Railway Accident Investigation Unit Ireland

INVESTIGATION REPORT

Luas isolation irregularity, Kylemore to Suir Road,

5th January 2021

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Where the report has been altered following its original publication, details on the changes will be given.

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Report structure

The report structure is taken from guidelines set out in “Commission Implementation Regulation (EU) 2020/572 of 24 April 2020 on the reporting structure to be followed for railway accident and incident investigation reports” having regard to “Directive (EU) 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety”.

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.

Preface

The RAIU is an independent investigation unit within the Department of Transport 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 (EU) 2016/798 enshrined in the European Union (Railway Safety) (Reporting and Investigation of Serious Accidents, Accidents and Incidents) Regulations 2020 and the Railway Safety (Reporting and Investigation of Serious Accidents, Accidents and Incidents Involving Certain Railways) Act 2020.

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.

Summary

A planned inspection of the Overhead Contact System (OCS), between Kylemore and Suir Road, was scheduled to occur, during a possession and isolation, between 02:00 hrs and 03:50 hrs on Tuesday 5th January 2021. As part of the planning process a Switching Programme Form was sent to the *Traffic Supervisor* (responsible for granting and receiving back possessions) located in the Luas Network Management Centre (LNMC) in the Red Cow.

At 01:07 hrs on 5th January 2021 the *Authorised Person* (responsible for carrying out all electrical *switching* in order to apply or remove authorised isolations) phoned the Traffic Supervisor to enquire about the starting time for the planned isolation of the Kylemore to Suir Road section. The Traffic Supervisor asked the Authorised Person to give him a second as he was dealing with another request. When the Traffic Supervisor had completed the task, he contacted the Authorised Person and asked, “Looking for a little switch there Kylemore yeah?” (throughout the conversations a news broadcast could be heard playing in the background of the LNMC). The Authorised Person agreed and the Traffic Supervisor de-energised the Suir Road to Kylemore Road sections at 01:09 hrs.

During this time, Tram 4010, the empty Service 24 (departing the Point Depot at 00:54 hrs and due to arrive at the Red Cow Depot at 01:33), had departed James’s Stop on route to the Red Cow Depot. The location of all trams, including Tram 4010, was available to the Traffic Supervisor on the *Automatic Vehicle Locating System* (AVLS) but the Traffic Supervisor did not carry out a check of the screen.

The Authorised Person and his team, at Kylemore, commenced the isolation process, including the placing of *Isolation Signage*, switching to local mode, removing the keys, testing the lines for conformation of de-energising and applying the *Short Circuit Straps* on both in Inbound and Outbound OCS at Kylemore. This process would also have to be repeated at the Suir Road ESS.

Tram 4010 passed through Suir Road Outbound Stop at 01:14:50 hrs before engaging the *Section Insulators* located after Suir Road Stop approximately twelve seconds later. The *pantograph* of Tram 4010 bridged the energised Heuston section to the de-energised Kylemore section. The connection caused a large *flashover* and Tram 4010 lost power, resulting in the Main Circuit Breaker (MCB) opening in Tram 4010 and the Tram coming to a stop before Golden Bridge Stop.

Driver 4010 contacted LNMC and advised the Traffic Supervisor of the loss of power. The Traffic Supervisor realised he had granted the de-energising of the Suir Road to Kylemore Road section without first checking that the line was clear of trams, through the AVLS.

The Traffic Supervisor contacted Network Maintenance Centre (NMC) and requested the Authorised Person to contact him. The Authorised Person contacted the Traffic Supervisor and the section was re-energised at 01:19 hrs allowing Tram 4010 to continue on its journey to the Red Cow depot.

The Traffic Supervisor did not immediately report the incident to the Transdev On-call Officer or log the incident on the Traffic Event Database (TED). The Traffic Supervisor did notify the Luas Duty Manager, by text, at 06:15 hrs after he had completed his shift at 06:00 hrs and left the LNMC premises; as a result no drugs and alcohol tests were carried out.

As part of the initial investigation, the RAIU found that safety critical communications were, in part, causal to the incident. Consequently, the RAIU issued an Urgent Safety Advice Notice (USAN) on 1st March 2021 requesting that Transdev "should urgently undertake a review of their safety critical communications for all modes of communication". Whilst the USAN should progress with immediate effect, the RAIU supported the USAN with the following safety recommendations, namely that Transdev should:

- Develop and publish a concise standard for safety critical communications for all modes of communication;
- Implement a robust competency management programme for initial and refresher training based on the requirements of this new standard;
- Continuously assess safety critical communications to ensure that staff are adhering to safety critical communications set out in the new standard.

In terms of the causal, contributory and systemic factors, the RAIU made the following findings. Tram 4010 entered the de-energised area, which was in the process of being isolated, as a result of the following causal factor:

- CaF-01 – The Traffic Supervisor de-energised the Kylemore to Suir Road section before the last tram had passed through the section as the Traffic Supervisor did not check the AVLS for the presence of trams.

Contributory factors include:

- CoF-01 – The Section Insulators, used by Transdev, allow current to travel from an energised section into a de-energised section when bridged by a tram pantograph;
- CoF-02 – The conversation between the Traffic Supervisor and the Authorised Person did not meet the requirements of safety critical communications; in addition, the playing of a news broadcast during a safety critical communication may have acted as a distraction to the message being communicated.

Systemic factors include:

- SF-01 – The "Isolation and *Earthing* of OCS" document and the Switching Programme Form" do not require the checking of the AVLS for the presence of trams prior to granting of an isolation;
- SF-02 – The safety critical communications suite of documents is not robust in terms of the monitoring of staff for the correct use of safety critical communications (e.g. there is no random downloads of voice communications).

Although not causal, contributing, or systemic, the RAIU make the following additional observation:

- AO-01 – The RAIU were not notified immediately of the incident but were notified two days later (paragraph 2);
- AO-02 – The Traffic Supervisor did not immediately report the incident and as such was not subject to drugs and alcohol testing, in line with Transdev protocols;
- AO-03 – The Isolation Signage is not illuminated or secured in position;
- AO-04 – There are some anomalies regarding the Transdev suite of earthing, isolation and switching documents, in that they do not reference each other and there are errors in terms of referencing.

The RAIU made the following safety recommendations as a result of causal, contributory and systemic factors, as well as additional observations:

- Safety Recommendation 202107-01 – Transport Infrastructure Ireland (TII), in conjunction with Transdev, should consider fitting Section Insulators with diodes to prevent the passage of current from an energised section into a de energised section when bridged by a pantograph.
- Safety Recommendation 202107-02 – Transdev should consider increasing the visibility of the Isolation Signage (through illuminating); as well as providing a means to secure the Isolation Signage (to prevent the signage being removed by unauthorised persons).
- Safety Recommendation 202107-03 – Transdev should review and update the suite of documents related to earthing, switching, possessions and isolations to ensure that the documents are consistent in terms of the actions to be taken, referencing and terminology.

Contents

RAIU Investigation

RAIU decision to investigate

1 In accordance with the Railway Safety (Reporting and Investigation of Serious Accidents, Accidents and Incidents Involving Certain Railways) Act 2020 (No. 18 of 2020) with reference to S.I. 430 of 2020 Regulation 5 (5), the RAIU investigate 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.

2 The RAIU on-call investigator received a notification on the 7th January 2021, an out-of-service tram entering a de-energised section that was in the process of being isolated on 5th January 2021, two days after the incident[1]. The RAIU completed a Preliminary Examination Report and the RAIU's Chief Investigator (CI) made the decision to conduct a full investigation into the incident, given its impact on railway safety (S.I. 430 2020 Regulation 6(2)(b)) as under slightly different circumstances the events may have led to a serious accident with the potential for fatalities or serious injuries due to infrastructure maintenance staff working on the OCS that should not have been open to a tram movement.

3 In terms of categorisation, the EU Agency for Railways categorisation for this occurrence would be considered an: Incident – Traffic Operations & Management[2].

4 The RAIU's CI allocated RAIU Senior Investigators, trained in accident investigation, to conduct this investigation, as appropriate. In this instance, no external parties were required to assist with the investigation.

[1] The RAIU consider this to be an Additional Observation, AO-01 (paragraph 123).

[2] However it should be noted that categorisation is not required for light rail incidents.

Scope & limits of investigation

5 The RAIU have established the scope and limits of the investigation as follows:

- Establish the sequence of events leading up to the incident;
- Identify any other precursors which led to the incident;
- Establish, where applicable, causal, contributory and systemic factors;
- Examine the standard of safety critical communications between the relevant staff;
- Examine the relevant operation standards, procedures and forms in relation to the isolation of the OCS;
- Examine the standards and training documents for safety critical communications.

Communications & evidence collection

6 During the investigation, the RAIU collate evidence through the submission of Requests For Information and interviewing. Related to this investigation, the RAIU collated and logged the following evidence:

- Front Facing Close Circuit Television (FFCCTV) of tram 4010 service 24 from Fatima to the Red Cow Depot;
- Voice communications between the relevant parties involved in the incident including the Traffic Supervisor (LNMC), the time period required was from 01:07 hrs to 04:05 hrs on 5th January 2021;
- Witness statements from parties involved in the incident;
- OCS isolation standards, procedures, forms and related documents;

7 The Traffic Supervisor did not accept an invitation to be interviewed; other parties fully co-operated with the RAIU investigation. However, the actions of the Traffic Supervisor can be determined through voice communications and documentation.

Other stakeholder inputs

8 No judicial authorities or emergency service were involved in this incident.

Other information relevant to the investigation process

9 On commencement of the RAIU investigation, it was evident, on review of the voice communications between the Authorised Person and the Traffic Supervisor, that the standard of communication was not of a level required for safety critical communications. The RAIU further requested randomly selected communications from a range of different roles from both the Red and Green Lines. On review of the additional communications, it was evident, that the poor communications on the night 5th January 2021 was not an isolated event of poor communications.

10 In relation to the calls made on the 5th January 2021 regarding the incident, the RAIU found that the communications did not meet the requirements set out in Transdev Radio Protocols (although it is noted that this was not radio communications; however, no other safety critical communications documentation was in place at the time of the incident) and that the safety critical communications were below that expected of a professional railway organisation in that:

- Parties routinely did not identify themselves;
- A clear understanding was not always reached between the parties;
- Instructions were often not repeated;
- Clear language was not always used.

11 As a result, the RAIU found that safety critical communications were, in part, causal to the incident. Consequently, the RAIU issued an USAN on 1st March 2021 requesting that Transdev "should urgently undertake a review of their safety critical communications for all modes of communication". Whilst the USAN should progress with immediate effect, the RAIU supported the USAN with the following safety recommendations, namely that Transdev should:

- Develop and publish a concise standard for safety critical communications for all modes of communication;
- Implement a robust competency management programme for initial and refresher training based on the requirements of this new standard;
- Continuously assess safety critical communications to ensure that staff are adhering to safety critical communications set out in the new standard.

Summary of the failure & background information

Synopsis of the incident

12 At 01:07 hrs on 5th January 2021 the Authorised Person (responsible for carrying out all electrical switching in order to apply or remove authorised isolations) phoned the Traffic Supervisor (responsible for granting and receiving back possessions) to enquire about the starting time for the planned isolation of the Kylemore to Suir Road section. The Traffic Supervisor asked the Authorised Person to give him a second as he was dealing with another request.

13 At 01:09 hrs, when the Traffic Supervisor had completed the task, the Traffic Supervisor contacted the Authorised Person and asked, “Looking for a little switch there Kylemore yeah?”. The Authorised Person agreed and the Traffic Supervisor de-energised the Suir Road to Kylemore Road sections.

14 At 01:09 hrs Tram 4010, the empty Service 24, had departed James’s Stop on route to the Red Cow Depot. The location of Tram 4010 was available to the Traffic Supervisor on the AVLS, but the Traffic Supervisor did not carry out a check of the screen.

15 The Authorised Person, at Kylemore, commenced the isolation process, including the placing of *Isolation Signage*, switching to local mode, removing the keys, testing the lines for conformation of de-energising and applying the Short Circuit Straps on both in Inbound and Outbound lines.

16 Tram 4010 passed through Suir Road Outbound Stop at 01:14:50 hrs before engaging the *Section Insulator* located after Suir Road Stop approximately twelve seconds later. The pantograph of Tram 4010 bridged the energised Heuston section to the de-energised Kylemore section. The connection caused a large flashover and Tram 4010 lost power and coasted to a stop before Golden Bridge Stop.

17 Driver 4010 contacted LNMC and advised the Traffic Supervisor of the loss of power. The Traffic Supervisor realised he had de-energised the Suir Road to Kylemore Road section without first checking that the line was clear of trams.

18 The Traffic Supervisor contacted NMC and requested the Authorised Person to contact him.

19 The Authorised Person contacted the Traffic Supervisor, and the section was re-energised at 01:19 hrs allowing Tram 4010 to continue on its journey to the Red Cow depot.

20 The Traffic Supervisor did not immediately report the incident to the Transdev On-call Officer or log the incident on the TED. The Traffic Supervisor finished his shift at 06:00 hrs and left the LNMC premises; at 06:15 hrs the Traffic Supervisor notified the Luas Duty Manager, by text; as a result no drugs and alcohol tests were carried out[3].

External circumstances at the incident location

Weather

21 The weather was dry and cold; weather data was taken from the nearest Met Éireann Weather Station at Phoenix Park, 6 kilometres (km) North East of Kylemore Stop. Records show there was no rainfall and an average temperature of 1.5ºC at the time of the incident.

22 The weather conditions were not contributory to the incident.

Fatalities, injuries & material damage

Fatalities & injuries

23 There were no fatalities or injuries as a result of the incident.

Material damage

24 There was no damage to Tram 4010.

25 The OCS at Kylemore where the Short Circuit Straps were fitted (Inbound and Outbound lines) were surface damaged and required dressing with a file and the fitting of joiners.

26 The Section Isolators at Suir Road Outbound line were also damaged and required dressing with a file (replacement was not necessary).

Other consequences as a result of the incident

27 As the Section Insulator at Suir Road was damaged by the flashover, an extended isolation of the Heuston to Suir Road section was required to examine and repair the Section Insulator at Suir Road.

28 As the incident took place after the last passenger service had stopped, there were no passenger service delayed as a result of the incident.

[3] The RAIU have identified this as an Additional Observation, AO-02 (paragraph 123).

Parties & roles associated with the incident

Parties involved in the incident

29 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 also the Vehicle Maintenance Contractor (VMC).

30 S2M a joint venture between Transdev and Efacec[4] was formed to deliver Power and Systems Maintenance for the Luas Infrastructure. S2M comprises of four disciplines: Track, Overhead Line, Traction Power and Communications. The four discipline managers report to the Joint Venture Manager who in turn reports to the Head of Infrastructure. Transdev provide shared services to S2M including Human Resources, Planning, Procurement, and Safety.

[4] Efacec is a Portuguese company with 70 years' experience focusing on the development of products and systems for the infrastructural sectors as Energy, Environment, Industry Mobility and Transport with a presence in over 65 countries.

Roles involved in the incident

31 The roles involved in the incident, from Transdev are as follows:

- Driver 4010 – Driver of Tram 4010. At the time of the incident, Driver 4010 had been in the driving grade for four years and completed his last assessment on the 6th February 2020 with no endorsements.
- Traffic Supervisor – On the night of the incident, the Traffic Supervisor was responsible for granting and receiving back possessions. The Traffic Supervisor had been in the role for twelve years having been previously employed as a tram driver for four years prior to his promotion. The Traffic Supervisor completed his last competency assessment on 4th August 2019 with no endorsements.
- Authorised Person – On the night of the incident, the Authorised Person was responsible for carrying out all electrical switching in accordance with the Electrical Switching Forms (ESF) in order to apply or remove authorised isolations. The Authorised Person had been in the role for four years and his relevant assessments with validation dates are as follows: Substation Overview / Awareness (15/04/2023); Substation Electric Shock Emergency Plan (15/04/2023); Isolation / Energisation of OCS (15/04/2023); Erect & Remove OCS Earth Bond[5] Straps (15/04/2023); Line Possession Supervisor (LPS) (23/02/2024).

Parties not directly involved in the incident

32 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. TII is the Irish State body that provides the rolling stock and infrastructure required for the Luas light rail network.

[5] Although Transdev refer to these straps as Earth Bond Straps, a more accurate description would be Short Circuit Straps as these straps do not earth the OCS.

General description of the tramway

33 Dublin's Luas network is made up of the Red and Green Lines; the network has sixty-seven stop and 44.5 km of track, Figure 1.

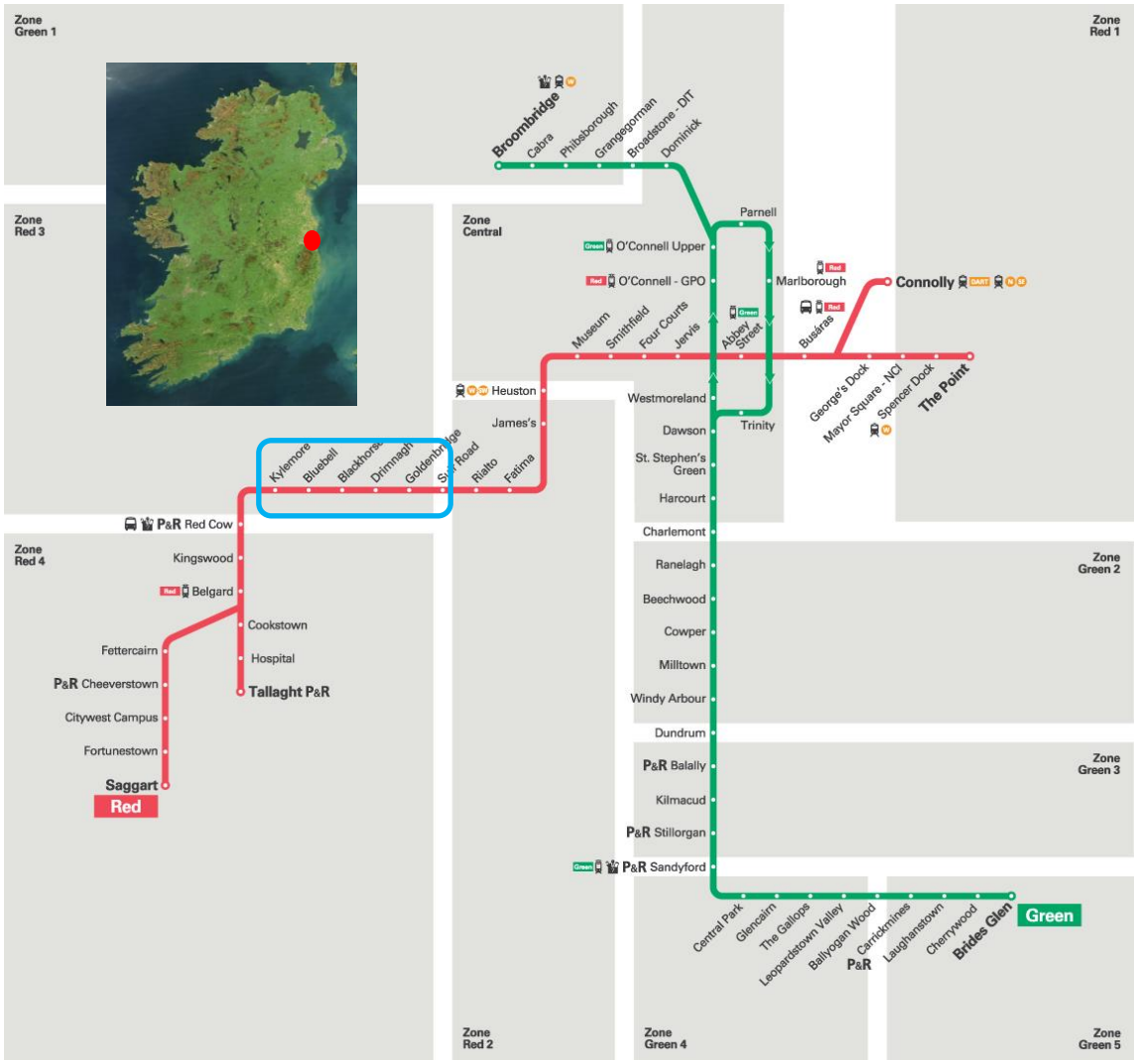


Figure 1 – Dublin's Luas Network

34 The Red Line (where Tram 4010 was operating) is 20 km in length and has thirty-two stops running from Tallaght to The Point and from Saggart to Connolly. The Green Line is 24.5 km in length and has thirty-five stops running from Brides Glen to Broombridge via the City Centre. Kylemore to Suir Road section is located on the Red Line.

35 Trams operate on a combination of separated track, segregated track, and shared running (where the trams share the road with other road users).

36 Trams are powered by an OCS providing 750 V DC delivered from twenty electrical substations (ESSs), the OCS is discussed further in paragraphs 44 to 46.

Rolling Stock

37 Tram 4010 is one of forty of the 401 tram fleet manufactured by Alstom Transport in La-Rochelle in France operating on the Luas Red Line. The 401 fleet are numbered 3001 to 3026 and 4001 to 4014. A 401 tram is 40.8 m long, 2.4 m wide, 3.45 m high (with the pantograph lowered) with a mass of 49,616 kilograms (kg).

38 The 401 trams consist of five modules, three motorised, one non-motorised (under the pantograph, see Figure 2) and one suspended unit.

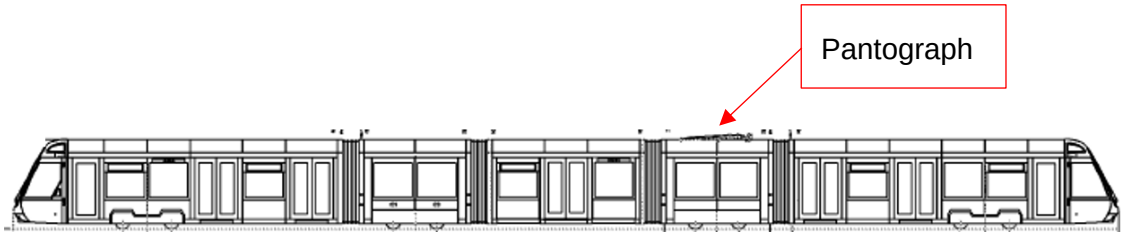


Figure 2 – Tram 401 configuration

39 When a tram fails to detect the 750V DC from the OCS the MCB opens, and the tram loses power.

Signalling and communications

40 Trams movements through the majority of junctions are regulated through the use of line side signals which must be obeyed by tram drivers and other road users. The signals, normally positioned to the left of the leading driving cab on the kerb, are provided by an array of light emitting diodes which are lit according to the type of signal to be displayed e.g. horizontal (stop), vertical (proceed). Tram signals and regulatory stationary signs are set out in the Department of Transport's Traffic Signs Manual, last updated in August 2019.

41 The means of communication between tram drivers and the LNMC is by Tetra radio or lineside help points. Communication between infrastructure staff and the Traffic Supervisor is by mobile phone.

Operations

42 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, stop boards, 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.

43 Luas passenger services operate Monday to Friday from 05:30 to 00:30 hrs, Saturday from 06:30 to 00:30 hrs and Sunday and Public Holidays from 07:00 to 23:00 hrs. Empty non-passenger services also operated outside of the passenger services timetable to return trams to the maintenance depots.

Evidence

Luas Overhead Contact System (OCS)

44 Trams are powered by an Overhead Contact System (OCS) providing 750 volts (V) Direct Current (DC) delivered from twenty ESSs (of these twenty, seven are on the Red Line at O'Connell Street, Heuston, Suir Road, Kylemore, Red Cow, Kingswood and Cookstown). Power is supplied to the ESSs from the national grid at 10 kV Alternating Current (AC). The 750V DC supplied to the trams via a roof mounted pantograph (Figure 3) is converted to AC to power the motorised bogies on each tram set. The return circuit is through the wheel rail interface and back to the ESS.

Figure 3 – Tram pantograph interface with OCS

45 The OCS is sectioned electrically to allow inspection and maintenance intervention including planned and emergency repair of the OCS without the need to de-energise the complete line. OCS inspections are carried out every 3 months, 6 months and 2 years.

46 The sectioning from Kylemore to Suir Road is achieved by Section Insulators (Figure 4) at the termination of one cable and the start of the next. The Section Insulator provides a continuous supply of power to the tram when the tram passes from one section to the next and also allows for de-energising of one section at a time.

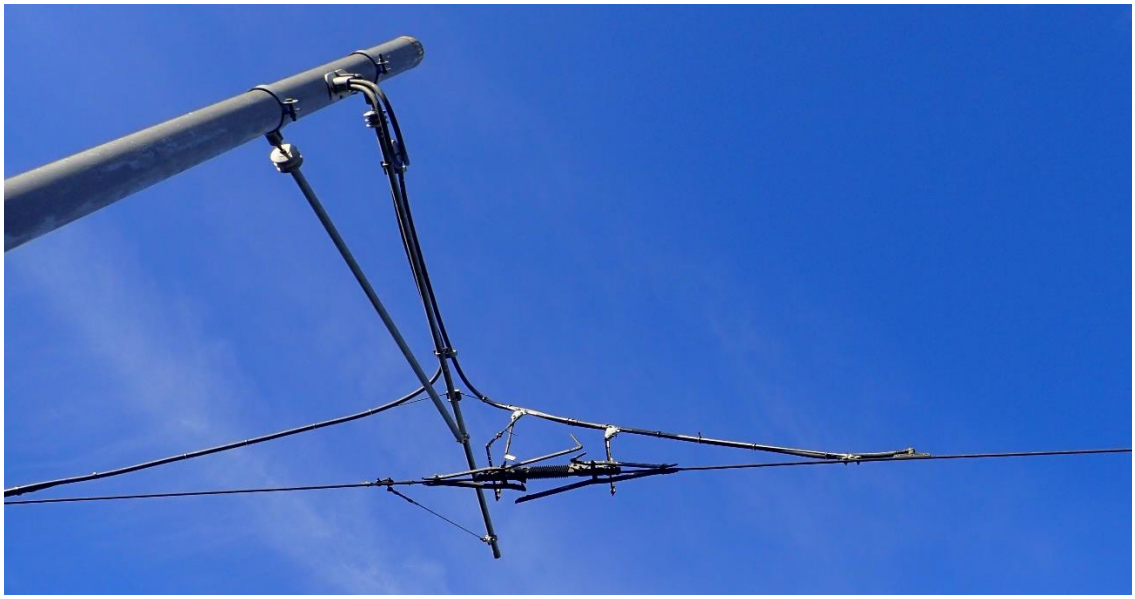


Figure 4 – Section Insulators on the OCS

47 The separation between the cables is such that, in the event of a de-energisation at one of the sections, there is no possibility of the two sections coming into contact with each other except when bridged by a pantograph. As a pantograph head traverses the Section Insulator the pantograph bridges both contact cables and electrically connects the two sections together (Figure 5).

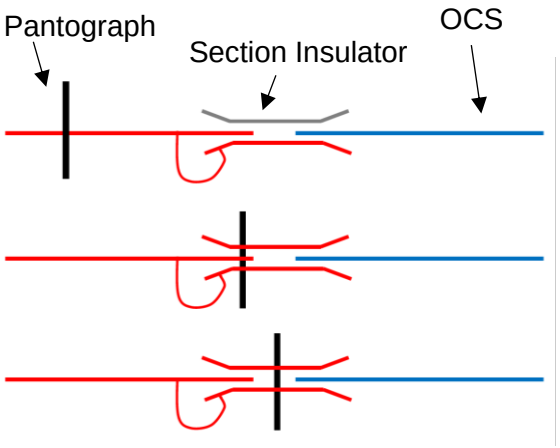


Figure 5 – Section Insulator with passing pantograph

Possession, Isolation, Earthing & Switching Documentation

Introduction to Possession, Isolations, Earthing & Switching

48 A possession is a period of time during which one or more tracks are blocked to trams to permit work to be safely carried out on or near the line. All possessions, in normal circumstances, are requested and authorised, in advance, in accordance with the procedure Submission Authorisation of Work Requests (OEP 102). The times, locations and switching (i.e. isolation) requirements agreed will be defined in the Work Request Forms (WRF) and ESF. All possessions are notified through the TED.

49 Isolations (de-energisation and electrical disconnection of the traction supply (OCS) in the area in which the work is to be undertaken) are applied to make the OCS safe for the staff to work on or near the OCS and are normally required to be planned.

50 In an isolation, low resistance cables known as Short Circuit Straps are attached to the de-energised OCS. In the event of current been present in the de-energised section, the current travels from the OCS through the Short Circuit Straps into the rail and on to the ESS where a circuit breaker will open and disconnect the flow of the current.

51 Switching is local connecting or disconnecting of an electrical switch with key locked protection to provide a safe working environment for staff working in a section.

Possessions and Isolations of the Tramway

52 Transdev issued the “Possession and Isolation of the Tramway”, Document ID Code TDLR-OP-PR-0007, Rev 01.0, on the 31st October 2019. The purpose of the document is to ensure that all work undertaken on, near or adjacent to, Transdev infrastructure is properly implemented and controlled to safeguard the safety of Transdev system, staff, passengers, contractor’s staff, vehicles, and members of the general public; as well as the reliable operation of the Transdev system. The scope of the document applies to all construction, maintenance, repair, warranty and/or remedial works carried out on, or near Transdev lines or tracks.

53 Section 4.0 of the Possession and Isolation of the Tramway document sets out responsibilities of staff involved in possessions and isolations. Of interest to this investigation are the responsibilities of the Traffic Supervisor and the Authorised Person.

54 The responsibilities of the Traffic Supervisor are as follows:

- To grant and receive back possession;
- To advise other Traffic Supervisors of work taking pace including any person relieving a Traffic Supervisor;
- To carry out *Supervisory Control And Data Acquisition* (SCADA) switching when required as part of isolation;
- To ensure that no tram movements are permitted into or through a possession unless a tram movement is indicated in the TED and only then with the specific agreement of the LPS for that movement to take place;
- To give permission for work to commence and to ensure that any restrictions associated with tram movements through the area of an occupation are made known to the relevant operational staff including drivers.

55 Responsibilities of the Authorised Person:

- To carry out all electrical switching in accordance with the ESF in order to apply or remove authorised isolations;
- To carry out live line testing;
- To apply and remove local earths;
- To terminate possessions where an isolation has been applied and to remove Isolation Signage (see Figure 6, for examples of Isolation Signage, note that the signage is not illuminated and is free standing[6]).

[6] The Isolation Signage is not illuminated or secured at its location and can be removed by unauthorised people; these factors have been identified as an Additional Observation, AO-03 (paragraph 123), and a safety recommendation has been issued (paragraph 138).

Figure 6 – Examples of Isolation Signage

56 It is noted that the "Possession and Isolation of the Tramway" document references a number of documents, however, it does not reference the "Isolation and Earthing of OCS" document, which is outlined in the next section of this report.

Isolation and Earthing of OCS using the Switching Programme Form

57 Transdev issued the "Isolation and Earthing of OCS", Document ID Code TDLR-S-SOP-0015, Rev 01.0, on the 3rd January 2020. The purpose of the document is to outline the safe methods and general safety precautions to be followed when isolating and earthing the OCS to allow work to proceed within specified electrical sections(s) under safe conditions.

58 Sub-section 6.2.1, Isolation & Earthing (under Section 6.2, Work Process), gives a list of tasks to be completed by the Authorised Person and the Traffic Supervisor. The Switching Programme Form sets out specific details for the OCS Kylemore (closest to Depot) to Suir Road (furthest from Depot) area (known as Sections 151-152-153). The tasks are as follows:

- The Authorised Person and his/her team should prepare themselves prior to the Isolation taking note of any Standard Operating Procedure (SOP) for Working in Substations (i.e. TDLR-S-SOP-022). The Authorised Person is responsible for completion of the *Isolation Control Form* and Switching Programme Form as each stage of the isolation is completed.
- The Traffic Supervisor will contact the Authorised Person when it is safe to place the Isolation Signage (Figure 6) in position.
- The Authorised Person will clearly communicate the switching sequence as per the Switching Programme Form.

- The Traffic Supervisor will carry out the remote switching to de-energise the required electrical sections as per Switching Programme Form, using SCADA. From the Switching Programme Form, for Sections 151-152-153, this requires the opening and checking that the electrical switches are in the open position in Kylemore and Suir Road ESSs (tasks 1 to 4).
- The Traffic Supervisor must confirm to the Authorised Person that remote switching steps have been completed (task 5 on Programme Switching Form).
- The Authorised Person and his/her team then ensure remote switching has been complete (i.e. ESS voltage monitors indicate green and line side isolations switches are physically open).
- The Authorised Person and his/her team then commence local switching in the relevant ESSs and line side isolation switches and retain possession of any relevant isolation keys. For Sections 151-152-153 the Switching Programme Form first require, that at Kylemore (tasks 5-12):
    - The Isolation Signage is placed under the Section Insulators (Kylemore);
    - The switches are open, and the keys retained;
    - Voltage monitors are checked for loss of voltage prior to opening switches and retaining those keys;
    - The OCS is then tested for the loss of 750V DC and the earth straps[7] are applied on Suir Road side of the Section Insulators Inbound; the OCS is tested again for the loss of 750 V DC before the earth straps are applied to the Suir Road side of the Section Insulators Outbound.
- For Sections 151-152-153 the Switching Programme Form (tasks 13 to 20) requires that at Suir Road:
    - The Authorised Person shall again contact the Traffic Supervisor to confirm switching programme is completed;
    - The switches are open and the keys retained;
    - Voltage monitors are checked for loss of voltage prior to opening the switches and retaining those keys;

[7] Although Transdev refer to these straps as earth straps/ bonds throughout this document, a more accurate description would be Short Circuit Straps as these straps do not actually earth the OCS.

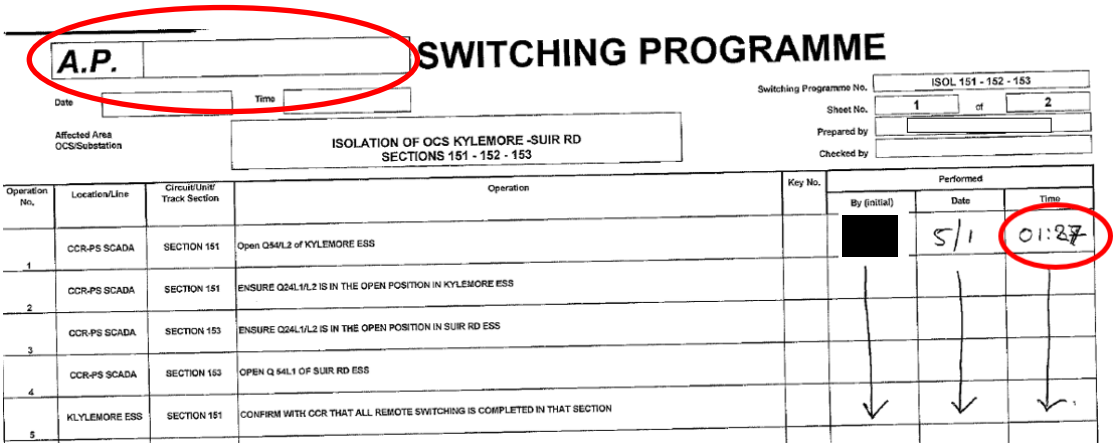
- The OCS is then tested for the loss of 750V DC and the earth straps are applied on Kylemore side of the Section Insulators Inbound; the OCS is tested again for the loss of 750 V DC on the and the earth straps are applied to the Kylemore side of the Section Insulators Outbound;
- The Isolation Signage is placed under the Section Insulators on the Inbound/Outbound line.

- Advise the Authorised Person that protection is now in place.
- When all local switching steps have been completed and all earths bonds and Isolation Signage have been put in place the Authorised Person will meet the LPS and confirm the electrical sections being isolated, the location of the earth bonds and Isolation Signage and hand-over the retained keys and the LPS will sign the Isolation Control Form.
- The Authorised Person will contact the Traffic Supervisor and confirm that the isolation is in place and the LPS has control of the isolation.

59 Figure 7 shows an example of a site set up for the isolation and electrical protection of the OCS.

Figure 7 – Example of a worksite

60 It is noted that the Switching Programme Form for the night of the incident was sent to the Traffic Supervisor in advance of the isolation. The form was not completed in full, in that name and contact number for the Authorised Person was omitted (circled left, Figure 8); however, the name and contact number for the Authorised Person was included in the body of the email that was sent to the Traffic Supervisor with at Switching Programme Form attached.



A.P. SWITCHING PROGRAMME

Date | Time | Switching Programme No. ISOL 151 - 152 - 153 | Sheet No. 1 of 2

Affected Area OCS/Substation: ISOLATION OF OCS KYLEMORE -SUIR RD SECTIONS 151 - 152 - 153

Prepared by | Checked by

Operation No.	Location/Line	Circuit/Unit/ Track Section	Operation	Key No.	Performed: By (initial)	Date	Time
1	CCR-PS SCADA	SECTION 151	Open Q54/L2 of KYLEMORE ESS		[redacted]	5/1	01:27
2	CCR-PS SCADA	SECTION 151	ENSURE Q24L1/L2 IS IN THE OPEN POSITION IN KYLEMORE ESS				
3	CCR-PS SCADA	SECTION 153	ENSURE Q24L1/L2 IS IN THE OPEN POSITION IN SUIR RD ESS				
4	CCR-PS SCADA	SECTION 153	OPEN Q 54L1 OF SUIR RD ESS				
5	KLYLEMORE ESS	SECTION 151	CONFIRM WITH CCR THAT ALL REMOTE SWITCHING IS COMPLETED IN THAT SECTION				

Figure 8 – Switching Programme Form from night of incident

61 The Switching Programme Form requires a signature declaration, certifying that the Traffic Supervisor has carried out each of the operations sequentially and relevant permits issued. This was initialled and time stamped by the Traffic Supervisor at 01:27 hrs on 5th January 2021 (circled right, Figure 8), although it is noted that this text appears to have been amended from 01:09 hrs to 01:27 hrs.

Observations on the Possession, Isolation, Earthing & Switching Documentation

62 The documents associated with the possession, isolation, earthing and switching, namely the “Possession and Isolation of the Tramway”, “Isolation and Earthing of OCS” and the “Switching Programme Form” do not require the Traffic Supervisor to check the AVLS for the presence of trams.

63 The “Isolation and Earthing of OCS” document references a number of documents, however, it does not reference the “Possession and Isolation of the Tramway” document. In addition, the document contains many references using number references that are not in the document, by way of example in the “Protection of the Possession” section, it states “Where Isolation is to be applied marker boards[8] will be positioned in accordance with clause 5.6.6”; however, no clauses are numbered.

[8] Isolation Signage

Transdev Radio Protocol

64 The purpose of the "Transdev Radio Protocol" (to be referred to as Radio Protocol for remainder of this report), issued on the 8th February 2019, is to "document employee responsibilities for the proper, secure, and appropriate use of the Transdev radio communication system" (although it is noted that this was not radio communications; however, no other safety critical communications documentation was in place at the time of the incident). It applies "to all authorised employees of Transdev; all contractors and third parties that are granted access to the Transdev radio communication system". It states that "All employees will be issued with a copy of this Radio Communications Policy. Employees required to engage in radio communication will be required to acknowledge their understanding and commitment to adhere to this policy". Transdev do not have a database of staff acknowledging their understanding of the standard.

65 The Radio Protocol lists the correct use of the radio system:

- Staff should be contacted using Service Number, Tram Number, or Staff Number only. No Personal details to be used at any time unless dictated by the circumstances of duty of care;
- LNMC communications are safety critical and should be followed accordingly unless the safety of staff and the operation are jeopardised;
- Use of indecent / profane language and general chit chat is strictly forbidden;
- Speak slowly and clearly, be short and concise;
- Any spelling done using phonetic alphabet;
- Numerals to be said individually, the number 0 being "zero".

66 The Radio Protocol also lists "prohibited uses" in relation to the communication system, namely:

- Radio protocol prohibits the use of profane or indecent language on the radio;
- Personal messages unrelated to company business are prohibited;
- Do not click your microphone or make odd noises on the air;
- Do not transmit anything other than your voice;
- Do not intentionally transmit over someone else unless an emergency exists;
- Personal Details including Staff Names should not be used and broadcast over the Radio unless dictated by the circumstances of duty of care.

Traffic Supervisor Role, Competency & Training

Traffic Supervisor Role

67 The "Luas Network Management Centre Manual" (to be referred to as the LNMC Manual for the remainder of this report), Issue 01, issued on the 6th November 2019, outlines the "scope" of the Traffic Supervisor as "to manage the safe, timely and efficient operation of the Luas tram services". The "duties" are as follows:

- Operating tram services to published timetable;
- Prime contact for drivers in relation to technical fault resolution and management of drivers on a real-time basis;
- Management of incidents within LNMC and liaison with emergency services and TDLR incident officer;
- Efficient restoration of services post-incident;
- Operation of technical systems to agreed TDLR standards;
- Interface with relevant teams via the asset and fleet management team to communicate infrastructure and tram defects;
- Timely and accurate recording of all events within company database;
- Systems alarm management and response.

68 In terms of training and assessment, the LNMC Manual states "Initial training and a work experience programme is provided for all trainee Traffic Supervisors. The training programme is comprised of:

- Systems training delivered by the LNMC Trainer: To ensure all technical systems can be operated proficiently. Systems training is carried out over 1.5 weeks;
- Procedural training delivered by the LNMC Trainer: To ensure all procedures and tactics can be applied appropriately. Procedural training is carried out over 1.5 weeks;
- Work Experience: Incremental responsibility whilst working with a qualified Traffic Supervisor. Work experience is carried out over 4 weeks".

69 The LNMC Manual continues "Throughout training regular exams are set and feedback solicited to ensure the trainee is meeting the required standard. Final assessment is carried out after a period of practical work experience in the LNMC by the Luas Duty Manager (LDM). Upon successful assessment, the trainee is certified as a qualified Traffic Supervisor".

70 In terms of reporting, the LNMC Manual requires that "The Traffic Supervisor on duty must log all events, incidents and defects that occur during their shift". The LNMC Manual further outlines the actions to be taken for a various number of incidents[9].

Traffic Supervisor Communication Training

71 In terms of communications training, The "Traffic Supervisor Communication Training" document, published early 2017, is a six page document which sets out requirements in relation to: Communications; general radio protocol; normal/emergency calls; group calls; code blue calls (emergency); etiquette; shift handover; etc. The document states that "a large element of the Traffic Supervisor's role involves communications. This is via a variety of mediums to an array of parties. It is essential the Traffic Supervisor consistently manages his communications effectively. Key elements of the communication process are:

- Timeliness, so radio should be answered as soon as possible;
- Accuracy with all Information received and given;
- Clarity, especially when instructing drivers;
- Professionalism and integrity is paramount at all times".

72 The "General Radio protocol" includes:

- Use of indecent / profane language and general chit chat is strictly forbidden;
- Speak slowly and clearly, be short and concise;
- Any spelling done using phonetic alphabet (it should be noted that a copy of the phonetic alphabet is not provided in the Traffic Supervisor's documentation);
- If any message is unclear, the user must request message to be re-transmitted or clarification.

73 After the initial training, no refresher training is provided in relation to communications.

[9] In addition, Transdev "Drugs and Alcohol Policy", TDLR-HR-PO-003, Rev 3.0, published issued on the 10/09/2020, outlines the procedures in place for the testing of drugs and alcohol of staff involved in incidents.

Traffic Supervisor Competency Assessment

74 The Traffic Supervisor's last competency assessment prior to the incident was on the 4th August 2019. The assessment document is completed by an assessor who must observe the Traffic Supervisor carrying out the role. In relation to communications the assessor checks against:

- User radio protocol;
- Manages other radio protocol, where appropriate;
- Correct use of the PA system;
- Correct use of the Passenger Information Display system;
- Communications skills with other staff.

75 The assessor found the Traffic Supervisor compliant will all communication checks.

76 At the time of the incident, Transdev did not have a system in place, whereby random voice communications were downloaded to evaluate the standard of safety critical communications when the Traffic Supervisor is not being directly observed.

Events before, during and after the incident

Events before the incident

77 A planned inspection of the OCS, between Kylemore and Suir Road, was scheduled to occur between 02:00 hrs and 03:50 hrs on Tuesday 5th January 2021.

78 At 19:00 hrs on Monday 4th January 2021 the infrastructure team met at the Red Cow Depot where briefings about the planned activities were discussed.

79 The planned inspection of the OCS required an OCS isolation between Kylemore and Suir Road ESSs. An Authorised Person was appointed, and the Switching Programme Form was emailed to the Traffic Supervisor, as well as other relevant documentation; the Authorised Person follows up with a phone call to the Traffic Supervisor.

Events during the incident

80 At 01:07 hrs the Authorised Person phoned the Traffic Supervisor with the intention of finding out the time that the de-energising of the Kylemore to Suir Road section would be available. It should be noted that throughout all the voice communications a news broadcast could be heard playing in the background of the LNMC.

81 The Traffic Supervisor was dealing with another request to clear a tram into the Red Cow Depot and asked the Authorised Person to “just give us a second there, you always ring at awkward times God bless you”.

82 On clearing a tram into the Red Cow Depot the Traffic Supervisor asked the Authorised Person: “Okay looking for a little switching there Kylemore yeah?” the Authorised Person replied “Kylemore to Suir yeah”.

83 The Traffic Supervisor was interrupted by a caller who overheard the phone call between with Authorised Person and the Traffic Supervisor and thought the message was for him.

84 A “general chit chat” between the Authorised Person and the Traffic Supervisor ensued until the Traffic Supervisor advised “Section 151, 152 and 153 de-energised and the time now is nine minutes past one”.

85 Tram 4010 was operating Service 24 with its last link an out-of-service journey departing the Point Depot at 00:54 hrs and arriving at the Red Cow Depot at 01:33 hrs.

86 At 01:09 hrs Tram 4010 was passing James’s outbound (Figure 9); the location of Tram 4010 was available to the Traffic Supervisor on the AVLS, but the Traffic Supervisor did not check the screen.

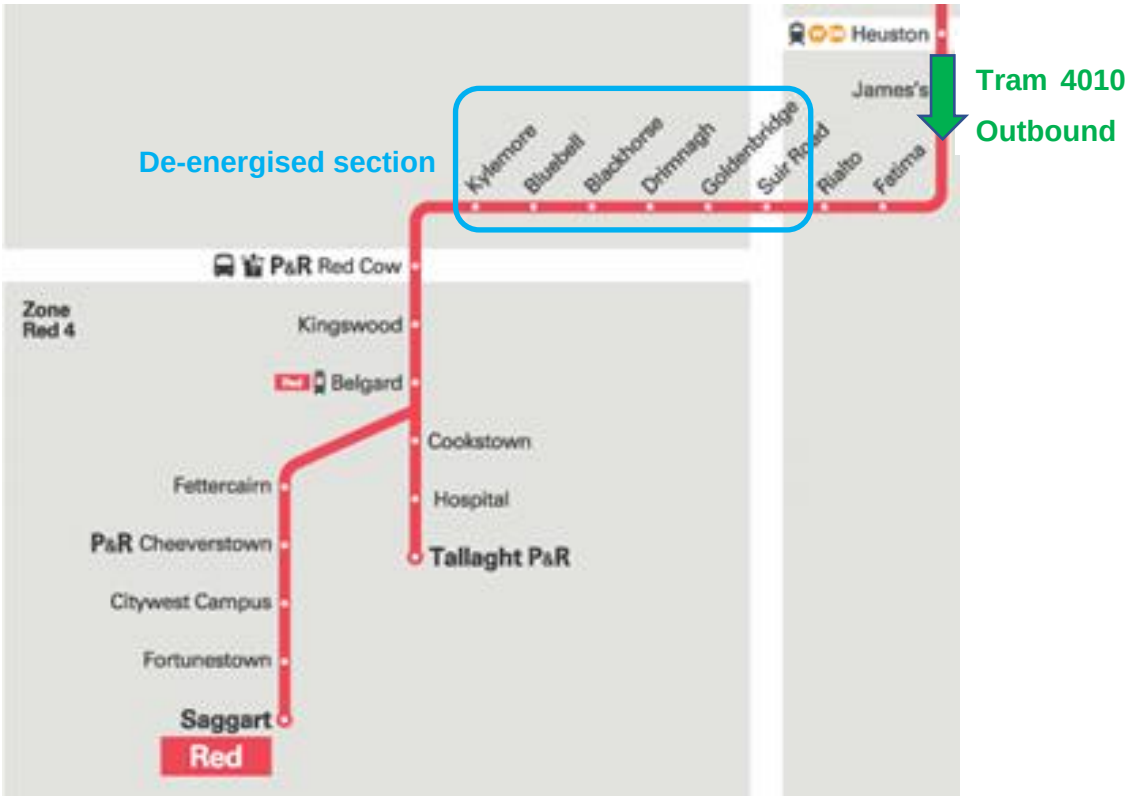


Figure 9 – Location of Tram 2010 in relation to de-energised section

87 The Authorised Person and team commenced the isolation process at Kylemore (paragraphs 52 to 58) by erecting the Isolation Signage, carrying out the local switching, checking the voltage monitor, testing for the loss of 750 V DC and applying the short circuit straps on Kylemore side of the Section Insulators Inbound.

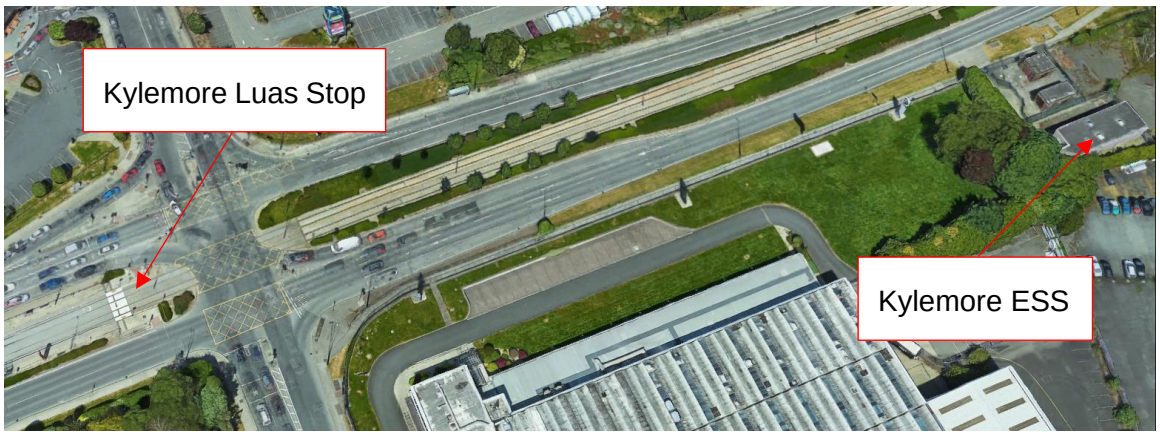


Figure 10 – Kylemore Luas Stop and ESS

88 At 01:14:50 hrs, Tram 4010 passed through Suir Road Stop, see Figure 11, for a FFCCTV image from Tram 4010 at Suir Road, note that there is no Isolation Signage, although it is noted that the Switching Programme Form does not require that the Isolation Signage be erected at Suir Road until the isolation has been completed at Suir Road.

Figure 11 – FFCCTV image from Tram 4010 at Suir Road Stop

89 At this time, the Authorised Person and some of the team were located at Kylemore ESS and some of the team were on route to Suir Road, see Figure 12.

Figure 12 – Location of Tram 4010 in relation to Kylemore ESS

90 At 01:15:02 hrs, the pantograph of Tram 4010 bridged the energised section of the OCS (the section on which Tram 4010 was travelling i.e. Heuston to Suir Road, see red in Figure 13) with the de-energised Kylemore to Suir Road Section (Section 151-152-153, see blue in Figure 13) through the Section Insulators. This caused a large flashover due to the current travelling from the energised section to the de-energised section, see 4b in Figure 13.

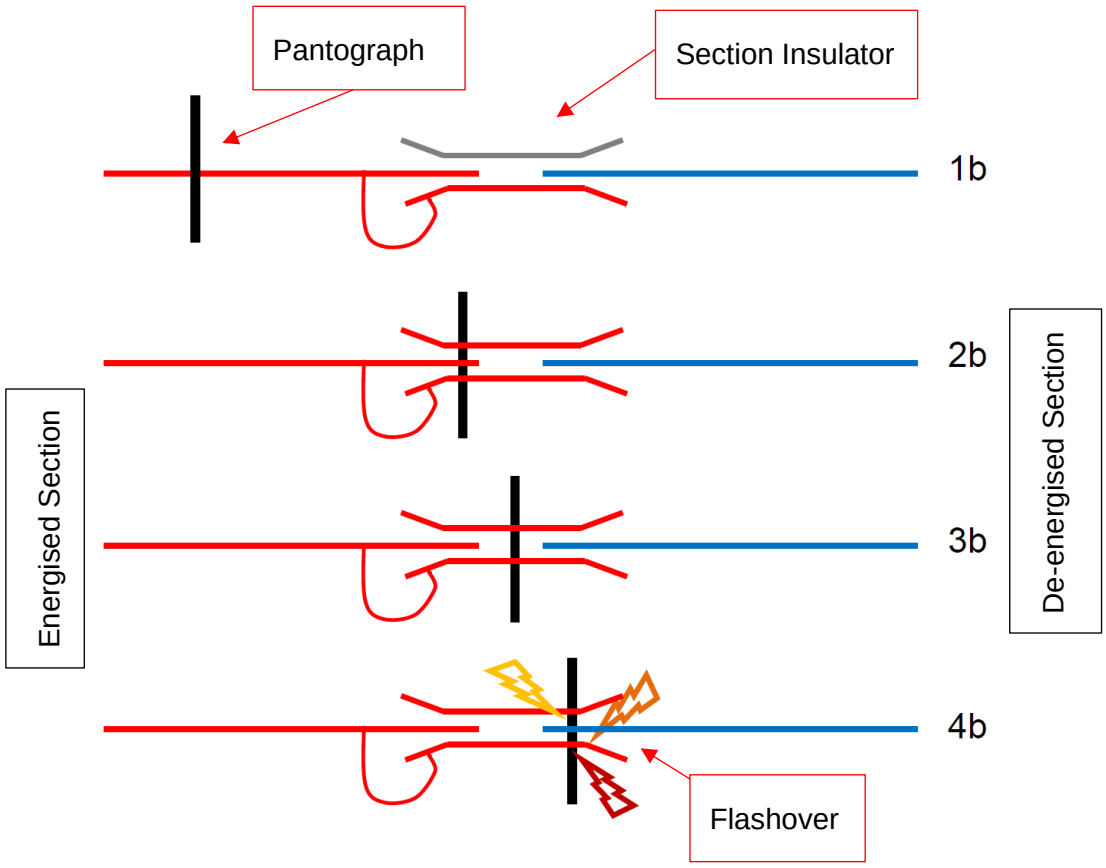


Figure 13 – Pantograph of Tram 4010 during bridging of Section Insulator

91 At the same time, the MCB on Tram 4010 opened as a result of losing the 750 V DC supply (as Tram 4010 was now positioned in the de-energised section). Tram 4010 coasted for approximately forty-eight seconds before coming to a stop prior to Golden Bridge Stop at 01:15:50 hrs, see Figure 14.

Figure 14 – FFCCTV image from stopped position of Tram 4010

Events after the incident

92 Driver 4010 contacted the Traffic Supervisor and advised him of the MCB opening.

93 On receiving the call from Driver 4010, the Traffic Supervisor realised that he had de-energised the Kylemore to Suir Road section while there was still an out-of-service tram on route to the Red Cow Depot.

94 The Traffic Supervisor contacted NMC to arrange for the Authorised Person to contact him as the Authorised Person's name was not recorded on the Switching Programme Form (the Authorised Person's name was included in the email that accompanied the Switching Programme Form attachment (paragraph 60)).

95 The Authorised Person contacted the Traffic Supervisor, the Authorised Person removed the Short Circuit Straps and Isolation Signage before closing the bypass switch at Kylemore ESS. The Traffic Supervisor then re-energised the section to enable Tram 4010 to continue its journey to the Red Cow at 01:19:32 hrs (this information was not included on the Switching Programme Form).

96 Section 151-152-153 was de-energised for a second time at 01:27 hrs (after the passing of Tram 4010). As the Section Insulator at Suir Road was damaged by the flashover, an extended isolation of the Heuston to Suir Road section was required to examine and repair the Section Insulator at Suir Road. The 01:27 hrs time, is the time recorded in the Switching Programme Form as opposed to the original de-energisation, which took place at 01:09 hrs (paragraph 61).

97 The Traffic Supervisor did not report the incident to the On-Call Incident Manager or input the details on the TED. The Traffic Supervisor did notify the LDM by text at 06:15 hrs after he had completed his shift at 06:00 hrs and left the LNMC premises; as a result no drugs and alcohol tests were carried out.

Similar Occurrences

98 The RAIU are not aware of any previous isolation irregularities that occurred on the Luas network.

Analysis

Luas Overhead Contact System

99 The pantograph of Tram 4010 bridged the energised section of the OCS (the section on which Tram 4010 was travelling i.e. Heuston to Suir Road) with the de-energised Kylemore to Suir Road Section through the Section Insulators (paragraph 90). Section Insulators provide a continuous supply of power to the tram when the tram passes from one section to the next and also allows for de-energising of one section at a time (paragraph 46). The movement of the pantograph over the Section Insulator caused a large flashover due to the current travelling from the energised section to the de-energised section.

100 Section Insulators fitted with diodes are now available and prevent the transfer of current from a live section into a de-energised section when bridged by a pantograph but still allow for isolation of individual sections. Section Insulators fitted with diodes are not fitted on the Luas network as they were not included in the original design.

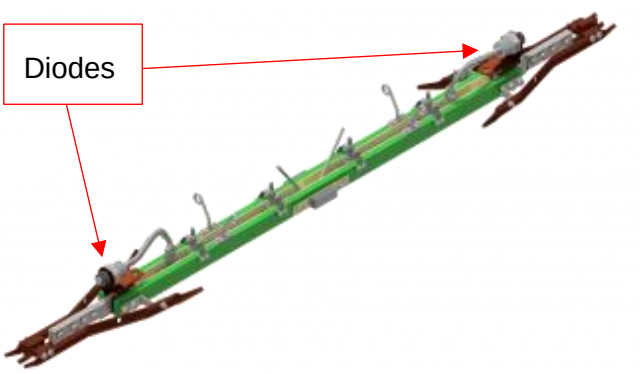


Figure 15 – Section Insulator with diodes

101 Had the Section Insulators been fitted with diodes this may have prevented the transfer of current from the live section into the de-energised section, when bridged by the pantograph of Tram 4010 (but still allows for isolation of an individual section).

Transdev Suite of Documents related to the incident

Possessions and Isolations of the Tramway

102 The "Possession and Isolation of the Tramway" document outlines the roles and responsibilities of staff involved in possessions and isolations, such as the Traffic Supervisor and Authorised Person (paragraphs 53 - 55).

103 The document does not reference the "Isolation and Earthing of OCS" which deals with the step-by-step instructions on how to carry out an isolation, safely (paragraph 56). In addition, the referencing in the document, in places, is incorrect (paragraph 63)[10].

Isolation and Earthing of OCS

104 The "Isolation and Earthing of the OCS" document is a detailed step-by-step list of instructions for the Traffic Supervisor and Authorised Person to ensure that a de-energisation and isolation is carried out in a safe manner (paragraphs 57-58).

105 The steps are concise and in a logical order, for the most part, however there is no requirement in the document for the Traffic Supervisor to check the AVLS to ensure there are no trams in the vicinity of the isolation (paragraph 62).

Switching Programme Form

106 The first section of the Switching Programme Form is required to be signed off by the Traffic Supervisor to confirm they have carried out the tasks related to the remote switching of the Kylemore to Suir Road section (paragraph 58); however, there is no requirement for the Traffic Supervisor to sign off to confirm he has checked the AVLS to ensure there are no trams in the location (paragraph 62).

Transdev Radio Protocol

107 The Radio Protocol applies to all authorised employees of Transdev; all contractors and third parties that are granted access to the Transdev radio communication system. Of interest to this investigation are that "general chit chat" and the transmission of "anything other than your voice" are prohibited (paragraphs 65 - 66); and that all message should be "concise" (paragraph 65).

[10] The RAIU consider this to be an Additional Observation, AO-04 (paragraph 123).

Traffic Supervisor Role, Competency & Training

108 The LNMC Manual is the primary documentation in relation to the role of the Traffic Supervisor, here the duties of the Traffic Supervisor are outlined (paragraph 67). The LNMC Manual outlines the training for the role of the Traffic Supervisor, namely systems training, procedural training and work experience (paragraph 68).

109 In terms of communications training, the "Traffic Supervisor Communication Training" document sets out the key elements of communication for the Traffic Supervisor, namely: accuracy (request clarification if required), clarity (speak slowly and clearly), professionalism; "general chit chat" is forbidden (paragraphs 71 - 72). There is no refresher training on communications provided (paragraph 73).

110 At the time of the incident, the competency management in place required the assessor to monitor the Traffic Supervisor while undertaking duties; there was no random downloads of voice communications taken (paragraph 76).

Actions of the Traffic Supervisor & Authorised Person

111 In terms of the actions of the Traffic Supervisor, the Traffic Supervisor:

- Allowed the broadcasting of news in the LNMC when transmitting messages over the communications system to the Authorised Person, this is in violation of Radio Protocol document which prohibits the transmission of anything other than your voice (paragraph 66). The transmission of the Sky New broadcast may have acted as a distraction to the Authorised Person;
- Did not check the AVLS to see if there were other trams in the area of the requested isolation (paragraph 86); although it is noted that the "Possession and Isolation of the Tramway", "Isolation and Earthing of OCS" and the "Switching Programme Form" do not directly require the Traffic Supervisor to check the AVLS for the presence of trams (paragraph 62); the "Possession and Isolation of the Tramway", does require that no tram movements are permitted into or through a possession unless (paragraph 54);
- Did not use appropriate safety critical communications techniques, in that the Traffic Supervisor pre-empted the Authorised Person by stating "Okay looking for a little switching there Kylemore yeah?", which in turn resulted in the informal "Kylemore to Suir yeah" from the Authorised Person (paragraph 82). In addition, there was some "general chit chat" (paragraph 84) which is prohibited (paragraphs 65 and 72);

- Did not complete the “Switching Programme Form” correctly in that the time recorded on the Switching Programme Form for the de-energisation is 01:27 hrs (the second de-energisation), with the first de-energisation being written over (paragraphs 61 and 96);
- Did not report the incident in line with the LNMC Manual (paragraph 70).

112 In terms of the Authorised Person, the Authorised Person:

- Initially contacted the Traffic Supervisor to enquire about a starting time for the isolation, however, this quickly developed into an offer and acceptance of a de-energising of the Kylemore to Suir Road section (paragraph 82);
- In terms of the “Switching Programme Form” from the night of the incident, the form was not completed in full, in that the name and contact number of the Authorised Person were not filled-in on the form (paragraph 60); this resulted in the Traffic Supervisor contacting NMC requesting that the Authorised Person contact that Traffic Supervisor, instead of the Traffic Supervisor contacting the Authorised Person directly (paragraph 94).

Conclusions

Luas Overhead Contact System

113 The pantograph of Tram 4010 bridged the energised section of the OCS (the section on which Tram 4010 was travelling i.e. Heuston to Suir Road) with the de-energised Kylemore to Suir Road Section through the Section Insulators (paragraph 86); which caused a large flashover. However, had the Section Insulators been fitted with diodes this may have prevented the transfer of current from the live section into the de-energised section (paragraph 99).

Transdev Suite of Documents related to the incident

114 The “Possession and Isolation of the Tramway” document outlines the roles and responsibilities of staff involved in possessions and isolations, such as the Traffic Supervisor and Authorised Person; however, the document does not reference the “Isolation and Earthing of OCS” which deals with the step-by-step instructions on how to carry out an isolation, safely. In addition, the referencing in the document, in places, is incorrect (paragraphs 102 - 103).

115 The “Isolation and Earthing of the OCS” document is a detailed step-by-step list of instructions for the Traffic Supervisor and Authorised Person to ensure that a de-energisation and isolation is carried out in a safe manner. The steps are concise and in a logical order, for the most part, however there is no requirement in the document for the Traffic Supervisor to check the AVLS to ensure there are no trams in the vicinity of the isolation (paragraphs 104 - 105); which the Traffic Supervisor did not do on the night of the incident.

116 As with the “Isolation and Earthing of the OCS” document the “Switching Programme Form”, does not require the checking of the AVLS for trams in the area to be isolated (paragraph 106).

Traffic Supervisor Role, Competency & Training

117 There are a number of training documents related to the role, competency and training of Traffic Supervisors, namely the LNMC Manual and the “Traffic Supervisor Communications Training” (paragraphs 108 - 109); however, at the time of the incident there was a notable absence of random downloads of voice communications to check for compliance with the standards in place (paragraph 110).

Actions of the Traffic Supervisor & Authorised Person

118 On the night of the incident the Traffic Supervisor allowed the news to be broadcast, something other than his voice, to be transmitted over the communications system and did not use appropriate safety critical communications etiquettes; did not check the AVLS for trams in the area of the isolation; did not complete the “Switching Programme Form” correctly and, did not report or log the incident immediately in line with LNMC Manual protocols (paragraph 111).

119 The Authorised Person allowed the Traffic Supervisor to grant an isolation, despite not contacting the Traffic Supervisor for that reason; the “Switching Programme Form” sent to the Traffic Supervisors, did not contain the Authorised Person’s name, in the appropriate place on the form (paragraph 112).

Causal, contributing and systemic factors

120 Tram 4010 entered the de-energised area (Sections 151-152-153), which was in the process of being isolated, as a result of the following causal factor:

- CaF-01 – The Traffic Supervisor de-energised the Kylemore to Suir Road section before the last tram had passed through the section as the Traffic Supervisor did not check the AVLS for the presence of trams.

121 Contributory factors include:

- CoF-01 – The Section Insulators, used by Transdev, allow current to travel from an energised section into a de-energised section when bridged by a tram pantograph;
- CoF-02 – The conversation between the Traffic Supervisor and the Authorised Person did not meet the requirements of safety critical communications; in addition, the playing of a news broadcast during a safety critical communication may have acted as a distraction to the message being communicated.

122 Systemic factors include:

- SF-01 – The “Isolation and Earthing of OCS” document and the Switching Programme Form” do not require the checking of the AVLS for the presence of trams prior to granting of an isolation;
- SF-02 – The safety critical communications suite of documents is not robust in terms of the monitoring of staff for the correct use of safety critical communications (e.g. there is no random downloads of voice communications).

Additional Observations

123 Although not causal, contributing, or systemic, the RAIU make the following additional observation:

- AO-01 – The RAIU were not notified immediately of the incident but were notified two days later (paragraph 2);
- AO-02 – The Traffic Supervisor did not immediately report or log the incident and as such was not subject to drugs and alcohol testing, in line with Transdev protocols (paragraph 118);
- AO-03 – The Isolation Signage is not illuminated or secured in position (paragraph 55);
- AO-04 – There are some anomalies regarding the Transdev suite of earthing, isolation and switching documents, in that they do not reference each other and there are errors in terms of referencing and terminology (e.g. use of earth straps instead of short circuit straps) (paragraph 102 - 103).

Measures taken by Transdev since the incident

Position of the Traffic Supervisor

124 As a direct result of the incident, the Traffic Supervisor is no longer performing the role of Traffic Supervisor.

Internal Transdev Investigation

125 Transdev Safety Department issued an Investigation Remit for the incident on the 13th January 2021; and published the Report of Investigation "Overhead catenary system (OCS) De-energisation / Isolation incident Kylemore Road / Sure Road 5th January 2021". The report found that the immediate cause of the accident was: "Tram 4010 entered a section of the tramway between Suir road and Kylemore that was de-energised by the Traffic Supervisor as per the planned isolation that was outlined in the switching programme. The Authorised Person was in the process of actioning the switching programme when the incident occurred".

126 The underlying cause identified was: "It was identified that the Traffic Supervisor de-energised and gave possession of the section of the line between Kylemore and Suir Road while there was an out of service tram present on the network, planned to traverse through the area en route back to the Red Cow depot as per timetable".

127 The root cause of the incident was: "The Traffic Supervisor did not observe the out of service Tram 4010 on the AVLS system in the LNMC which was still on the line, as per the timetable, prior to actioning the switching programme. Resulting in Tram 4010 entered a section of the tramway between Suir road and Kylemore that was de-energised by the Traffic Supervisor as per the planned isolation that was outlined in the switching programme".

128 Outlined in the internal report are a number of measures commenced, namely that Transdev commenced plans to:

- Support and bolster the current staffing of the LNMC; in this a short term plan was introduced to support LNMC;
- Train and assess staff expected to conduct safety critical communication;
- Monitor the performance of the LNMC staff;
- Enhance processes surrounding engineering possessions and isolations;
- Review the competence management system Traffic Supervisor assessment documentation to ensure it complies with Transdev's document control procedure.

Safety Critical Communications Procedure

129 Transdev initially issued "TDLR Safety Critical Communications Procedure" in April 2021; Issue 03, was issued on the 12th November 2021. The document:

- Describes the requirements for the training, assessment (including the use of score cards) and monitoring (through downloading voice communications on a random basis, personal monitoring while undertaking duties and scenario based simulations) of all Transdev staff undertaking safety critical communications;
- Outlines the correct methods of communications and phrases to be used during normal and emergency situations (appropriate phrases and the phonetic alphabet are provided);
- Applies to all means of communication used on the network but not limited to radios, mobile phones, emergency help points;
- Provides feedback on the safety critical communications performance of staff to facilitate continuous improvement.

Notification of occurrences to the RAIU

130 On the 1st April 2021, the Transdev Head of Safety issued an email to the relevant parties in relation to the notification of incidents to the RAIU; attached to the email was the RAIU's "Notification of occurrences for railway organisations" document, RAIU-GU001, Version 3, issued on the 1st January 2020.

Safety Recommendations

Introduction to safety recommendation

131 In accordance with the European Union (Railway Safety) (Reporting and Investigation of Serious Accidents, Accidents and Incidents) Regulations 2020), recommendations are addressed to the national safety authority, the Commission for Railway Regulation (CRR). The recommendation is directed to the party identified in each recommendation.

Absence of safety recommendations due to measures already taken

Safety critical communications

132 In relation to the calls made on the 5th January 2021 related to the incident, the RAIU found that the communications did not meet the requirements of Transdev documentation and that the safety critical communications were below that expected of a professional railway organisation. As a result, the RAIU found that safety critical communications were, in part, causal to the incident and issued a USAN on 1st March 2021 (paragraph 11). The associated recommendations are in the process of being implemented.

133 Stated in the new "TDLR Safety Critical Communications Procedure" (paragraph 129) is "Do not transmit anything other than your voice" (CoF-02).

134 For the reasons outlined above the RAIU do not consider that any further safety recommendations be made in terms of safety critical communications.

Notification of occurrences to the RAIU

135 The RAIU were not informed of the incident until two days after the incident. However, on the 1st April 2021, the Transdev Head of Safety issued an email to the relevant parties in relation to the notification of incidents to the RAIU; attached to the email was the RAIU's "Notification of occurrences for railway organisations" document, RAIU-GU001, Version 3, issued on the 1st January 2020. As a result of this action, that RAIU do not consider that a safety recommendation is warranted.

Reporting and logging of incidents within Transdev

136 Transdev have protocols in place, in the LNMC Manual, for Traffic Supervisors related the reporting and logging of events; protocols are also in place regarding drugs and alcohol testing (paragraph 70). It is noted that the Traffic Supervisor, on the night of the incident, did not carry out his duty in this regard to reporting/logging of the incident, which in turn would have resulted in the testing for drugs and alcohol (AO-02). The actions of the Traffic Supervisor on the night of the incident, resulted in the Traffic Supervisor being removed from the role of Traffic Supervisor (paragraph 124). As protocols are in place for reporting /logging of incident and the testing of drugs and alcohol, post-incident, but were not adhered to on the night, by one individual, the RAIU do not consider that any safety recommendation is warranted, in this instance.

Safety recommendations as a result of this incident

137 The pantograph of Tram 4010 bridged the energised section at Heuston to the de-energised section at Suir Road and resulted in the short circuit. The Section Insulators allow a Pantograph to bridge both sections of the OCS. As a result, the RAIU make the following safety recommendation (CaF-01):

Safety Recommendation 202107-01

TII, in conjunction with Transdev, should consider fitting Section Insulators with diodes to prevent the passage of current from an energised section into a de energised section when bridged by a pantograph.

Safety recommendations as a result of additional observations

138 Although noted as not being a contributory factor in the incident, the following safety recommendation is as a result of additional observations made by the RAIU during this investigation. The Isolation Signage is not placed until the final task of the switching programme at the outermost location has been undertaken. The Isolation Signage is not illuminated or secured in position (paragraph 123, AO-03); as a result, the RAIU make the following safety recommendation:

Safety Recommendation 202107-02

Transdev should consider increasing the visibility of the Isolation Signage (through illuminating); as well as providing a means to secure the Isolation Signage (to prevent the signage being removed by unauthorised persons).

139 There are some anomalies regarding the Transdev suite of earthing, isolation and switching documents, in that they do not reference each other and there are errors in terms of referencing and terminology (paragraph 123, AO-04).

Safety Recommendation 202107-03

Transdev should review and update the suite of documents related to earthing, switching, possessions and isolations to ensure that the documents are consistent in terms of the actions to be taken, referencing and terminology.

Additional Information

List of abbreviations

AC	Alternating Current
AVLS	Automatic Vehicle Location System
AP	Authorised Person (Overhead Contact System)
CI	Chief Investigator
CRR	Commission for Railway Regulation
DART	Dublin Area Rapid Transit
DC	Direct Current
ESF	Electrical Switching Forms
ESS	Electrical Sub Station
EU	European Union
FFCCTV	Forward Facing Close Circuit Television
hr	hour
HSCB	High Speed Circuit Breaker
km	kilometre
LDM	Luas Duty Manager
LNMC	Luas Network Management Centre previously known as Central Control Room (CCR)
LPS	Line Possession Supervisor
m	metre
NMC	Network Maintenance Centre
MCB	Main Circuit Breaker
OCS	Overhead Contact System
RAIU	Railway Accident Investigation Unit
S2M	Joint Venture Systems Maintenance Team
SCADA	Supervisory Control And Data Acquisition
SOP	Standard Operating Procedure
SI	International System of Units
TED	Traffic Event Database
TSI	Tramway Safety Instruction
USAN	Urgent Safety Advice Notice
V	Volt
VMC	Vehicle Maintenance Contractor
WRF	Work Request Forms

Glossary of terms

Accident	An unwanted or unintended sudden event or a specific chain of such events which have harmful consequences. For heavy rail, the EU Agency for Railways divides accidents into the following categories: collisions, derailments, level-crossing accidents, accidents to persons caused by rolling stock in motion, fires and others.
Alternating Current	Alternating Current (AC) is an electric current which periodically reverses direction and changes its magnitude continuously with time in contrast to direct current (DC) which flows only in one direction.
Article 20 of Directive (EU) 2016/798, Obligation to investigation	Article 20 (1) Member States shall ensure that an investigation is carried out by the investigating body referred to in Article 22 after any serious accident on the Union rail system. The objective of the investigation shall be to improve, where possible, railway safety and the prevention of accidents. Article 20 (2) The investigating body referred to in Article 22 may also investigate those accidents and incidents which under slightly different conditions might have led to serious accidents, including technical failures of the structural subsystems or of interoperability constituents of the Union rail system. The investigating body may decide whether or not an investigation of such an accident or incident is to be undertaken. In making its decision it shall take into account: (a) the seriousness of the accident or incident; (b) whether it forms part of a series of accidents or incidents relevant to the system as a whole; (c) its impact on railway safety; and (d) requests from infrastructure managers, railway undertakings, the national safety authority or the Member States.
Authorised Person	Authorised Person Overhead Catenary System (OCS). A competent person with the required technical knowledge and expertise to prevent danger or injury and is appointed to carry out trackside and or substation switching and or isolations.

Automatic Vehicle Location System	Antennae positioned under the tram driving cabs transmit signals to Automatic Vehicle Location System (AVLS) loops embedded in the track. The AVLS operates by electrical induction with the antenna transmitting requests to the AVLS loops. The AVLS loops allow: The location of the tram to be detected, in real time, by the Traffic Supervisors, etc; Tram drivers to request a proceed aspect from line side signals (in certain locations); Tram drivers to request the movement of points.
Causal Factor	Any action, omission, event or condition, or a combination thereof that if corrected, eliminated, or avoided would have prevented the occurrence, in all likelihood.
Central Control Room	Location from which tram operations are managed and monitored now known as Luas Network Management Centre.
Circuit Breaker	A switch arranged to open automatically when a current above a predetermined value flows through it.
Conductor	A body or substance which permits the flow of electricity.
Contributing Factor	Any action, omission, event or condition that affects an occurrence by increasing its likelihood, accelerating the effect in time or increasing the severity of the consequences, but the elimination of which would not have prevented the occurrence.
De-energised	The remote switching undertaken by the Traffic Supervisor through the SCADA system to remove the traction power supply feeding the OCS.
Diode	A semiconductor device with two terminals, typically allowing the flow of current in one direction only.
Direct Current	Direct current (DC) is one-directional flow of electric charge. Direct current may be converted into alternating current (AC) via an inverter.
Earth	The potential of the general mass of the earth and of any conductor in direct electrical connection with it. Note: “Earth” for the purpose of overhead line equipment only, is the general mass of earth not directly connected to the traction return circuit.

Earthing	Earthing of the OCS is the process whereby low resistance cables are attached from the OCS to the rail to allow for an instantaneous discharge of the current to take place, directly to earth.
Earth Wire	A bare overhead wire electrically connecting the steelwork of two or more structures together and to the track return.
Electrical Sub-Station	An installation of electrical equipment for converting alternating to direct current for the supply of power for electric traction (i.e. supplying 750 V DC to the trams).
Energised	Power is in the OCS, no contact may be made with the OCS and a minimum 2.75 meters safe distance must be kept from the OCS.
Flashover	A high voltage electrical short circuit made through the air between exposed conductors.
High Speed Circuit Breaker	A switch in an electric circuit which is usually remotely controlled and will open automatically should an excessive current pass through it.
Incident	Any occurrence, other than an accident or serious accident, associated with the operation of trains and affecting the safety of operation. For heavy rail, the EU Agency for Railways divides incidents into the following categories: infrastructure; energy; control-command & signalling; rolling stock; traffic operations & management and others.
Insulator	Material which offers extremely high resistance to the passage of electricity.
Investigation	A process conducted for the purpose of accident and incident prevention which includes the gathering and analysis of information, the drawing of conclusions, including the determination of causes and, when appropriate, the making of safety recommendations
Isolated	Electrical equipment is said to be isolated when it is disconnected from any source of electricity supply
Isolation Signage	Signage placed on the track to protect a section of line that has been isolated. No trams are permitted in this section.

Luas Network Management Centre	Luas Network Management Centre Location from which tram operations are managed and monitored previously known as Central Control Room.
Luas Possession Supervision	The responsibilities of the LPS are: to ensure the possession is managed safely in accordance with the Possession and Isolations of a tramway document; except in the case of planned possessions to agree with the Traffic Supervisor the limits of the possession; to accept the possession from the Traffic Supervisor; to ensure that the necessary protection is in place to protect the safety of tram operations and personnel during a possession; to liaise with all Luas Engineering Supervisors (LESs) and to identify to each LES the extent of permissible Engineering sites within a possession and any isolation of the OCS; to ensure that the possession is cleared and safe for tram operations and highway use.
Pantograph	A collapsible frame mounted on insulators on the roof of electric motor cars which bears against the contact wire and through which the electrical current is collected from the overhead line equipment.
Planned Isolation	An isolation is the de-energisation and local electrical disconnection of the traction supply to the OCS and application of local earth bonds using a switching programme. Isolations are applied to make the OCS safe for people to work on or near the OCS and are normally required to be planned.
Possession	A period of time during which one or more tracks are blocked to trams to permit work to be safely carried out one or near the line
Possession with Isolation	Electrical disconnection of the traction supply (OCS) from the area in which work is to be undertaken. Possession of work area must be taken before isolation can be put in place.

Section Insulator	Provide a continuous supply of power to the tram when the tram passes from one electrical section to the next and also allows for de-energising of one section at a time. The separation between the wires is such that, in the event of a de-energising at one of the sections, there is no possibility of the two sections coming into contact with each other except when bridged by a pantograph.
Serious Accident	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 safety regulation or the management of safety. For heavy rail, the EU Agency for Railways divides serious accidents into the following categories: collisions, derailments, level-crossing accidents, accidents to persons caused by rolling stock in motion, fires and others.
Short Circuit Straps	Straps connected between the OCS and the rails, so that if current is applied to the OCS in a section when the short circuit straps are in place and will flow back to the ESS causing a short circuit. The high-speed circuit breaker feeding the traction power to that section has protection relays that notice this short circuit and will cause it to trip/open (i.e. stop feeding current to it) within a number of milliseconds. If two ESSs are feeding the same section, then both ESSs high speed circuit breakers will trip/open.
Supervisory Control And Data Acquisition	Used to remotely monitor and control all the power supply equipment of the Luas network. Information displayed on screen allows the operator to see which part of the Luas is energised or not, also equipment in failure mode. Commands can be sent to isolate one or more substations or a section of a line. All information relevant to the substations, i.e. fire alarm, intrusion is also reported on these screens. The status of the power is also represented by colour coding. Green: De-energised, Red: Energised, Yellow: Inconsistent status (unknown), Orange/Pink: Identifies a fault

Switching	Switching is local connecting or disconnecting of an electrical switch with key locked protection to provide a safe working environment for staff working in a section.
Systemic Factor	Any causal or contributing factor of an organisational, managerial, societal or regulatory nature that is likely to affect similar and related occurrences in the future, including, in particular the regulatory framework conditions, the design and application of the safety management system, skills of the staff, procedures and maintenance.
Traffic Event Database	A repository for everything that occurs on or near the network during an operational shift is recorded. All incident details must be recorded in Traffic Event Database with each incident detail recorded chronologically.
Traffic Supervisor	The duties of a Traffic Supervisor are as follows: Operating tram services to published timetable; Prime contact for drivers in relation to technical fault resolution and management of drivers on a real-time basis; Management of incidents within LNMC and liaison with emergency services and TDLR incident officer; Efficient restoration of services post-incident; Operation of technical systems to agreed TDLR standards; Interface with relevant teams via the asset and fleet management team to communicate infrastructure and tram defects; Timely and accurate recording of all events within company database; Systems alarm management and response. In terms of possessions and isolations, the Traffic Supervisor is role is: To grant and receive back possession; To advise other Traffic Supervisors of work taking pace including any person relieving a Traffic Supervisor; To carry out SCADA switching when required as part of isolation; To ensure that no tram movements are permitted into or through a possession unless a tram movement is indicated in the TED and only then with the specific agreement of the LPS for that movement to take place; To give permission for occupations to commence and to ensure that any restrictions associated with tram movements through the area of an occupation are made known to the relevant operational staff including drivers.

Urgent Safety Advice Notice	At the early stages of an investigation the RAIU may make some early findings on safety issues that require immediate action, in these cases the RAIU issue a USAN. The purpose of issuing USANs is that the RAIU can make safety recommendation to Implementers and Addressees promptly, without having to complete the full Investigation Report.

References

RAIU (2021), USAN 03.

Transdev (2020), Drugs and Alcohol Policy, TDLR-HR-PO-003, Rev 3.0.

Transdev (2020), Isolation and Earthing of OCS TDLR-SOP-0015, Rev 01.

Transdev (2021), Overhead catenary system (OCS) De-energisation / Isolation incident Kylemore Road / Sure Road, 5th January 2021.

Transdev (2019), Possession and Isolation of the tramway, TDLR-OP-PR-0007, Rev 01.0.

Transdev (2017), Traffic Supervisor Communication Training.

Transdev (2019) Transdev Radio Protocol.