS-WI-02427 Threshold plate inspection, to be undertaken every 120,000 km (Revision D published in January 2017).
- 49 In relation to ATS-LUAS-WI-00903, Door test of the obstacle detection devices, the WI states, in text, that it requires the use of a 10 mm flat bar to check the door closing obstacle detection (see circled red text in Figure 5); however, the illustrative photograph shows a round bar, which is 30 mm being used for testing (see photograph in Figure 5). The RAIU verified that it was, in fact, the round bar that Alstom were using for a 30 mm obstacle detection test.

- (d) From the outside, place the **10mm** flat at shoulder height in the centre of the two doors or in the case of the single doors against either the door or the body of the tram. [Q]
(e) Wait for the door to close (this should take **10 seconds**). [Q]
(f) Let the door close onto the **10mm** flat (see Fig. 4). [Q]

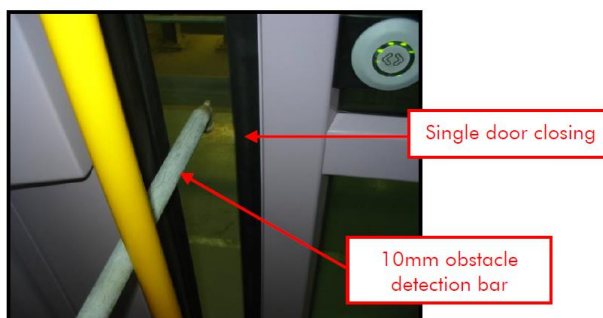


Figure 4

- (g) The door reopens for **1 second** and will attempt to close again. [Q]
(h) Move the bar and place the **10mm** flat just below the level of the door open push button. [Q]
(i) With the obstacle still present the door will reopen again for **1 second**. [Q]
(j) Move the flat to roughly **150 mm** from the floor. [Q]
(k) The door should try to close another **3 times**. [Q]
(l) The close/ open cycle should have repeated now **5 times** in total. [Q]
(m) The door should open and stay open with the green LEDs in the push button continuously illuminated (see Fig. 5) until reset or a closure signal is given from the driver's desk.

Figure 5 – 10 mm obstacle detection round/ flat bar

Requirements set out in I.S. EN 14752

50 In comparison, although not required in relation to this tram, I.S. EN 14752 requires the following testing:

- Sensitivity of obstacle detection using a 30 mm cross-sectional non-elastic rod which should be trapped vertically (in three positions) between the door leading edge and the frame or between two door leaves, resulting in the door not indicating as closed and locked in the driver's console;
- Door impact for closing forces, which sets out the maximum forces to be exerted by using an appropriate measuring device;
- Obstacle removal force, which requires that an obstacle with maximum dimensions of 10 mm x 50 mm should be trapped between the leading door edge and the frame or between two door leaves shall be removed by being slowly drawn in an outward direction with the force not higher than 150 Newton (N);
- Anti-drag testing which requires that a secondary feature shall detect dynamically the force incurred on the door leafing edge.

Post-incident inspection of Tram 3011

- 51 As part of the investigation the passenger doors on Luas tram 3011 were examined, doors were compliant to the Alstom standards.
- 52 The RAIU also noted, as part of the examination that there are no labels on the doors warning of the dangers of closing doors.

Luas Infrastructure

Heuston Stop Infrastructure

- 53 On the day of the incident, the mounted inbound platform mirror was missing. It cannot be determined how long it had been missing as it was not reported by drivers, see Figure 6 for missing mirror (circled in red); see Figure 7 for replacement mirror.



Figure 6 – Missing mirror



Figure 7 – Replacement mirror

- 54 A close up of the mirror at Heuston Stop (Figure 8) shows that the signal pole is obstructing some of the driver's view. By way of comparison in relation to platform viewing, the inbound platform at Charlemont Stop on the Green Line is fitted with a colour CCTV monitor to assist tram drivers looking at the platform and doors (Figure 9); it should be noted however, this has been installed primarily as a result of the curvature of the line.



Figure 8 – Mirror Close-Up



Figure 9 – Charlemont CCTV Monitor

Tram Safety

General description

55 Transdev manage safety of staff, passengers and the public through a suite of standards. The Transdev Management Standards relevant to this investigation are:

- Transdev Safety Management System (SMS) Issue 13, published on the 7th February 2019, was live at the time of the incident (it has since been updated);
- TSI Manual, Revision 4, published on the 20th April 2018;
- Transdev Radio Protocol (TRP), first issued in 2014, the latest revision was issued on the 8th February 2019.

56 As part of this investigation, the RAIU also reviewed information that was issued to drivers that was in direct reference to doors. The RAIU found that a general notice, a safety alert and a safety notice had been issued, to be discussed in paragraphs 72, 73, 74 respectively.

Transdev SMS

57 Transdev's responsibilities to their staff, passengers and the public are defined in their Safety Management System document as follows:

- The operation of the Luas customer-carrying Light Rapid Transit Rail System in Dublin;
- The management and support of all staff working for Transdev;
- All aspects of customer service and Luas stop operations within the system;
- Maintaining collaborative, proactive, relationships with our client, TII, the Commission for Railway Regulation (CRR) and other stakeholders such as Dublin City Council, South Dublin County Council, other transport operators within Dublin, An Garda Síochána and emergency services;
- Service planning;
- Supporting activities;
- Ensuring effective vehicle and infrastructure maintenance is undertaken by Alstom.

58 The Transdev SMS is supported by additional documents relevant to the incident:

- SM 017 Driver Training Plan, Issue 3, published on the 30th November 2018 – which includes instruction on 'Trams In Service'; stating "Correct door control procedures: correct side & check internal mirrors & cameras before closing doors ensuring all doors are closed properly".

59 Competency assessment for drivers is addressed in the following documents:

- TTI Luas SM 019, Competence Assessment for Driver with less than two years of service, Issue 2, issued on the 12th December 2018 (to be referred to as SM 019 Competence Assessment for the remainder of this report);
- TTI Luas SM 018 Competence Assessment for Tram Drivers over two years of experience, Issue 2, issued the 1st January 2019 (to be referred to as SM 018 Competency Assessment for the remainder this report). As the Driver in this incident, had over two years' experience, this is the document relevant to this investigation.

60 SM 018 Competence Assessment requires a tram driver with over two years' experience to be assessed every quarter in a two-year cycle. Each quarterly assessment focused on a different topic. Year 1, Quarter 1 requires competence assessment of: "Depot / Line Side Signalling (LSS) Procedures / Defensive Driving Techniques & Drive Safe Management Skills". SM 018 Competence Assessment lists the remaining seven quarter assessments as "To be agreed"; however, although not formally identified in SM 018 Competence Assessment, the assessments are as follows¹:

- Quarter 1 – Depot / LSS Procedures / Defensive Driving Techniques & Drive Safe Management Skills;
- Quarter 2 – Tramway Signals 3 – 3.11.2 Tramway Junctions & Highway Crossings;
- Quarter 3 – Professional Drivers code of conduct, Human Factors;
- Quarter 4 – General Rules Ref TSI 6;
- Quarter 5 – Fault and Degraded Operation;
- Quarter 6 – Emergency Situations;
- Quarter 7 – Passenger Service Normal Operation;
- Quarter 8 – TSI Operations Principles and General Procedures Refresh.

61 Quarters 1, 4 and 7 assessments all have door related competence that are relevant to the incident:

- Quarter 1 – Question 5(M) – Check internal mirrors & camera's before closing doors & ensure doors are closed properly before moving off;
- Quarter 4 – Question 12(M) – Driver ensures doors are operated in a safe and efficient manner;
- Quarter 7 – Question 11(M) – Does driver follow correct door operation procedures; Question 4(M) – Why is it important to ensure all doors operation buttons are depressed prior to moving off from a platform; Question 5(M) – Why is it important to open and close doors in correct sequence.

¹ The assessments were identified by the RAIU through the 'Competence Assessment doe Drivers Staff Management SM 018' documents.

Tramway Safety Instruction (TSI) Manual

General

62 The TSI manual, developed by Transdev, is compliant with the Passenger Safety Case and defines the rules and regulation to be applied on the Luas network. Below are the sections relevant to this RAIU investigation.

Starting a Journey

63 Section 5.4, Starting a Journey, states that before a tram departs from the depot or terminus, the driver must check that:

- The departure time is according to the timetable or as instructed by CCR, the destination banners are correct;
- The doors are clear before activating closure;
- If necessary, in case of large crowds or if the driver does not have a clear view of the length of the tram, the driver must alert passengers via a Passenger Announcement (PA) that the doors are closing;
- When the doors have been closed, proceed if safe to do so;
- Enter a Ready to Start (RTS) command prior to departure from each stop;
- Trams have to be driven according to the timetable, or as instructed by CCR.

Door Operation

64 Section 5.10, Door Operation, states to drivers:

- Do not commence the door selection before the tram comes to a complete stop;
- Select side selection button;
- Select door authorisation button;
- Selecting open all doors button is forbidden unless: a) Instructed by CCR; b) An emergency evacuation; c) At a platform when identifying that a passenger has difficulty entering the tram (elderly, mobility impaired).

65 In terms of doors closures, it states:

- Use cameras (and mirrors if available) to confirm doors are clear of passengers/obstructions;
- Use the chimes and make a PA announcement in case of crowding;
- Deselect authorisation button;
- Wait until all doors are closed;
- Deselect side selection;
- Do not deselect side selection button until all doors are closed otherwise the obstacle detection is no operative (passengers may be trapped and injured).

Transdev Radio Protocol

General

- 66 The Luas Tetra radio system allows drivers, security staff and CCR to communicate, messages transmitted can be heard by all Luas Tetra radio holders.
- 67 The purpose of the Transdev Radio Protocol is to define the employees and contractors' responsibilities for the proper, secure and appropriate use of the Transdev radio communication system.

Emergency Calls

- 68 An emergency call may be made from the tram radio system or mobile handset, this call has priority above all other calls. Use of the emergency call facility for any purpose other than a genuine emergency is strictly forbidden. The emergency call must include the following:
- State clearly TWICE that "This is an Emergency call";
 - The tram number or service number when relevant;
 - The location of the emergency;
 - The nature of the emergency;
 - Whether an emergency di-energisation of the OCS is required;
 - Whether any of the emergency services are required;
 - Whether any other lines are blocked.
- 69 CCR must repeat all the details given by the user, to demonstrate that the call has been understood, and the caller must confirm this understanding.
- 70 If the caller omits to give any of the required details, the Traffic Supervisor must obtain this information from the caller.

Training

- 71 It was reported by Transdev that the Transdev Radio Protocol was briefed to both tram drivers and STT staff; however, there is no form of competency assessment conducted for the STT Staff.

Alerts & Notices issued to tram drivers

General Notice GN06/2018

72 On the 8th February 2018, Transdev's Safety Department issued GN06/2018 stating "For information, recently on a Nottingham tram, a pushchair trapped in the doors remains attached by its plastic weather guard to the tram and was dragged while the tram was travelling between two stops". The general notice continues "we remind all staff to only depart a stop when all doors are closed and to check the camera or mirror that they are unobstructed as the consequences in not doing so could be serious".

Passenger Door Safety Alert

73 After an incident in Greater Manchester (UK), in May 2018, where a passenger was trapped in a door, the Safety Department issued a Safety Alert (Figure 10) soon afterwards.

SAFETY ALERT

Safety alert/ incident report:
Passenger trapped in tram doors
and dragged at Bury tram stop,
Greater Manchester, 30th May 2018

This incident demonstrates:

- The importance of tram drivers not relying on tram doors closed and locked indications (interlock system) as an assurance that nothing is trapped in the doors
- The need for managers to provide comprehensive and consistent safety messages to their staff in response to safety incidents




Figure 10 – Safety Alert for Tram Drivers in relation to passenger doors

Safety Notice SN20/2018

74 Safety Notice SN20/2018, issued on the 12th September 2018 states “Please be aware that there has been an increase of complaints from passengers being trapped in doors including children resulting in alleged injuries². We remind all driving staff to make sure that all doors are unobstructed before commencing door operation as the consequence in not doing so could be serious. Please observe the following:

- Always check your camera monitors and internal cab mirrors for passenger movements entering or exiting your tram;
- If you cannot see the length of the tram, make an announcement that doors are about to close before commencing your de-selection of doors;
- Allow ample time for passengers to board and disembark before commencing your door de-selection;
- Always make announcements at peak times and at busy stops;
- Be aware of mobility impaired passengers awaiting to board or who may be disembarking your tram as they will be slow to do so, and give ample time for them to clear your doors before commencing your door de-selection;
- Traveling with the side select button engaged is strictly forbidden;
- Do not select/authorise doors before the tram comes to a complete stop;
- Activating the "Open all Doors" button is forbidden except in an emergency or instructed by CCR;
- Please refer to page 32³, and 58⁴ to 61⁵ of your TSI for correct door operation procedures”.

² Please note that these were trapping incidents, and not trap and drag incidents.

³ The doors must only be released once the tram has stopped. The driver must stop at/or after the yellow dots on the platform. Activating the Open All Doors button is forbidden unless instructed by CCR in an emergency or at a platform when identifying that a passenger has difficulty entering the tram (elderly, mobility impaired),

⁴ Sets out the door operation requirements.

⁵ Set out the instructions related to forced door closure and single leave door button.

Events before, during & after the incident

Events before the incident.

- 75 On the 26th March 2019, Tram 3011 departed Tallaght on route to Connolly. The journey was uneventful up to Heuston Stop with a good volume of passengers exiting and boarding at the stops along the way.
- 76 Tram 3011 stopped on the inbound platform at Heuston Stop at 14:20:57. At 14:20:59 the Driver pressed the left-hand door side selection button and then pressed the door authorisation button to allow passengers to open the doors. All entrance doors were opened by the passengers and the passengers exited and boarded the tram (Figure 11, footage taken from platform CCTV for all the below images).



Figure 11 – Passengers boarding Tram 3011



Figure 12 – Passengers clear of doors

- 77 At 14:21:24 the Driver checked the console mounted CCTV monitors, in cab, to ensure all passengers were clear of the doors (see Figure 12), before deselecting the authorisation button, waiting a few seconds and then deselecting the left hand door side selection button.

Events during the incident

- 78 At 14:21:26 an intending passenger ran towards the rear most door on Tram 3011 and placed his hand between the door seal and the door pillar. All the doors closed, and the passenger's fingers became trapped in the rear door (see Figure 13).
- 79 The door adjacent to the passengers door re-opens, likely due to an obstruction greater than 10 mm being detected, however, on the rear most door, the passenger's hand remains trapped as the passenger's hand was less than 10 mm (Figure 14).

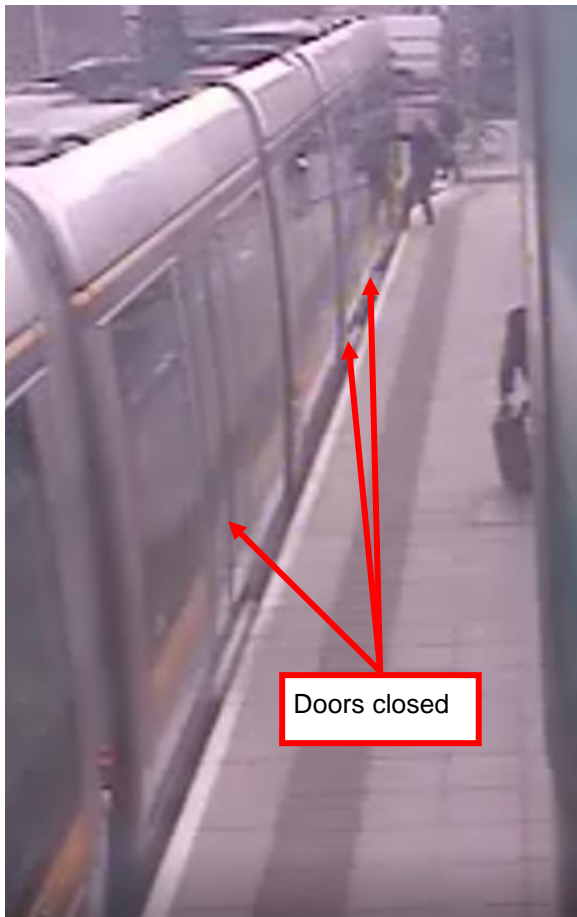


Figure 13 – Passenger's hand trapped in door

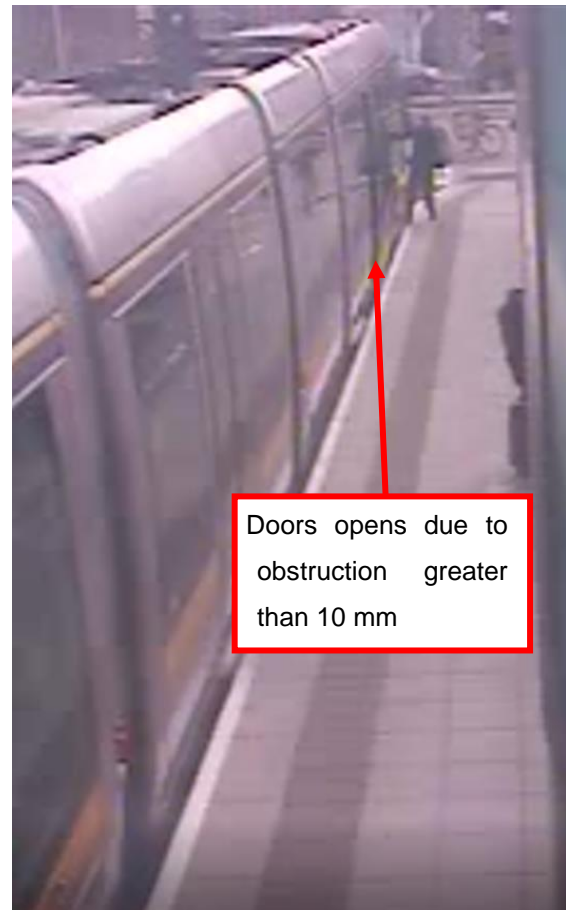


Figure 14 – Door, in front of trapped passenger's door, opens

- 80 Approximately at the same time, the Driver viewed the TCMS Console, that showed all doors locked and closed before pressing the RTS button.

- 81 At 14:21:42 two STT Security Staff working at Heuston platform came to the assistance of the passenger (see Figure 15). STT1 made a call to the Driver on the Tetra Radio System:

STT1: "Heuston inbound will you open up there";

Driver: "The signal has just changed";

STT1: "Heuston can you open up the doors please";

Driver: "Signal has just changed there, what's the problem?".

- 82 During the conversation, the Driver checks his TCMS console which shows that the doors were closed and locked; as a result of this and as he had already sent the an RTS command, the Driver did not open the doors.



Figure 15 – STT staff assisting passenger



Figure 16 – Passenger & STT staff moving with the tram

- 83 At 14:21:46 the Driver starts to move the tram off the platform. The intending passenger walks along the platform with his hand trapped in the door as the STT staff attempt to free the passenger's fingers (see Figure 16).
- 84 At 14:21:51 the STT staff are successful in freeing the passengers trapped fingers.

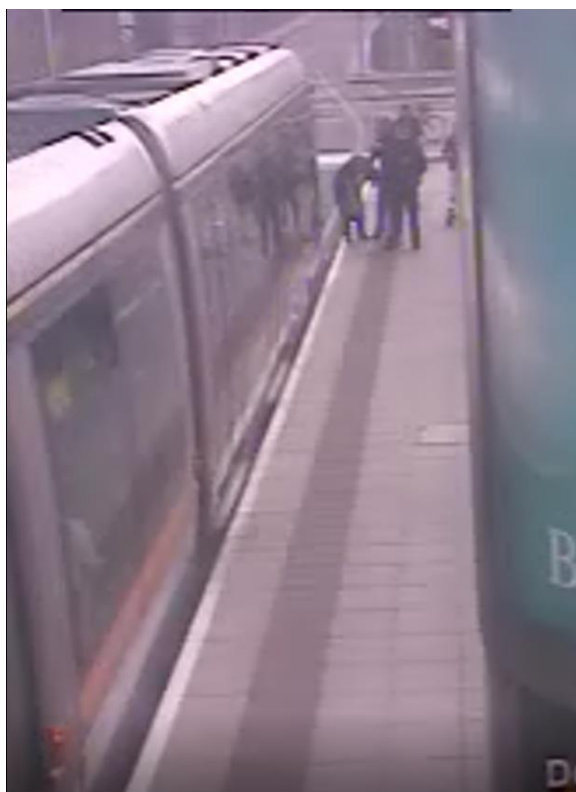


Figure 17 – Passenger's hand is freed



Figure 18 – Tram stops

85 A jogger passing near the front of the tram shouts at the Driver to stop his tram.

86 At 14:21:54 the Tam 3011 is brought to a stop.

Events after the incident

87 The Driver immediately reported the incident to CCR in accordance with the TSI Manual protocol.

88 The passenger who had his hand trapped in the door moves away from the platform and speaks to the STT Security Staff.

89 The Driver spoke to CCR and requests permission to move back onto the platform. CCR grant permission and the Driver walks through the tram to the rear cab before moving back on to the platform. The Driver speaks to STT staff.

90 The Driver walked back to the leading cab of the tram and proceeds on his journey; the driver continued driving for his full shift.

91 The Driver was interviewed by, and provided a statement to, Transdev post-incident and was not subject to any driving restrictions. The Driver was not tested for drugs and alcohol as a result of the incident. The RAIU requested information on whether the Driver was accompanied on his first duty post-incident, Transdev could not find a record of whether this occurred.

92 The incident was reported to the RAIU through Transdev's monthly accident/incident report for March 2019; the RAIU commenced a full investigation.

Similar occurrences

Similar occurrences prior to the incident at Heuston Stop on the 26th March 2019

Saggart Door Entrapment 22nd August 2018

93 On the 22nd August 2018 a family of two adults (one male and one female) and one minor were planning to board an inbound tram at Citywest. Tram 3002 arrived on the platform and the driver pressed the side selection followed by the door authorisation buttons. The female and minor from the family boarded the tram, the male walked to an adjacent door before turning back and attempting to board the tram as the doors were closing. The Driver released the doors for a couple of seconds before closing the doors again. The male placed his hands between the closing doors as the doors were closing. A short time later the tram moved from its stationary position. The male walks along the platform with his fingers trapped in the door before the tram comes to a stop after the driver was alerted to the occurrence by the other family members. The driver walked through the tram to the door and freed the passenger's hand.

94 Transdev's internal investigation, published the 1st October 2018, found that the immediate cause of the incident was that the tram moved off the platform with the male's fingers trapped in the door. Underlying causes were identified as:

- The driver was unaware that the male's hand was trapped in the door;
- The driver cab warning devices did not alert the driver to any door trap issues;
- The tram had traction and moved away from the platform.

95 Transdev identified root causes as:

- The current door set-up has the capacity to fail to danger but only in a specific set of circumstances – i.e. "obstruction has to be inserted less than 30 mm⁶ so that the door trap sensor does not register the obstruction and open the doors (the door capture device was working as intended, however, the fingers were caught in the 'extra' lip of rubber which causes the entrapment)";
- The male's behaviour did not show that he intended to board the tram (it was established that he was trying to pass a mobile phone to a member of his family).

96 As a result of the incident, the driver was assigned to a driver trainer for re-training and coaching in the following areas: correct procedures for reporting occurrences; further competency assessment before returning to duty. The driver was not drugs and alcohol tested as a result of the incident as the incident was only reported as a complaint by a passenger the day after the incident.

97 In addition, the safety department issued company communications and driver staff briefings as a result of the incident occurring.

⁶ Transdev's report is incorrect, the appropriate measurement is 10 mm. Transdev state that this was a typographical error.

Kylemore Door Entrapment 13th September 2018

98 On the 13th September 2018 a female with a small child and buggy intended exiting the tram at Kylemore outbound platform. The female was delayed in exiting the tram as she had difficulty moving the buggy. The child placed their hand in the doorway as the doors were closing and the child's hand became trapped in the door while the child was inside the tram. A female passenger who witnessed the occurrence came to the assist and pressed the SOS microphone but was unaware that she had to talk into the microphone and the driver remained unaware of the occurrence. A schoolboy passenger made his way to the driver's cab to alert the driver of the incident, but the driver presumed that the schoolboy was messing as he had confirmation of all doors being closed and locked on his TCMS Console and continued driving the tram. On arrival at the Red Cow Stop, the child's hand was freed, and the driver spoke to the female passenger who pressed the SOS microphone who informed the driver that she thought that the tram would stop when she pressed the SOS button.

99 Transdev found that the immediate cause of the occurrence was that the tram moved off from the platform with a young female child's fingers trapped in the door. Underlying causes were:

- The driver was unaware that the young child's fingers were trapped in the door;
- The driver cab warning devices did not alert the driver to any door trap issues;
- The driver was aware that the SOS button had been pressed but no one spoke into the microphone;
- The tram had traction and moved away from the platform at Kylemore.

100 The root cause was identified as:

- The current door set-up has the capacity to fail to danger but only in a specific set of circumstances – i.e. "obstruction has to be inserted less than 30 mm⁷ so that the door trap sensor does not register the obstruction and open the doors (the door capture device was working as intended, however, the fingers were caught in the 'extra' lip of rubber which causes the entrapment)".

101 There appears that no recommendations were made as a result of this incident.

102 The driver was not tested for drugs or alcohol as a result of the incident as the incident occurred at approximately 12:15 hrs with the driver finishing his duty at 12:25 hrs; after the sequence of events had been established.

⁷ Transdev's report is incorrect, the appropriate measurement is 10 mm

Similar occurrence since the incident at Heuston Stop on the 26th March 2019

Jervis Stop door trap and drag 22nd January 2020

103 On the 22nd January 2020 at approximately 18:06 hrs, Tram 3002 (a Citadis 401 type tram) stopped at the inbound platform at Jervis Stop, enabling the doors; with passengers alighting and boarding the tram.

104 The driver checked the console mounted CCTV monitors, in cab, to ensure all passengers were clear of the doors before deselecting the authorisation button, waiting a few seconds and then deselecting the left-hand door side selection button; with the doors beginning to close while a passenger with a buggy (circled in yellow in Figure 19) travels at pace towards the doors.



Figure 19 – Doors begin to close

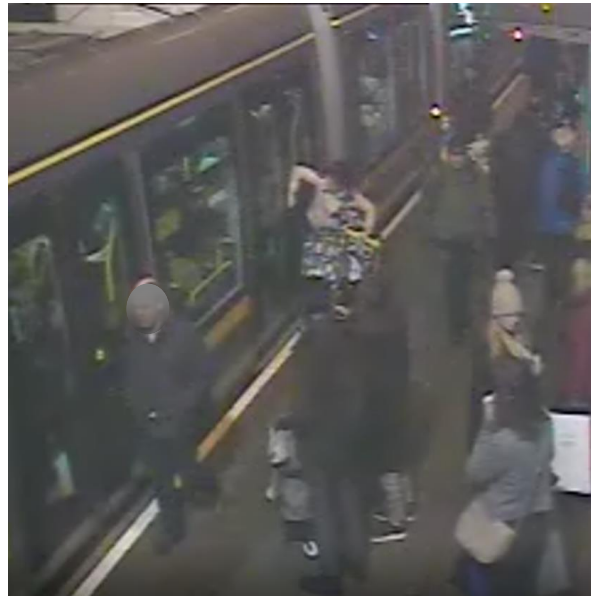


Figure 20 – Woman's hand trapped in doors

105 Approximately two seconds later, the passenger puts her hand between the doors as they are about to fully close resulting in her hand being trapped in the doors (see Figure 20); she began trying to pull her arm free after the initial trapping.

106 At the same time the driver viewed the door open indicator lamp had extinguished on the driver's console and the TCMS Console showed all passenger doors were closed and locked. The driver sent an RTS command. The driver checked his rear-view monitors (he did not see the passenger with her hand trapped) and checked the pedestrian crossing in front of the tram; before he commenced his departure from Jervis Stop (five seconds after the passenger first got her hand trapped) with the passenger's hand remaining trapped in the door (Figure 21). The driver was unaware that the passenger's hand is trapped.



Figure 21 – Tram begins to depart with hand trapped in doors



Figure 22 – Passenger being dragged along the platform

107 The woman is dragged along the platform (see Figure 22), begins to fall (see Figure 23), frees her hand and fall onto the platform (still Figure 24, which is a still of the CCTV taken three seconds after the tram begins its departure for Jervis Stop).



Figure 23 – Passenger frees hand and begins to fall onto the platform




Figure 24 – Passenger falls onto the platform

108 Security staff, present at Jervis Stop, attended to the passenger and accompanied her on another tram to her destination; she did not request medical attention and was uninjured.

109 The driver was interviewed by, and provided a statement to, Transdev post-incident. The Driver was not tested for drugs and alcohol as a result of the incident. On commencement of his next duty, post-incident, the driver was accompanied and assessed by a driver team leader and deemed fit to drive.

110 Transdev fleet maintenance inspected the tram door following the incident and confirmed the door was operating within specification i.e. obstacle detection was working correctly.

111 In addition, Transdev issued a safety alert on the incident the following day (23/01/2020), highlighting the importance of: using cameras and mirrors; following correct door operations; and, emphasising that objects less than 10mm may become trapped and not identified by the obstacle detection system, see Figure 25.



Transdev
the mobility company

Transdev Dublin Light Rail Ltd.

Safety Alert 23rd January 2020

Red Line/Green Line

Passenger Trapped & Dragged at Jervis Platform Inbound

TO ALL DRIVERS,

There was an incident of Trap & Drag at the Jervis inbound platform 22nd January 2020. The passengers hand got trapped in the door seal as the tram departed the platform. The person then became untrapped and fell to the ground. There was no reported injury at that time.

When departing the platform (paying particular attention to crowded platforms) drivers must comply with the following:

- Use cameras and mirrors to perform a thorough check after obtaining door interlock before moving the tram to confirm that nothing outside the tram is trapped in the doors.
- Always follow the correct door operation as per the TSI refer to page 32, and 58 to 61.

Please note that objects less than 10mm may become trapped and not identified by the obstacle detection system. Always check your camera before moving.

Let's continue to work together to improve on our safety performance

Issued by: Safety Team

If you have any difficulty with this notice, please contact CCR or a TL

Figure 25 – Safety Alert issued on the 23rd January 2020 after Jervis incident

Analysis

Passenger doors

Passenger door operation

112 The doors on the tram operate the 'Driver Authorisation, Passenger Open' principle, where the driver must press the required buttons in the appropriate sequence (paragraphs 42 - 43); and, there is another sequence for the closure of the passenger doors (paragraph 44). On the day of the occurrence the Driver applied the correct sequences and from the CCTV footage, it can be seen that obstacle detection was working while that tram was at Heuston Stop; this is relevant as it is noted that the pressing of the side selection button before the door authorisation button will result in the door closing without obstacle detection (paragraph 44).

113 Mass transit vehicle (trains and trams) fitted with powered passenger doors and obstacle detection systems all face the problem, the removal of the obstacle detection for the last 10 mm of travel to allow the doors to close (paragraph 46). This leads to a risk of objects less than 10 mm being trapped by a closing door and not being detected even though the TCMS Console will show all doors closed and locked; and the tram can take power.

Maintenance of the passenger doors

114 The Alstom passenger door schedule maintenance is a suite of WIs to be carried out at required frequencies (paragraphs 47 - 48).

115 ATS-LUAS-WI-00903, Door test of the obstacle detection devices, the WI text requires the use of a 10 mm flat bar to check the door closing obstacle detection, whereas the illustration shows a 30 mm round bar (paragraph 49), however, the RAIU verified that the round bar was being used; they also do a 30 mm testing for obstacle detection; these are the only tests carried out in relation to obstacle detection.

Luas Infrastructure

116 The RAIU found that the mirror at Heuston Stop was missing on the day of the incident (paragraph 53); and the replacement mirror had obstructions in its view (paragraph 54). Despite, the mirror being missing, STT1 told the Driver to open the doors; however, the Driver was reliant on the information given to him on the TCMS Console (paragraph 80); so it is unclear what impact the missing mirror on the Driver's behaviour on the day of the incident.

117 The colour rear view monitors fitted to the newer fleets on the Green Line provide a clearer image than the black and white rear view monitors on the Red Line.

118 CCTV monitor on the Charlemont inbound platform gives a clear image of the platform and tram (paragraph 54, Figure 9).

Tram Safety

Transdev Safety Management System

SM 017 Driver Training Plan

119 SM017 Driver Training Plan's correct doors control procedures states that trainers check that trainee driver's examination should observe trainee drivers choosing the correct door selection buttons and that they check internal mirrors and cameras before closing the doors ensuring all doors are closed properly (paragraph 58). This shows that there is a clear emphasis on checks before the closing the doors but not while the doors are closing or have just closed.

120 Ensuring that all doors are closed properly could be interpreted as a check of the TCMS Console to confirm all doors are closed and locked and not a visual check of the side of the tram. As discussed in paragraph 113, there can be an obstacle up to 10 mm trapped in the doors and the TCMS Console will display that the doors are closed and locked.

121 In the case of the incident at Heuston Stop, the Driver was unaware that the passenger's hand was trapped as the TCMS Console showed that the doors were closed and locked and he maintained this despite the call from STT1 (paragraph 82). The driver was also unaware of that a passenger's hand was trapped during the incident at Jervis Stop on the 22nd January 2020 (paragraphs 103 - 111).

SM 018 Competence Assessment

122 Although SM 018 Competence Assessment for Tram Drivers over two years of experience does not identify the eight quarterly assessments in the document, these assessments are conducted by Transdev (paragraph 60).

123 The competency assessment for quarter 1 of checking of internal mirrors & cameras before closing doors & ensure doors are closed properly before moving off (paragraph 61); could be interpreted by the driver as checking the mirrors and camera's before closing the doors and using the TCMS console to ensure doors are closed properly before moving off. As in the case of this incident, with the passenger arriving late after the driver had checked that the platform was clear but before the door closing sequence had completed, a passenger could be trapped by a closing door, with the TCMS console check not identifying the presence of an obstruction less than 10 mm trapped in the door (paragraph 113).

124 The competency assessment for quarter four relates to drivers ensuring doors are operated in a safe and efficient manner (paragraph 61). As the driver's assessment is of a limited time the chances of a driver being assessed for an unusual occurrence like a passenger placing his hand in a closing door; would be unlikely and the competency assessment of ensuring doors are operated in a safe and efficient manner would only relate to normal passengers entering and exiting.

TSI Manual

125 The TSI Manual gives itemised instruction for many of the situations a Luas tram driver is likely to be presented with in the course of their duties. The door closing instruction recommends the use of cameras and mirrors if available to confirm doors are clear of passengers/ obstructions but this instruction is not repeated when the driver is ready to depart the platform (paragraphs 62 - 65).

Transdev Radio Protocol

126 Transdev Radio Protocol requires emergency calls to state clearly “This is an Emergency call” twice (paragraph 70) along with specific details about the tram, location and nature of the emergency (paragraph 70).

127 In the case of this incident, the STT staff did not state “This is an Emergency call”, instead informally requesting “Heuston inbound will you open up there”. In addition, despite the Driver hearing the call, the Driver ignored the request, instead, the Driver relied on the information that was on the TCMS Console (paragraph 82).

128 Although the STT are briefed on the Transdev Radio Protocol, there is no form of competency assessment (paragraph 71).

Alerts & Notices issued to tram drivers

129 In 2018, after a number of door entrapment incidents and accidents in the UK and Ireland, Transdev issued three alerts/ notices in relation to door entrapments reminding drivers: to only depart a stop when all doors are closed and the check the camera or mirror that they are unobstructed as the consequences in not doing so could be serious; not to rely on tram doors closed and locked indications; and, general door opening/closing procedures (paragraphs 72 - 74).

130 On the 23rd January 2020, the day after the incident at Jervis Stop Transdev issued a safety alert, highlighting the importance of: using cameras and mirrors; following correct door operations; and, emphasising that objects less than 10mm may become trapped and not identified by the obstacle detection system (paragraph 111).

Conclusion

Passenger doors

Passenger door operation

131 The Alstom Citadis passenger doors operating on the Dublin Luas tramway do not differ from the passenger doors on heavy rail and tram systems around the world, in relation to the removal of obstacle detection for the final 10 mm of door travel (paragraph 46); and, it is not believed that a modification to the current door seals would be of benefit in reducing the risk as the issue is related to the removal of obstacle detection for the last 10 mm of travel.

132 As a result, tram drivers should not be solely relying on the tram's doors closed and locked indications (interlock systems) as an assurance that nothing is trapped in the doors. A thorough final visual door check (using CCTV if appropriate) is essential after obtaining doors closed and locked indications and before moving the tram to confirm that nothing inside and outside the tram is trapped in the doors.

133 A review of the door closing sequence also identified that obstacle detection could be inadvertently removed from the door if the door side selection was deselecting before deselecting the door authorisation button (paragraphs 44 and 112); obstacle detection was not removed on the day of the incident, with the correct sequence being carried out (paragraph 79).

134 In relation to communicating with the passengers in relation to doors closing, there are no labels on the doors used to instruct passengers on the use of the door equipment (paragraph 51), as set out in I.S. EN 14752 (paragraph 50); although, it is again noted that this standard was not required to be complied with at the time of the incident.

Maintenance of passenger door

135 The Alstom passenger door schedule maintenance is a suite of WIs to be carried out at required frequencies (paragraph 114). In relation to obstacle detection, the relevant WI requires the use of a 10 mm flat bar to check for obstacle detection, however, the WI shows a 30 mm round bar (paragraph 115).

136 There are no tests in relation to: sensitivity of obstacle detection; door impact for closing forces; obstacle removal forces as set out in I.S. EN 14752 (paragraph 50); although it is again noted that this standard was not required to be complied with at the time of the incident.

Luas Infrastructure

137 The RAIU investigation found that the in-cab rear view monitor does not appear to have been used by the Driver at Heuston Stop or it was ineffective at showing the Driver that there was a passenger's hand trapped in the door; in addition the mirror at Heuston Stop was absent. The newer colour rear view monitors fitted to the newer fleets on the Green Line provide a clearer image to drivers than the black and white rear view monitors on the Red Line (paragraph 117).

138 As a result, the Driver was relying on the information given to him on the TCMS Console (paragraph 116); this is evident, given the actions of the Driver during the exchange between the Driver and STT1, where the Driver checks the TCMS console which shows that the doors were closed and locked (paragraph 82).

Tram Safety

SMS Documentation, TSI Manual, Notices & Alerts

139 Transdev have a suite of documents in relation to training (SM 017 Driver Training Plan (paragraphs 119 - 121)) and assessing (SM 018 Competence Assessment (paragraphs 122 - 124) drivers in correct door control procedures; as well as the provision of a TSI Manual (paragraph 125). These documents outline that there are checks required (mirrors and cameras) before the doors are closing; but the procedures do not appear to be robust in terms of door checks prior to departing the platform. In addition, there seems to be an over-reliance on the TCMS Console for confirmation that the doors are closed and locked. As was the case in this the Heuston incident, where the Driver was mistaken in thinking that it was safe to proceed as the TCMS Console showed that the doors were closed and locked and he maintained this despite the call from STT1; and despite the fact that a Safety Alert had been issued in 2018 warning the drivers not to rely on the interlocking system (paragraph 129) the Driver also may have been unaware that obstacle detection is removed for the last 10 mm of door travel to allow the doors to close. This was also the case for the incident at Jervis Stop, where the driver did not see that a passenger's hand was trapped in the door (paragraph 121).

140 It is noted that SM 018 Competence Assessment does not identify what should be assessed in each quarter (paragraph 60). Given the infrequency of entrapments, the current assessment procedures are not robust in ensuring that drivers have a full and clear understanding of the door mechanism as it is not likely to be captured during routine assessments.

Transdev Radio Protocol

141 Transdev Radio Protocol requires emergency calls to state clearly "This is an Emergency call" twice not stated by STT1 in the Heuston incident, instead he informally asked for the doors to be opened, it should be noted that there is no competency assessments for STT staff (paragraph 128). Despite the informality, the Driver did not attempt to establish what had occurred, ignored the request; instead, the Driver relied on the information that was on the TCMS (paragraphs 126 - 127).

Immediate cause, contributory factors, underlying causes & root causes

142 The immediate cause of the passenger hand being trapped in the door of Tram 3011 was the passenger placed his hand in the door opening, as he attempted to board the tram, during the door closing sequence.

143 Contributory factors associated with the incident were:

- CF-01 – The Driver did not conduct an adequate visual check, using rear view monitors and mirrors during or after the door closing sequence; this, in part, may be as a result of deficiencies in the mirrors (absent from Heuston Stop) and ineffective in-cab monitors (older black and white monitors);
- CF-02 – There were no labels warning the passenger of the risk of attempting to board or exit a tram while the doors are closing;
- CF-03 – STT1 did not follow the instructions in the Transdev Radio Protocol which requires emergency calls to commence by saying “This is an Emergency call” twice.

144 The underlying cause associated with the incident was:

- UC-01 – There appears to be an over-reliance on the part of the drivers in relation to the TCMS Console for confirmation of the doors being closed and lock; this is in part, as a result of drivers⁸ not fully understanding that that obstacle detection is removed for the last 10 mm of door travel to allow the doors to close.

145 The root causes associated with the incident was:

- RC-01 – The Transdev suite of documents (SM017 Driver Training Plan, SM 018 Competency Assessment, SM 019 Competence Assessment, TSI Manual, etc) are not robust in ensuring that drivers are not relying on the tram’s doors closed and locked indications (interlock systems) as an assurance that the door is free from obstacles. Therefore, a thorough final visual door check (using CCTV and mirrors) after obtaining doors closed and locked indications and before moving the tram to confirm that nothing is trapped in the doors is essential.

⁸ It is apparent, that staff within Transdev are also unclear on the operation of obstacle detection of the doors, see paragraphs 95 and 100.

Relevant actions taken or in progress

Luas Infrastructure

146 As of the publication of this RAIU report, Transdev have notified the RAIU of the following actions:

- Labels warning passengers not to board or exit the tram as the doors are closing have been proposed by Transdev and sent to TII for approval;
- Completed testing for new coloured cameras and monitors to replace the current rear-view cameras and monitors. As a result of the tests Transdev will shortly issue a variation proposal to TII, for their approval, for the implementation of installation of these new coloured cameras and monitors;
- Updated their “Door test of the obstacle detection devices” WI (ATS-LUAS-WI-00903) in relation to the required use of the 10 mm flat bar; and are updating associated documentation to reflect this change.

Training & Competency Management of drivers

147 Transdev have updated driver training, assessment and refresher training with information, in particular in relation to “the correct procedure to prevent passenger door entrapments”, which states “always check camera monitors and internal cab mirrors for passenger movements entering or exiting your tram before closing the doors. Allow sufficient time for passengers to enter/exit tram in order to complete the coating process. For busy platforms make announcements to stand clear of doors”; as well as stating “Door obstacle detection will not detect items trapped in the doors less than 10 mm”.

148 In addition, CCTV footage from door entrapments incidents are now shown during training.

Drugs & Alcohol Policy

149 As part of this investigation, the RAIU reviewed Transdev’s drugs and alcohol policy as the Driver involved in the incident at Heuston Stop was not tested for drugs or alcohol; despite his actions being contributory to the incident (CF-01, paragraph 143). The drivers involved in the incidents at Saggart on the 22nd August 2018 (paragraphs 93 - 97) and Kylemore on the 13th September 2018 (paragraphs 98 - 101) were also not subject to drugs and alcohol testing as a result of the incidents.

150 Transdev reviewed their drugs and alcohol policy (TDLR-HR-PO-0003) twice after the incident, with the latest revision issued on the 14th November 2019. In relation to ‘For Cause’ screening, the document states “Screening for both alcohol and drugs to help identify the cause of an accident/incident or in the light of suspect behaviour”. In ‘Post accident/incident screening the document states “This will occur when there are reasonable grounds to suspect that your actions or omission contributed to the cause of a safety critical accident/incident”. The policy document,

despite stating that where omissions contributed to an incident, did not result in drugs and alcohol testing of the driver after the incident at Jervis Stop. There is also no means, in the policy document, of formally documenting why testing did or did not occur.

151 It should be noted that the RAIU have no reason to believe that drugs and alcohol contributed to the four incidents discussed in this report. However, given that the testing was not conducted, the possibility of drugs and alcohol being present cannot be eliminated.

Post incident/accident management of drivers

152 Also, as part of this investigation, the RAIU reviewed the management of driver post-incident, who was interviewed by, and provided a statement to, Transdev post-incident (paragraph 91); Transdev cannot establish whether the driver was accompanied on his next driving duty, although it should be noted that he continued driving on the day of the incident. This was also the case for the Jervis Stop incident (paragraph 109), who was also accompanied during his first driving duties post-incident.

153 Transdev have issued two revisions of “Chain of Care Procedures” (TDLR-HR-PR-0001) in 2019, post Heuston Stop incident. Under Section 11, “Return to work procedure”, the document states that “The following return to work steps shall be considered following any period of absence from work: interviews; competency assessments (where applicable); pre-assessment training need analysis followed by suitable training and coaching as identified post incident; provision of an accompanying driver for initial duties; assessment for additional monitor and supervision”. Given that neither of these drivers were “absent from work” and that the steps are only for consideration; this leaves it possible for drivers not to be subject to any of the above. The drivers involved in the incidents at Heuston Stop and Jervis, although interviewed, assessed and in one case accompanied were not subject to ongoing additional monitoring and supervision for any specified period of time, despite their actions being identified as a contributory factor to the incidents.

Safety recommendations

General description

154 In accordance with the Railway Safety Act 2005 (Government of Ireland, 2005a) and the European railway safety directive (European Union, 2004), recommendations are addressed to the national safety authority, the CRR. The recommendation is directed to the party identified in each recommendation.

Safety recommendations associated with the incident

155 Transdev's suite of documents (SM017 Driver Training Plan, SM 018 Competency Assessment, SM 019 Competence Assessment, TSI Manual, etc) are not robust in ensuring that drivers are not relying on the tram's doors closed and locked indications (interlock systems) as an assurance that nothing is trapped in the doors; and, requiring a thorough final visual door check (using CCTV if appropriate) is essential after obtaining doors closed and locked indications and before moving the tram to confirm that nothing outside the tram is trapped in the doors; as a result, the RAIU make the following safety recommendation (CF-01, RC-01):

Safety Recommendation 2020001-01

Transdev should update their suite of documents for driver training (SM 017 Driver Training Plan), operations (TSI Manual) and competence assessment (SM 018 & SM 019 Competence Assessment) to include a requirement for drivers to conduct a thorough final visual check (using CCTV and mirrors) after obtaining doors closed and locked indications and before moving the tram to confirm that nothing is trapped in the doors.

156 To assist drivers in conducting a thorough final visual check after obtaining doors closed and locked indication and before moving the tram to confirm that nothing outside the tram is trapped in the doors, improvements to monitors (such as is present on the newer trams) and colour CCTV platform monitors (such as is present in Charlemont) should be considered, as a result, the RAIU make the following safety recommendations (CF-01):

Safety Recommendation 2020001-02

TII should conduct a risk-based review on whether CCTV platform monitors should be installed at high-use tram stops.

Safety Recommendation 2020001-03

TII should conduct a risk-based review on whether the tram fleet operating on the Red Line should be upgraded with coloured rear view monitors.

157 There were no labels present on the doors, warning passengers not to board or exit the tram as the doors are closing (CF-02). It is noted that Transdev have sent TII a proposal for new labels, as a result the RAIU make the following safety recommendation:

Safety Recommendation 2020001-04

Transdev and TII should develop new labels, for the application on tram doors, which warn passengers of the dangers of closing doors.

158 As part of the RAIU investigation, the RAIU found that SM 018 Competence Assessment has only formally addressed what should be assessed in the first quarter, with “to be agreed” in the next seven quarters (paragraph 60); and along there appears to be an informal agreement as to what these are, this needs to be addressed, as such the RAIU make the following recommendation:

Safety Recommendation 2020001-05

Transdev, as part of the update to the SMS 018 Competence Assessment, should formally include the assessments that should be conducted every quarter.

159 There appears to be an over-reliance by drivers on the TCMS Console for confirmation that doors are closed and locked; and there appears to be a lack of understanding in relation to the 10 mm allowance for obstacle detection. Staff in Transdev appear not to have a clear understanding in obstacle detection also (paragraphs 95 and 100). To assist drivers in fully understanding the door operation mechanism, the RAIU make the following safety recommendation (UC-01):

Safety Recommendation 2020001-06

Transdev should brief drivers on the operation of the door mechanism, and specifically explain the removal of obstacle detection for the final 10 mm of door travel; this briefing should then be incorporated into their suite of training and competence management documents.

160 STT1 did not follow the instructions in the Transdev Radio Protocol which requires emergency calls to commence by saying “This is an Emergency call” twice; this, in part was as a result of the absence of any form of competency assessment for security staff, as a result the RAIU make the following safety recommendation (CF-03):

Safety Recommendation 2020001-07

Transdev should develop and implement an induction training and competency assessment program for security staff, which should include training and assessment in the use of safety critical communications.

Safety recommendations associated with additional observations

161 Alstom conduct the maintenance through their WIs, and although there is an examination for the 10 mm obstacle detection, there are no examinations in relation to: sensitivity of obstacle detection; door impact for closing forces; obstacle removal forces as set out in I.S. EN 14752 (paragraph 136); although it is again noted that this standard was not required to be compiled with at the time of the incident; as a result the RAIU make the following recommendation:

Safety Recommendation 2020001-08

Transdev should update their WIs to ensure that appropriate testing is conducted for sensitivity of obstacle detection, door impact for closing forces and obstacle removal forces; the requirements set out in I.S. EN 14752 should be used, as appropriate.

162 The drivers involved in the four incidents outlined in this report were not tested for drugs and alcohol; despite their actions being contributory to the incidents (CF-01, paragraph 143 in the case of the Heuston Stop incident). Although, it should be noted that the RAIU have no reason to believe that drugs and alcohol contributed to these four incidents, Transdev's current policy is ambiguous in what a safety critical accident/incident is and there are no incident/accident types specifically identified where drivers must be tested; in addition, there is means of formally documenting why testing occurred or did not occur (paragraph 149). As a result, the RAIU make the following safety recommendation:

Safety Recommendation 2020001-09

Transdev should update their drugs and alcohol policy to include explicit requirements that testing is conducted post incident/accident where the actions of a driver may have contributed to the incident/accident. Transdev should also develop a system whereby a decision not to test an individual is documented with clear justification for the decision provided.

163 The drivers involved in the incidents at Heuston Stop and Jervis Stop were not subject to ongoing monitoring and supervision for any specified time period; despite their actions being contributory to the incidents. Transdev's current "Chain of Care Procedure" is also not vigorous in ensuring drivers are subject to any requirements as the document only applies where there is a period of absence; and, are only for consideration (paragraph 152). As a result, the RAIU make the following safety recommendation:

Safety Recommendation 2020001-10

Transdev should update their Chain of Care Procedure mandating that drivers are subject to appropriate developmental supports (such as assessment, monitoring and supervision) post incident/accident. Depending on the type of incident/accident, and whether the actions of the driver contributed to the incident/accident, specified periods of time of continuing developmental supports should be set.

Additional information

List of abbreviations

AO	Additional Observations
CCR	Central Control Room
CCTV	Closed Circuit Television
CF	Contributory Factors
CRR	Commission for Railway Regulation
DTTAS	Department of Transport, Tourism and Sport
IMC	Infrastructure Maintenance Contractor
LSS	Line Side Signalling
m	Metre
mm	Millimetres
N	Newton
NSAI	National Standards Authority of Ireland
No.	Number
OCS	Overhead Conductor System
PA	Passenger Announcement
RAIU	Railway Accident Investigation Unit
RC	Root Cause
RTS	Ready To Start
SI Units	International System of Units
SMS	Safety Management System
STT	Special Task Team
TCMS	Traction Control Management System
TOL	Tram Operations Limited
TRP	Transdev Radio Protocol
TSI	Tramway Safety Instruction
UC	Underlying Causes
UK	United Kingdom
V	Volts
VMC	Vehicle Maintenance Contractor
WI	Work Instruction

Glossary of terms

Accident	An unwanted or unintended sudden event or a specific chain of such events which have harmful consequences including collisions, derailments, level-crossing accidents, accidents to persons caused by rolling stock in motion, fires and others.
Central Control Room	Place from which tram operations are monitored and managed.
Competence	IÉ IM Operations define competence as the ability to perform activities to the standard expected within employment, it includes practical and theoretical knowledge, experience and skill required to carry out duties to ensure the safety of any person who may be affected (by their duties).
Contributory Factor	Factors relating to actions taken by persons involved or the condition of rolling stock or technical installations.
Extensive damage	Damage that can be immediately assessed by the RAIU to cost at least €2,000,000 in total.
Immediate cause	Direct and immediate causes of the occurrence including contributory factors relating to actions taken by persons involved or the condition of rolling stock or technical installations.
Inbound Incident	Travel of trams towards the city. Any incident, other than an accident or serious accident, associated with the operation of trains and affecting the safety of operation.
Line of Sight	A method of working trams where the driver observes the tram in front and controls the speed of their tram appropriately to maintain a safe distance between them, this also allows for the control of speed for road vehicles.
Obstacle detection	System used to identify the presence of an object.
Overhead Conductor System	System of overhead wires used to supply electrical current to a tram.
Rear view monitor	CCTV screen on the driver's console used for checking the platform side of the tram while stopped at a Luas stop and to give a view along both sides of the tram as the tram is moving.
Root cause	Causes related to framework conditions and application of the SMS.
Serious accident	Any train collision or derailment of trains, resulting in the death of at least one person or serious injuries to 5 or more persons or extensive damage to rolling stock, the infrastructure or the environment, and any other similar accident with an obvious impact on railway safety regulation or the management of safety, where extensive damage means damage that can be immediately assessed by

	the RAIU to cost at least €2,000,000 in total.
Segregated running	Tram has a segregated right of way
Serious injury	Any injury requiring hospitalisation for over 24 hours.
Shared running	Trams share the road with other road users.
Standard	A document that mandates technical, operational or managerial requirements.
Tetra radio	Radio communication system used to assist in the conduct of business within the operation of the Luas tram network.
Traction Control Management System Console	Screen on the driver's console showing the status of operational systems of the tram.
Traffic Regulator	Traffic Regulators proactively monitor real-time train operations against the daily train plan intervening and directing as required to minimise the effect of disruption and return services to right time running.
Underlying cause	Causes related to skills, procedures and maintenance.

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