



**Railway Accident
Investigation Unit
Ireland**



INVESTIGATION REPORT

Trend investigation into Signals Passed At Stop on the LUAS network

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Report Description

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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. 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 (DoT) which conducts investigations into accidents and incidents on the national railway network including 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 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

In February 2020, the RAIU received the monthly occurrence notifications from Transdev Dublin Light Rail (TDLR) in relation to incidents and accidents on the Luas network in January 2020; here it was notified that there had been a signal passed at Stop (SPAS) at Cookstown Interchange, County Dublin, with a conflicting movement. After the RAIU conducted a Preliminary Examination Report, the RAIU made the decision to conduct a full investigation into the incident. On review of SPAS history on the Luas network, the investigation was expanded to a trend investigation into all SPAS events in the previous year, 2019; SPAS events in 2020 and SPAS events in the first six months of 2021; a total of thirty-six SPAS incidents.

The RAIU identified three *causal factors* which were applicable to **some** of the SPAS incidents, namely:

- CaF-01 – Drivers did not input the Ready To Start (RTS) request for the call for a Proceed aspect;
- CaF-02 – Drivers, on seeing a Stop signal, did not apply the emergency brake, which may have prevented the tram passing the signal;
- CaF-03 – There is no *Driver Reminder Appliance* (DRA), or similar, in the driving cab for the avoidance of Start Against Signal (SAS) SPAS incidents.

In terms of *contributing factors*, as to why there are SPAS incidents, the RAIU found the following factors applicable to **some** SPAS incidents:

- CoF-01 – There appears to be a link between the occurrence of a SPAS and the Line Signalling System (LSS) and depot locations. This may be the result of more complex movements which involve approval from Luas Network Management Centre (LNMC), in particular in Sandyford Depot; and, being the locations where drivers take their meal breaks;
- CoF-02 – Drivers did not check signals prior to taking traction from a stationary position, resulting in SAS SPAS incidents;
- CoF-03 – Drivers checked the Points Position Indicator (PPI)/ Points instead of the signal aspect;

- CoF-04 – Drivers did not input the service files into the Automatic Vehicle Location System (AVLS) correctly or were inputting while the tram is in motion; resulting in distraction and automatic proceeds not being given, which further resulted in an incorrect expectation of a Proceed aspect;
- CoF-05 – Drivers had an incorrect expectation of signals upgrading to proceed on approach as a result of:
 - Normally having a proceed at certain locations;
 - Inputting an RTS request and assuming the signal has upgraded (but hasn't);
 - Reading road traffic signals in error;
 - Looking at the movements of other trams.
- CoF-06 – Drivers operating in degraded mode.
- CoF-07 – Drivers being distracted, preoccupied or losing situational awareness as a result of personal issues, pedestrians, in-cab distractions (AVLS, sun glare), and forgetting signals.

Systemic factors to the SPAS incidents were:

- SF-01 – Driver training is deficient in terms of the:
 - Minimum activity criteria related to the LSS Locations;
 - Training criterion for depot movements;
 - Understanding of the importance of RTS requests, emergency brake applications and the correct input of the AVLS.
- SF-02 – The Tramway Safety Instruction (TSI) Manual is not robust enough in terms of some of the movements to be carried out around depots and LSS locations; and, the application of emergency brake.
- SF-03 – There were number of instances of driving rule breaks in terms of non-application of the emergency brake and inputting of the AVLS.

The RAIU made eight *additional observations*:

- AO-01 – TDLR do not refer to the “Stop” aspect as a “Stop” aspect and instead it is referred to as a “Do not Proceed” aspect in the TSI Manual, internal investigation reports, Traffic Event Database (TED) recordings, etc. In addition, it does not refer to the “Stop, unless too close to Stop Safely” aspect as a “Stop” aspect, instead it is referred to as a “cluster” in investigation reports, TED recordings and a safety notice. Also, the “Stop, single dot, contact CCR for instruction” aspect is not referred to as a “Stop” aspect, but instead as a “Single dot aspect”.
- AO-02 – TDLR do not have a formalised Signal Sighting Committee (SSC); where the positioning of the signal can be examined to see if it was contributory to a SPAS event and where this is the case changes to the asset or its operational context would reduce the likelihood of a further accident or incident occurring, the SSC should recommend what retrospective action is appropriate.
- AO-03 – Drivers are regularly not applying the emergency brake and making a normal braking application on the approach to a Stop aspect, resulting in trams passing the signals; this is mainly as a result of drivers being concerned about possible injuries to passengers as a result of emergency brake applications. The RAIU consider that drivers are over-reliant on the line-of-sight principles rather than obeying the controlling signals. The TSI Manual does not specifically state that drivers should apply the emergency brake to prevent SPAS incidents.
- AO-04 – TDLR do not currently score any of the SPAS events in terms of severity (they are currently classified by type only), therefore there is no means of calculating the likelihood of an accident, its potential consequences or as an indication to the variations of SPAS risk over time.
- AO-05 – Presently, suspected SPAS incidents can only be detected at LSS locations; resulting in a reliance on driver self-reporting SPAS incidents.
- AO-06 – Presently, LNMC can see a suspected SPAS event at LSS locations through a visual representation on the LSS mimic; however, there is no audible alarm;
- AO-07 – After a SPAS event, drivers are coached/ re-trained and permitted back to full driving duties, without support (e.g. additional monitoring for a fixed period of time) within days of the incident.
- AO-08 – The current internal investigation process produces generic reports which do not capture the trends around SPAS incidents, in particular, at multi-SPAS signals; or other specific conditions which may prevent the re-occurrence of a similar SPAS incident.

As a result of these findings, the RAIU have made fifteen safety recommendations:

- Safety Recommendation 2022003-01 – TII should determine if in-cab technological and/or mechanised systems could be introduced to assist drivers with the prevention of SPAS incidents, taking into account requirements for ensuring safety risk is as low as reasonably practicable (ALARP). Analysis should include an appraisal of available systems and the effect they may have on mitigating sub-standard driver performance.
- Safety Recommendation 2022003-02 – TDLR should enhance the TSI Manual operating instructions for all depot and LSS locations based off site-specific risk assessments for the different locations. These enhancements should include step-by-step guidance on how trams are moved at these locations; this should include how verbal permissions are granted by LNMC.
- Safety Recommendation 2022003-03 – TII should review the technical specification of the onboard AVLS console to see if it is possible to limit the inputting of the AVLS service files to when the tram is stationary; and if so, implement this change.
- Safety Recommendation 2022003-04 – TDLR should, with the assistance of a qualified human factors expert, review the timings and locations of SPAS incidents to establish reasons as to why drivers are involved in SPAS incidents at certain times and locations.
- Safety Recommendation 2022003-05 – TDLR should, with the assistance of a qualified human factors expert, introduce training in relation to *error prevention techniques* as a tool for drivers to manage distraction, pre-occupation and incorrect expectation.
- Safety Recommendation 2022003-06 – TDLR should review its current training regime with a view to increasing training and competency assessment of drivers, in particular in terms of driving in depots and LSS locations and in degraded mode.
- Safety Recommendation 2022003-07 – TII should, as part of the increased driver training and competency assessment, consider the introduction of a driver training simulator which would assist in driving training in depots, LSS locations and in degraded mode.
- Safety Recommendation 2022003-08 – TDLR should ensure that tram signals are referenced correctly in the TDLR suite of documents, this in turn should reinforce, to the drivers, which signals are Stop signals.

- Safety Recommendation 2022003-09 – TDLR should establish a formalised SSC, to include stakeholders from the relevant internal and external departments (e.g. TII and local authorities) to ensure that:
 - In the event of a SPAS event an SSC is convened, where appropriate, to determine if any immediate actions can be taken at the signal location which may prevent a SPAS re-occurrence;
 - Any changes to signalling sequencing (including the introduction of new signals) are carried out as per the relevant SMS procedure to ensure that risks are not inadvertently introduced at signals;
 - Multi-SPAS signals are reviewed to see if there are any trend to the SPAS incidents;
 - Previous recommendations, related to SPAS events, from internal investigations have been addressed.
- Safety Recommendation 2022003-10 – TDLR should update the TSI Manual and training and competency management suite of documents to include clear instructions on when emergency brake applications should be made in relation to the prevention of SPAS incidents; these instructions should be properly communicated to the drivers.
- Safety Recommendation 2022003-11 – TDLR should introduced a SPAS risk scoring process for high-risk SPAS events on the Luas network, to ensure that the severity of a SPAS can be measured (best-practice should be applied if available). This scoring process can be used to assess if risks associated with the SPAS conform to TDLR risk acceptance criteria and are ALARP. The scoring process will also ensure that correct system interventions are applied, where required.
- Safety Recommendation 2022003-12 – TII should research if technological and/or mechanised systems could be implemented for the entire Luas network to ensure SPAS events are immediately detected, taking into account requirements for ensuring safety risk is ALARP. Analysis should include appraisal of available systems, including systems that report detection of SPAS events to LNMC and to the driver in the cab.
- Safety Recommendation 2022003-13 – TII should evaluate if it is possible to introduce an audible alarm for suspected SPAS incidents at LNMC.
- Safety Recommendation 2022003-14 – TDLR to review and strengthen the current process for the management of drivers post SPAS incident, to ensure drivers skill are further developed (through adequate re-training) and they are supported (through increased monitoring) post SPAS incident.

Trend investigation into SPAS incidents on the Luas Network

- Safety Recommendation 2022003-15 – TDLR should develop their internal investigation processes, to develop a:
 - Training and competency management system for internal investigators;
 - Manual, or similar, outlining internal investigation processes.

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Section 1 – RAIU Investigation Framework

RAIU decision to investigate

- 1 In accordance with the Railway Safety Act 2005 and European Union (Railway Safety) (Reporting and investigation of Serious Accidents, Accidents and Incidents) Regulations 2020, 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.
- 2 In February 2020, the RAIU received the monthly occurrence notifications from TDLR in relation to incidents and accidents on the Luas network in January 2020; here it was notified that there had been a signal passed at Stop (SPAS)¹ at Cookstown Interchange, County Dublin, with a conflicting movement. After the RAIU conducted a Preliminary Examination Report, the RAIU's Chief Investigator (CI) made the decision to conduct a full investigation into the incident, given its potential seriousness and its impact on railway safety (*Article 20 (2) (a) (c)*)², as under slightly different circumstances this incident may have led to a serious accident with the potential for fatalities or serious injuries due to risk of collision of two trams³.
- 3 On review of SPAS history on the Luas network, the investigation was expanded to a trend investigation into all SPAS events in the previous year, 2019; SPAS events in 2020 and SPAS events in the first six months of 2021; a total of thirty-six SPAS incidents.
- 4 The RAIU's CI allocated RAIU Senior Investigators, trained in accident investigation, to conduct this investigation, in accordance with recognised investigation techniques.
- 5 In this instance, no external parties were required to assist with the investigation process.

¹ The RAIU are using the Signal Passed at Stop terminology in relation to these types of occurrences as the Signal is a "Stop" signal; some Transdev documentation refer to Signals Passed at Danger (SPAD) which is common terminology in the heavy rail sector.

² It should be noted that light rail incidents and accidents do not fall under the remit of Article 20; however, the RAIU apply the same rational to light rail occurrences for statistical reasons.

³ The RAIU previously investigated an incident of SPAS at the junction of O'Connell Street and Abbey Street, on the 16th September 2009, where a tram proceeded through a Stop signal and collided with a Dublin Bus, injuring twenty-one people (three of which were serious injuries).

Scope & limits of investigation

- 6 The RAIU have established the scope and limits of the investigation as follows:
- A review of thirty-six SPAS incidents from January 2019 to the end of June 2021;
 - Determine any trends in terms of causal, contributory and systemic factors;
 - Examine the relevant elements of TDLR's TSI Manual, Revision 4, published on the 20th April 2018;
 - Examine the relevant elements of the DoT's Traffic Signs Manual (TSM) in terms of regulatory signs and tram signals, last updated in August 2019;
 - Review the Safety Management System (SMS) documentation TDLR SMS, Issue 13, published on the 7th February 2019;
 - Review how SPAS incidents are currently managed by TDLR;
 - Identify any *additional observations* i.e. safety issues identified during the investigation, but without relevance to the conclusions on causes and consequences of SPAS incidents.

Communications & evidence collection

- 7 During this investigation, the RAIU collate evidence through the submission of Requests for Information and reviewing of documentation. Related to this investigation, the RAIU collated and logged the following evidence:
- TDLR investigation reports;
 - On-Tram Data Recorder (OTDR) download & Forward Facing Closed Circuit Television (FFCCTV) footage;
 - Relevant standards and training procedures in relation to driving on the Luas network;
 - Relevant standards in relation to the operation of trams;
 - Driver's competency records;
 - Driver rostering and meal break scheduling;
 - Management of drivers post-SPAS incident.
- 8 All relevant parties co-operated fully with the RAIU investigation; with no difficulties arising.

Other stakeholder inputs

- 9 Emergency services or other stakeholders did not attend any of the incident sites; and, there are no other ongoing investigations, by other external stakeholders, related to these incidents.

Section 2 – Parties associated with the incidents

Transdev Dublin Light Rail

- 10 TDLR operates the Luas light rail tram system in Dublin. As of the 1st December 2019, TDLR are the Vehicle and Infrastructure Maintenance Contractor.

Transport Infrastructure Ireland

- 11 Transport Infrastructure Ireland's (TII) 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.
- 12 TII is the Irish State body that owns the rolling stock and infrastructure required for TDLR to operate the Luas light rail network.
- 13 TII is also the design authority for the system, and the decision making authority of all changes and modifications to the Luas infrastructure and rolling stock.

Section 3 – Luas infrastructure

Track

- 14 The Luas network is made up of the red and green lines, located in Dublin (see red circle, inset Figure 1). Luas Red Line is 20 km in length and has thirty-two Stops running from Tallaght to The Point and from Saggart to Connolly. Luas Green Line is 24.5 km in length and has thirty-five Stops running from Brides Glen to Broombridge via the City centre, see Figure 1.

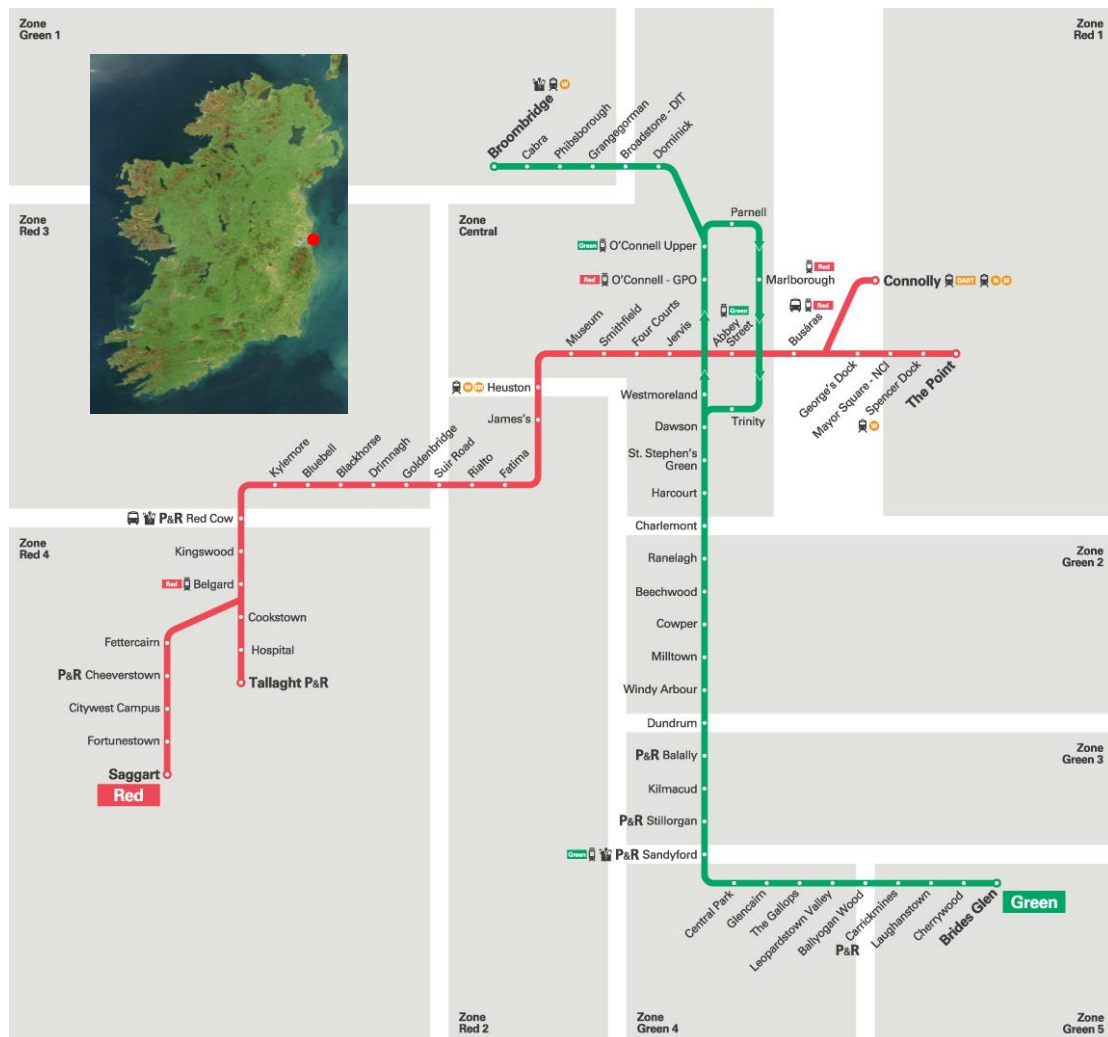


Figure 1 – Luas network map

- 15 Trams operate on a combination of separated track, segregated track and shared running (where the trams share the road with other road users). The lines are generally double track lines, with the exception of certain areas which are single track lines.
- 16 Trams are powered by an Overhead Catenary System (OCS) providing 750 volts (V) Direct Current (DC).

Signage

- 17 Signage is used to provide information on instructions, prohibitions or restrictions which road users and tram drivers must obey. To be effective, signs must be readily recognised and must have messages which can quickly be read and understood.
- 18 Set out in TDLR's TSI Manual and the DoT's TSM, are the special signs, prescribed for the observance of Luas drivers. These signs are regulatory signs as set out in S.I. No. 97/2003 - Road Traffic (Signs) (Amendment) Regulations 2003 of the Road Traffic Act.
- 19 Examples of regulatory signs are the Light Rapid Transit (LRT) Speed Limit Sign (which specifies the maximum speed for trams in km/h) and the Stop Sign, see Figure 2 for illustrations.
- 20 Information signs are also provided at various locations, such as those illustrated in Figure 3. In particular, they are positioned in depot locations.



Figure 2 – Regulatory Signs

Figure 3 – Information signs

Section 4 – Signalling & PPIs

Introduction

21 Trams are 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. This section will set out in the key factors associated with tram detection, tram signals and PPIs on the Luas network.

Tramway Signals

22 Tramway Signals are outlined in the DoT's TSM (Chapter 9) and TDLR's TSI Manual (Section 3.1). Tramway signals consist of a series of lights forming a narrow white line or plus sign on a black circular background, see Figure 4, which indicate for the tram when to proceed and when to stop. Note, the bottom two signals are directional proceeds and should not be confused with PPIs (outlined in paragraph 25).

Tramway signals apply to all movements and display the following signal images:



The following signal images indicates a tram proceed authorisation.

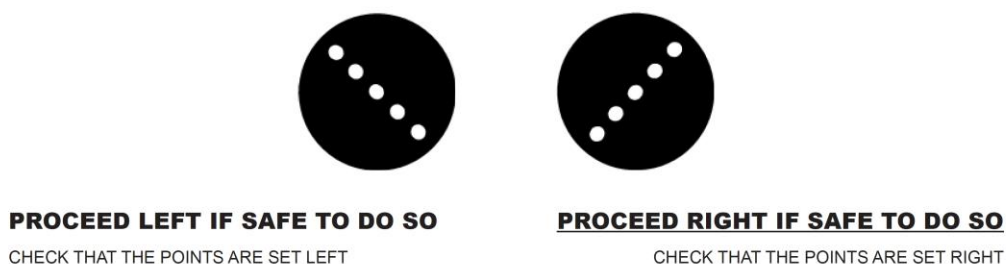


Figure 4 – Tramway Signals

23 Further illustrations are shown in Figure 5, which includes the “Stop – Single Dot” aspect.

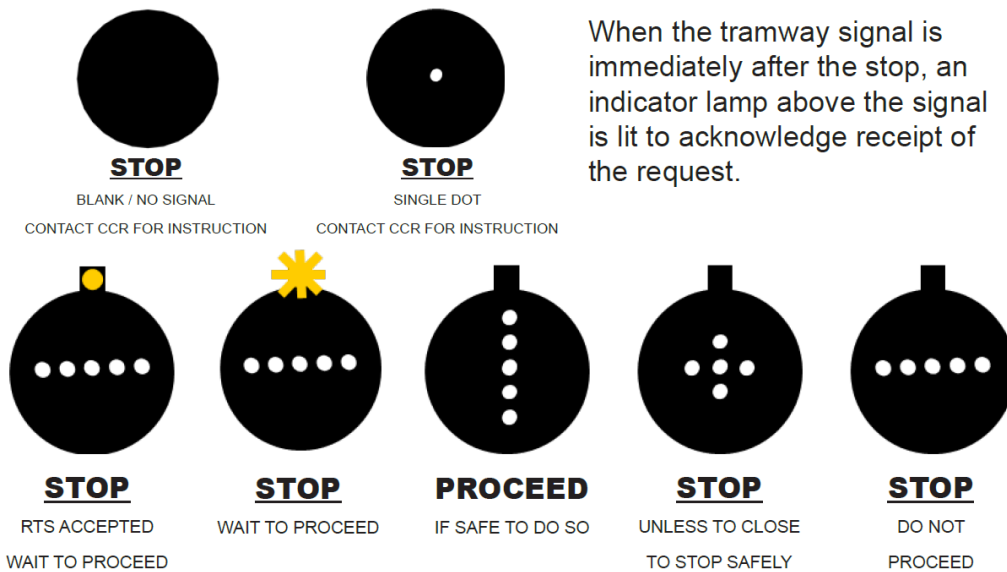


Figure 5 – Additional diagrams for tram signals⁴

24 Note, “Stop” aspect is now referred to as “Stop, do not proceed”; “Stop” being the primary indication. It should be noted that TDLR do not refer to the “Stop” aspect as a “Stop” aspect and instead it is referred to as the secondary description, “Do not Proceed”, in the TSI Manual, internal investigation reports, TED recordings, etc. In addition, it does not refer to the “Stop, unless too close to Stop Safely” aspect as a “Stop” aspect, instead it is referred to as a “cluster” in investigation reports, TED recordings and a safety notice. Given that this RAIU report is a report into trams passing signals at stop, the RAIU consider that the word “Stop” is a more definitive description than “Do not Proceed” and as such have identified this to be an additional observation, AO-01 (paragraph 317), which warrants Safety Recommendation 2022003-08 (paragraph 334).

⁴ CCR refers to Central Control Room (CCR) which is now referred to as the Luas Network Management Centre (LNMC). It will be referred to as the LNMC in this RAIU report, unless in quoted text or in reference to the above tram signals.

Points Position Indicators

- 25 At locations where points are *in advance* of signals, a second black circular background, a PPI, displays the layout of points (route selection) using LEDs. The movements are set out as illustrated in Figure 6, as set out in and TDLR's TSI Manual (Section 3.2).
- 26 The RAIU noted that at some locations, the PPI appeared more prominent than that signal head. The RAIU queried whether TII had reviewed the prominence of the PPI versus the signal head. TII confirmed that a review had been undertaken in the past, with a view to possibly changing the PPI colour; however, it was not feasible. TII did make some changes related to the heights and hoods at PPIs as a means to improve visibility of the signal and PPI heads. The RAIU consider that this can also be addressed through incorrect-expectation error prevention techniques (Safety Recommendation 2022003-05).

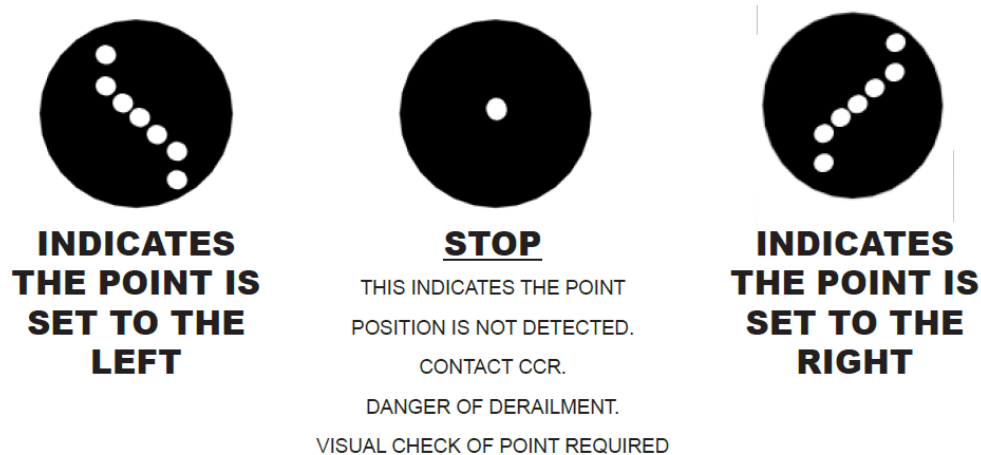


Figure 6 – Points Position Indicators

Automatic Vehicle Location System & interaction with the LSS

- 27 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;
 - Tram drivers to request a proceed aspect from line side signals (in certain locations);
 - Tram drivers to request the movement of points.
- 28 A proceed aspect can be given:
- Automatically by the AVLS system when a tram is detected on the approach to a signal;
 - In certain locations and under certain conditions, when requested manually by a driver by pressing the Ready To Start (RTS) button on the AVLS controls in the driver's cab;
 - When requested by *Central Control Room (CCR)* via the AVLS system;
 - When requested by the relevant Local Authority Traffic Control Centre.
- 29 When a driver is taking a tram into service, the driver must enter the tram service number (unique tram identifier) onto the tram's on-board AVLS. This action downloads the service file (which includes information related to the timetable and route of the tram) from the AVLS server.
- 30 At certain points on the Luas network (LSS locations⁵), auto-routing is enabled (whereby the tram automatically selects the route, based on the service file information), which is activated from an AVLS loop (paragraph 27) via a trip code in the service file e.g. when a tram passes over the AVLS loop, the trip code related to the service number activates, which changes the position of the points to the direction of the destination in the service file and a proceed aspect is displayed. It should be noted that the LSS operates a failsafe check before the auto-routing is enabled.
- 31 Should a tram fail to receive an automatic proceed aspect, either automatically or after manual RTS request by the driver, the driver can contact CCR who can remotely request a proceed aspect from the traffic light system junction controller through the AVLS. Should CCR have difficulty obtaining a proceed aspect, the relevant Local Authority is contacted to request a proceed aspect for the tram.

⁵ Broombridge Shunt, Broombridge East Gate, Sandyford Platforms (entry and exit); Sandyford Depot (entry and exit); Cookstown Interchange.

Signal Sighting Committee

- 32 A Signal Sighting Committee (SSC) is a team of assessors with competence and knowledge of lineside signalling systems. SSCs can make decisions on what needs to be done to achieve compatibility of a lineside signalling asset (e.g. signals) with operations. SSCs can be used where changes are proposed at signals or post-incident where the positioning of the signal may be thought to be contributory to the incident (e.g. SPAS events). SSCs are common in the heavy rail industry.
- 33 In terms of SPAS incidents, an SSC can conduct a post-incident Signal Sighting Assessment, the assessment of signal sighting of an existing operational asset might include a check: against the current asset record and results of previous assessment(s); of the assumptions, dependencies and caveats underpinning a previous assessment result or decision to see if anything was missed; that any prior recommendations have been acted upon, are still valid and remain in place; and, for compliance with relevant standards.
- 34 If a signal sighting assessment confirms that making changes to the asset or its operational context would reduce the likelihood of a further accident or incident occurring, the SSC should recommend what retrospective action is appropriate.
- 35 Currently, TDLR do not have a formal SSC.
- 36 The RAIU note that rarely are any safety recommendations made by TDLR in relation to the physical signal. However, in 2013, after a SPAS at Signal S-2 Southbound, Sandyford, a recommendation was made at the time calling for the signal to be lowered to improve visibility. The RAIU queried whether this has been done and the response, on the 9th December 2020, was “not to the knowledge of the current safety team”⁶. The presence of an SSC would ensure that this action would have been conducted.
- 37 It is noted, that presently, TDLR do not appear to attend the signal location, post-incident, and internal investigation reports do not indicate any immediate actions to be taken by TDLR post-SPAS event. The RAIU consider that an SSC is best practice in the rail industry and as such consider that one should be established by TDLR, TII and other relevant stakeholder and as such have identified this to be an additional observation, AO-02 (paragraph 317), which warrants Safety Recommendation 2022003-09 (paragraph 335).

⁶ It should be noted that it cannot be determined whether the lowering of the signal head would have prevented the SPAS incidents at S-2 Southbound, Sandyford.

Section 5 – Communications

- 38 The means of communication between tram drivers and the LNMC is by Tetra radio, emergency help points and in an absolute emergency, a mobile phone (normally mobiles should be turned off when driving).
- 39 On the 1st March 2021, the RAIU issued an Urgent Safety Advice Notice (USAN 003) to TDLR in relation to safety critical communications, namely “TDLR should urgently undertake a review of their safety critical communications for all modes of communication”. The recommendation from USAN 003 remains open, at the time of publication of this report and as such the RAIU has not included the review of safety critical communications in this report.

Section 6 – Operations

Luas directional operations

40 In terms of directional operations:

- Green Lines trams operate from Brides Glen or Sandyford to Parnell or Broombridge;
- Green Line trams operate from Broombridge or Parnell to Sandyford or Brides Glen;
- Red Line trams operate from Tallaght to The Point; and, from Saggart to Connolly;
- Red Line trams operate from The Point to Tallaght; and, from Connolly to Saggart.

Driving

General

- 41 The operation of the trams is set out in TDLR's TSI Manual. The TSI Manual is a 124-page document which all safety critical staff (including drivers) must be in possession of, and each individual is responsible for continuously following instructions and safety communications set out in its pages. The TSI Manual contains the following headings, of which the relevant sections will be outlined in this report: traffic management; tramway signals; driving mode; passenger service normal operation; general rules; fault and *degraded* operation management; and, recovery of failed trams.
- 42 Section 5 of the TSI Manual, Passenger Service Normal Operation, sets out requirements in relation to: reporting for duty; tram preparation⁷; actions whilst in motion; starting a journey; driver change; crossing and interchange areas; engineering links; line speeds; door operation; and, track works.

⁷ Tram preparation includes a number of actions to be taken by the driver, while the tram is stationary, such as visual checks of tram; checks of bells and horns, wipers, brakes and lights; entering the AVLS requirements, etc.

Line-of-sight

43 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. For example, a tram may have a proceed signal through a road junction, however, cars maybe blocking the passage of the tram, so the tram cannot proceed.

Cab Discipline

44 In terms of cab discipline, Section 6.3 of the TSI Manual set out the following rules:

- The cab door must be closed at all times;
- A driver must not allow his/her attention to be distracted by anyone, anyone causing a distraction can be asked to leave;
- Only specified persons are allowed in the cab;
- No personal radios, earphones, personal handsets or mobile phones are to be used in the cab.

Speed limits

45 Design speeds vary on the line depending on conditions, but in general the maximum speed allowed (relevant to this investigation are):

- On any part of the Luas network is 70 km/h;
- For an in-service tram approaching a platform is 25 km/h;
- Approaching spring points is 15 km/h;
- When moving within the depot area is 10 km/h;
- When performing *sweep tram* movements is 25 km/h.

46 The TSI Manual states that “the speed indicated is the design speed; not a target speed, trams are driven under the line-of-sight principle, and speeds have to be adjusted according to the environment or adverse weather conditions”.

Depot movements

47 TSI Manual instructions are outlined for specific depots at the relevant sections of this report, where relevant. However, in general terms, Section 6.8 of the TSI Manual, “Tram movements in the depot, workshop and sanding shed rules”, states that:

- All depot/workshop tram movement requests must be authorised by the LNMCI;
- Depot moves are performed only when authorised by the LNMCI;
- Before conducting any move, always confirm it with LNMCI.

Section 7 – Luas rolling stock

Physical characteristics

- 48 There are two types of Alstom Citadis light rail vehicles (LRV) on the Luas network, namely the 401 and 502. The 401 trams operate on the Red Line (can operate passenger services on the Green Line, where necessary). 502 trams operate on the Green Lines (they cannot operate passenger services on the Red Line).
- 49 The LRVs are powered by an OCS at a nominal voltage of 750 V DC. They have a maximum speed of 70 kilometres per hour (km/h).
- 50 The 401 consist of fourteen new 401s and twenty-six extended 301s (older rolling stock that were 30 m in length). The 401s are 40 m long, 2.4 m wide, 3.45 m high (with the pantograph lowered), has a tare weight of approximately 49 tonnes, and consists of two high floor motorised end section, a trailer section with a non-motorised bogie, a suspended section and an intermediated motorised section. There are forty on the network. The tram numbers are (3001 – 3026 and 4001 – 4014).
- 51 There are forty-one 502 trams. They are 54.7 m long, 2.4 m wide, 3.45 m high (with the pantograph lowered). The tram numbers are 5001 – 5041.
- 52 As the condition or physical attributes of the rolling stock were not found to be a factor in the SPAS occurrences, the condition or physical attributes of the rolling stock will not be discussed further in this report.

Braking

53 Luas trams have three types of braking:

- Electro-dynamic braking – when the electric tractor motor is used as a generator when slowing a tram (only available on motor-bogies);
- Friction braking – Braking achieved by the application of brake pad to the brake disk;
- Magnetic track braking – Braking is achieved using the friction between magnetic shoes and rails.

54 In terms of braking in the event of critical situation i.e. not the *service brake*, there are two *brake blending* options, as defined by TDLR:

- Safety Braking: Maximum brake available without *load compensation* and electro-dynamic brake. The red mushroom has to be pushed to apply it. If applied at speed the *body-catcher* will drop. The safety brake should be applied when deceleration of the tram still remains inadequate/insufficient having applied normal brake and/or emergency brake.
- Emergency Braking: Maximum brake available including the electro-dynamic brake. Emergency brake is applied by the driver when driver puts the master controller to the emergency brake; or, automatically when a safety critical function is not met (vigilance device failure, door open/fault, and Emergency Exit handle activation).

On-Tram Data Recorder

- 55 Trams are equipped with OTDRs, manufactured by Deuta-Werke which record parameters such as speed, brake applications, horn activations, headlights, etc. This information can be presented in graphic or tabular displays.
- 56 The memory available for these OTDRs is 256 KB, 512 KB or 1MB; the memory used on the trams used on the Luas network is the lowest, 256 KB. Microsoft XP is the information technology operating system used to support the data on the OTDR.
- 57 The OTDRs on the 301 and 401 trams are overwritten after 42 km; the OTDRs on the 402/502 trams are overwritten after 53 km. The average weekday kilometres, per tram, on the Red and Green Lines is 258 km and 253 km, respectively. Meaning the OTDRs are overwritten approximately four to six times every weekday.
- 58 The RAIU found, the OTDRs were overwritten on at least two occasions when SPAS incidents occurred:
- Sylvan Drive/Embankment Road, 17th May 2019 – incident was reported by a member of the public as the tram breached a road junction; however, the OTDR was overwritten at the time of notification;
 - Belgard Road Inbound Junction A05, 15th July 2019 – the SPAS was not identified until the 16th July and by that time the OTDR had been overwritten.
- 59 Since the commencement of the RAIU investigation, TII have upgraded the OTDRs on tram, this is outlined in paragraphs 318.

Closed-Circuit Television

- 60 FFCCTV and internal CCTV is installed on all trams.
- 61 Presently, SPAS events can only be confirmed by viewing the FFCCTV.
- 62 It is noted that in some instances there is a delay in the confirmation of the SPAS due to delays in the viewing of the FFCCTV by Team Leaders (e.g. Sandyford on the 25th July 2019).
- 63 TDLR's drugs and alcohol policy only allows for testing of drivers on confirmation of a SPAS incident.

Section 8 – Driver training & competency management

Driver training

Driver Training Plan

- 64 In terms of driver training, TDLR's SMS is supported by SM 017 Driver Training Plan, Issue 3, published on the 30th November 2018. The document states "To make best use of the available time whilst training, a task-based approach will be used. It will ensure that all basic functions of tram driving are carried out by the trainee at least a minimum number of times. These will be assessed continuously during the training and instruction process. Once the trainee has demonstrated competence at carrying out a particular task, he/she will be formally assessed on that task. This approach, combined with a certain minimum number of time periods, will ensure that trainees have the opportunity during the programme to experience a variety of operating conditions that they will be exposed to as tram drivers".
- 65 The course is an eight-week course, with each day consisting of six hours training; with the ratio of trainees to trainer/assessor/instructors clearly defined. The training plan requires particular activities to be undertaken a certain number of occasions/ hours/ times before assessment, see Figure 7.

Activity	Minimum number of occasions
Preparation of Tram	10 occasions
Depot Moves	10 times
Brake Testing	10 times
Depot Entry & Exit	4 times
Trams in Service	30 hours
Defensive Driving	30 hours
Towing / Pushing	4 times
Driving in degraded mode	3 times

Figure 7 – Minimum activity criteria

- 66 The RAIU reviewed examples of the individual eight-week driver plans, which include at least ten occasions of "depot entry / exit", included in the "mainline driving" course content, which also includes "Route Knowledge, Awareness of speed restrictions, signals, PPIs, loops, Hazard locations".

67 Trainee drivers are continuously assessed⁸ during driver training with final assessments being undertaken by a qualified member of staff.

Training for “Trams in Service”

68 In relation to "Trams in Service", trainees are required to have a minimum of thirty hours in the following tasks:

- Operation of the horn/bell & indicators and cameras used were appropriate;
- Acceleration & braking were performed smoothly in all conditions;
- The speed of the tram is controlled in accordance with line speed restrictions;
- The tram is stopped at correct locations & all signs, signals are observed;
- Correct doors control procedures;
- The operation of the tram is regularly monitored i.e. headway/timetable;
- Understands & obeys all instructions received from LNMCC;
- PA announcements are clear, concise, informative & accurate;
- Effectively communicates relevant information with the driver being relieved from duty or taking over the tram.

Training for “Defensive Driving”

69 In relation to "Defensive Driving", trainees are required to have a minimum of thirty hours in the following tasks:

- Obeys all tram signs & signals & PPIs: not anticipating a proceed or PPI on approach;
- Shows awareness & anticipation of actions of others;
- Anticipates hidden hazards & acts appropriately at known hazard locations;
- Observes line of sight principles with regard to poor visibility, safe distance from road vehicles & people;
- Understanding of driving on slippery conditions, low rail adhesion.

⁸ This is done through a suite of training documents such as: weekly exams (e.g. there is a Week 1 exam for Sandyford / Broombridge), minder assessment & recording forms; staff training files; trainee driving logs; weekly reports and the overall Training Plan document.

Training for “Depot Movements”

70 In terms of "Depot Moves", the following tasks are required to be undertaken a minimum of ten times, with the trainee demonstrating:

- Practical knowledge of storage lanes, avoidance, ladder etc;
- Correct understanding of communication protocol with LNMC for depot move;
- Correct handling of tram in and out of work sheds at the Red Cow and Sandyford;
- Correct understanding of the crane procedure at Sandyford;
- Practical knowledge of Sand Shed and Tram Wash;
- Correct understanding of stop position in the depot;
- Knowledge of correct movements within the depot.

71 In terms of "Depot Entry & Exit", the following tasks are required to be undertaken a minimum of four times, whereby the trainee:

- Requests authority from LNMC to exit depots;
- Demonstrates sufficient knowledge of signage, signals, PPIs and points in the depot;
- Shows correct understanding entry and exit procedures at the Red Cow & Sandyford;
- Shows correct understanding of the procedure to enter the Red Cow Depot Inbound;
- Shows sufficient knowledge of the loops / RTS operation for depot entry and exit;
- Checks the route prior to movement.

Training in “Degraded Mode”

72 The SM 017 Driver Training Plan identifies that there is two mornings training in relation to driving in degraded mode, and the minimum activity criteria is three (Figure 7). The minimum activity criteria maybe limited to the degraded mode on the training day as TDLR do not currently have a driver training *simulator*.

Driver instructions for Emergency Brake Applications

- 73 The TSI Manual defines the emergency brake as the “maximum brake available including the electro dynamic brake. Emergency brake is applied by the driver when the *master controller* is moved to the emergency brake position, or automatically when a safety critical function is not met (*vigilance device* non-activation, door open/fault, and emergency exit handle activation).
- 74 There is no reference in the TSI Manual in relation to the application of the emergency brake if the driver thinks that he is going to pass a signal at Stop; or, equally there is no reference to the avoidance of emergency brake applications for the prevention of passenger injuries. Although it is noted that this subject is assessed during the competency cycle (paragraphs 79 and 81).
- 75 During the course of the RAIU investigation, the RAIU found at least twenty occasions⁹ where the emergency brake was not applied when the driver saw that the signal was at stop (i.e. the driver was aware of the signal aspect). The main reason given, by drivers, for the non-application of the emergency brake, despite being aware that they were approaching a Stop signal; is that the drivers did not want to potentially injure passengers by applying the emergency brake. The RAIU, requested from TDLR, any clear reasons as to why drivers are doing this, TDLR responded on the 15th January 2021 by stating that “Following a discussion with the team here and speaking to some of the team leaders, who were directly involved in most of the investigations below, their feedback was that the drivers were more concerned about the possible injuries to passengers at the time. But when asked by the Team Leaders they were fully aware that they should have emergency braked and should always emergency brake. In reality it probably comes down to the personality of the driver involved. But we continually remind drivers to emergency brake at all costs”.

⁹ 2013 – Red Cow Delta on the 30/04/2013 and 27/05/2013; Cookstown on the 04/04/2013; 2015 – Cookstown 17/05/2015, 13/06/2015 and 07/07/2015; Sandyford on the 31/03/2015; 2016 – Belgard Road on the 09/05/2016; 2017 – Red Cow Delta on the 28/01/2017, 19/04/2017, 03/07/2017 and 17/12/2017; Belgard Road on the 18/02/2017 and 03/07/2017; 2018 – Red Cow Delta on the 21/05/2018; 2019 – Sandyford on the 25/08/2019; Blackhall Place on the 20/05/2019 and Belgard Road on the 04/01/2019; 2020 – Cookstown Outbound, 30th July 2020; 2021 – Kingswood, Sylvan Drive/Embankment Road Inbound, 12th May 2021.

- 76 The RAIU requested, from TDLR, what instructions have been issued to drivers in relation to SPASs and emergency brake applications; TDLR responded on the 9th December 2020 that “we have and will continue to instruct our drivers to EB¹⁰ at all costs”.
- 77 Considering drivers are not complying with instructions in relation to the application of the emergency brake, for which they are trained and competency assessed; and continue with non-application of brakes, based on their own personal opinion (i.e. injury to passengers); the RAIU have identified this as an additional observation, AO-03 (paragraph 316) and made a safety recommendation, Safety Recommendation 2022003-10 (paragraph 336).

¹⁰ Emergency brake

Competency Management & Monitoring for Drivers

Competency Management

78 TDLR have addressed the competency assessment for drivers in formalised documents¹¹.

79 A new driver shall be subjected to continuous support and monitoring and shall be assessed during the first twenty-four months of their duties as a tram driver (full assessment four times in a twenty-month period). These assessments must be carried out whilst the driver is operating a tram in service. The elements of assessment include: Taking over tram / moving off / stopping / terminus procedure; driving skills; and, communication skills. Each of these elements has a number of performance criteria that the assessor must observe or ask. In terms of signals, these include:

- Observations: Presses RTS if required, obtains & checks proceed signal before moving away; Obeys all tram signs, signals & PPIs; Does not anticipate a proceed on approach;
- Question: You are approaching a signal, you just notice you do not have your proceed, how should you stop your tram to avoid passing signal at danger? Answer: Depending on distance apply maximum possible braking, emergency brake. Never anticipate a proceed signal.

80 Following the first twenty-four months of driving, drivers will be placed on a continuous twenty-four month recertification cycle and will be subjected to assessment (recertification assessment undertaken every twenty-four months together with a minimum of three follow up monitoring visits from a Driver Team Leader).

¹¹ Due to the COVID-19 pandemic, TDLR went through a number of changes to the competency management documentation (e.g. assessors could not travel in the cab with the drivers, etc) over the course of the investigation, namely: “TTI Luas SM 019, Competence Assessment for Driver with less than two years of service”, Issue 2, issued on the 12th December 2018; and, “TTI Luas SM 018 Competence Assessment for Tram Drivers over two years of experience”, Issue 2, issued the 1st January 2019. These were eventually replaced with “Competence assessment for Luas Drivers procedure”, TDLR-HR-PR-004; and, “Certification of tram drivers procedure”, TDLR-HR-PR-0005; both are on Issue 02, and both issued on the 3rd February 2021. The content outline in this report was included in all documents.

81 In terms of signals, the following must be observed or queried:

- Observation: Does not anticipate signal on approach;
- Observation: Requests RTS from a stationary position, obtains & checks proceed signal before moving position;
- Question: How can a driver prevent a SPAD¹² from occurring? Answer: Check & double check your signal before proceeding past it. Approach your signal at a speed that is appropriate to the driving conditions. Never anticipate a proceed signal. Expect the unexpected;
- Question: Why is it necessary to only programme the AVLS when stationary/stopped? To avoid distraction & potential safety related incidents, in particular SPADs.
- Question: What actions should a driver implement into driving technique in order to avoid incidents of SPADs? Answer: Concentrate solely on signal management, never anticipate signal on approach, drive at correct speed as per location, manage distraction. At all times to implement defensive driving techniques, taking in to account the prevailing driving conditions. From a stationary position move position only after confirming signal is present. Be more vigilant when approaching High Priority Locations on the network.

82 It is noted that none of the sample answer, states that the emergency brake should be applied if a driver thinks he may have a SPAS; this will be addressed through Safety Recommendation, Safety Recommendation 2022003-10.

Monitoring driving through OTDR and FFCCTV

83 OTDR downloads are not used to monitor driver performance.

84 FFCCTV is currently not used to monitor driver performance; this is currently the only way to confirm if a SPAS incident has occurred as the signal aspects can be seen as the tram passes them.

¹² Note, SPAS are sometimes referred to as Signals Passed at Danger (SPAD), particularly in the heavy rail industry.

Section 9 – Categorisation & identification of a SPAS

Categorisation of SPAS events on the LUAS Network

85 There are seven different categories of SPAS on the Luas network; these have been formally set out in TDLR-S-F-0004, Rev 02.0 issued on the 11/08/2020, as follows:

- A – Tram is stopped passed the signal head, but before yellow box or points or driver engaged the area under line of sight. No conflict with pedestrians or road traffic;
- B – Tram passed the signal on a non-conflicting route;
- C1 – Tram passed the signal and crossed points on a conflicting route, but no other tram in the area;
- C2 – Tram passed the signal and crossed points on a conflicting route, with another tram in the area, possibility of collision;
- D1 – Tram passed the signal and entered a traffic junction or pedestrian crossing with no contact;
- D2 – Tram passed the signal and entered a traffic junction or pedestrian crossing leading to a contact;
- E – SPAS which occurs when a Stop Aspect is displayed as a result of failed equipment or Signal Reversion, which the driver may or may not have time to react to correctly. If it is suspected that a technical fault has caused the incident, this must be investigated by the appropriate technical experts, in line with current procedures.

86 Despite the SPAS being categorised, the SPASs are not “ranked” i.e. there is no measurement of the severity of the SPAS. This ranking of SPADs is common practice in heavy rail i.e. the higher the number, the higher risk the SPAD. The SRR is dependent on a number of criteria related to the likelihood of an accident and its potential consequences and gives an indication of how the level of national SPAD risk (i.e. SPADs over the entire heavy rail network) is varying over time.

87 RAIU consider that SPAS events high risk SPAS occurrences should be scored in terms of severity and consider this to be an additional observation, AO-04 (paragraph 317) and consider a safety recommendation is warranted, Safety Recommendation 2022003-11 (paragraph 337).

Identification of SPAS incidents

Detection of SPAS incidents at the LNMCM

- 88 LNMCM can see a suspected SPAS event through a visual representation on the LSS mimic in LSS locations only i.e. the vast majority of locations cannot be identified at LNMCM. The RAIU consider this to be an additional observation, AO-05 (paragraph 317) which warrants safety recommendation, Safety Recommendation 2022003-12 (paragraphs 338).
- 89 There is no audible alarm on the LSS mimic i.e. a Traffic Supervisor must look at the console to check if a SPAS has occurred. This means that a SPAS can go undetected at the LNMCM (e.g. 3rd September 2020, Broombridge East Gate, a visual representation of a SPAS event was present on the LNMCM mimic at 20:32 hrs but went unnoticed by the on-duty Traffic Supervisor. It was only detected at 22:17 hrs when there was a change in Traffic Supervisor who noticed the SPAS on the LNMCM mimic screen. SPAS was confirmed at 06:17 hrs, using the FFCCTV. The RAIU consider that the absence of an audible alarm to be an additional observation, AO-06 (paragraph 317), which warrants a safety recommendation, Safety Recommendation 2022003-13 (paragraph 339).
- 90 SPAS incident must be confirmed through FFCCTV.

Identification of SPAS incidents at other locations through driver reporting

- 91 The primary means of identifying a SPAS is by the driver reporting (there is no in-cab alarm to notify drivers they have been involved in a SPAS); this driver reporting occurs when:
- A driver realises that they have been involved in a SPAS, as they saw the Stop aspect but could not stop the tram in time;
 - A driver sees a “Stop – Single Dot” aspects appear in the next signals (this is as a result of the LSS crashing);
 - The next driver to approach the signal involved in the SPAS sees a “Stop – Single Dot” aspects.
- 92 Where a driver does not realise that they have been involved in a SPAS they can continue driving as normal (if there are no “Stop – Single Dot” aspect displaying in the next signals).

Reports from members of the public

- 93 On occasion, members of the public have reported in incidents where tram has entered a junction when the cars have the green light. In terms of frequency of reporting from members of the public, in 2019, there was a total of nineteen calls from members to the Luas Call Centre regarding breaches of tram signals / alleged conflict with a car.
- 94 TDLR do investigate these incidents and in the case of the SPAS at Sylvan Drive on the 17th May 2019, this was reported three days after the event.

Multi-SPAS Signals

- 95 TDLR do not formally identify multi-SPAS signals stating that “there is a focus on repeat signals, Sandyford Cookstown and Broombridge LSS areas”.
- 96 The RAIU consider that the establishment of an SSC (paragraphs 32 - 35) will address concerns related to multi-SPAS signals; this has been identified as an additional observations AO-02 (paragraph 36 and 317) and a safety recommendation, 2022003-09 (paragraph 335), has been made in relation to the SSC, which specifically addresses concerns related to multi-SPAS signals.

Section 10 - SPAS incidents from 2019 to mid-2021

Introduction

- 97 As mentioned previously, the scope of this investigation includes the SPAS at Cookstown Interchange on the 3rd January 2020 and was expanded to include SPAS incidents that occurred in the previous year, 2019; in 2020; and, in the first half of 2021.
- 98 These summaries of the SPAS incidents will outline key events only that occurred before and during the SPAS. The events after the SPAS are not included in this section and are addressed in paragraphs 268 - 280.
- 99 The RAIU noted that there was no key feature in terms of driver experience and the event of the SPAS incident, as a result, this is not further discussed.

Fatalities, injuries & material damage

- 100 There were no fatalities or injuries as a result of these SPAS events.
- 101 Damage to rolling stock or infrastructure will be outlined in the event summary, where applicable, otherwise, it can be understood that there was no material damage.

External circumstances at the location of the incidents

- 102 It can be understood that external circumstances (such as weather) were not contributory the incidents, unless, expressly identified in the outline of the incident.

Roles associated with the incident

Drivers

- 103 Drivers, TDLR employees, are trained and assessed as outlined in paragraphs 64 - 84. Drivers performed all post-incident requirements as necessary, unless expressly stated. To provide anonymity, drivers are identified by the Tram number they were driving at the time of the incident.
- 104 Post incident, all drivers were stood down from driving duties after the SPAS incident, pending internal investigation.

Traffic Supervisors

- 105 Traffic Supervisors are based in the LNMC, Red Cow, and employed by TDLR. They are trained and deemed competent in carrying out traffic supervisions duties.

SPAS incidents at Cookstown

Introduction

106 Cookstown is an LSS location on the Luas network, see Figure 8. The maximum permitted speed at Cookstown Interchange is 30 km/h in the inbound and outbound directions¹³.

107 As an LSS location, the interaction between the AVLS and the LSS applies (paragraphs 27 - 31). This means that auto routing is enabled at this location i.e. changing points and upgrading signals; manual selection from the cab may be required in the following cases: tram failure; tow and push; tram out of service; tram not logged into the AVLS system; LNMC instruction.

108 Since 2012, there have been over twenty SPAS incidents at Cookstown LSS.

TSI Manual requirements

109 Section 5.6.6, Cookstown Interchange, of the TSI Manual sets out the requirements specific for the operation of trams through Cookstown Interchange for normal operation passengers services in the inbound and outbound directions, namely:

- On approach, before reaching the pre-loop check that the points area is clear (outbound direction only);
- Route setting and proceed signal is automatic through the auto-routing;
- If your route setting or a proceed signal is not given immediately, stop on the command loop at the tram signal;
- Set the route from the cab;
- Repeat route selection until a proceed is obtained;
- On receipt of your signal, check your route and proceed if safe to do so.

¹³ During the course of the investigation, the RAIU queried some irregularities in relation to the speed limits between Belgard Stop to Cookstown Interchange (Outbound) i.e. the speed increases to 70 km/h for approximately 250 m and drops to 30 km/h (i.e. a 40 km/h drop), which is not in line with the cascaded speeds applied elsewhere on the network. TII then undertook a review of the speed limits and the 70 km/h speed limit removed. TII did a further review on limits speed on the network and adjusted speed limits at a limited number of locations, mainly at uncontrolled pedestrian crossing locations.

Cookstown Interchange, S-2e Inbound, 3rd January 2020

110 On Friday the 3rd January 2020, while operating his last route, the inbound Tallaght to Red Cow passenger service, Driver 3007 departed Cookstown Stop Inbound Platform to travel to Belgard Stop.

111 At approximately 15:07 hrs, outbound tram to Saggart, Tram 3025, approached Cookstown Interchange (see Figure 8 for location and signal locations).

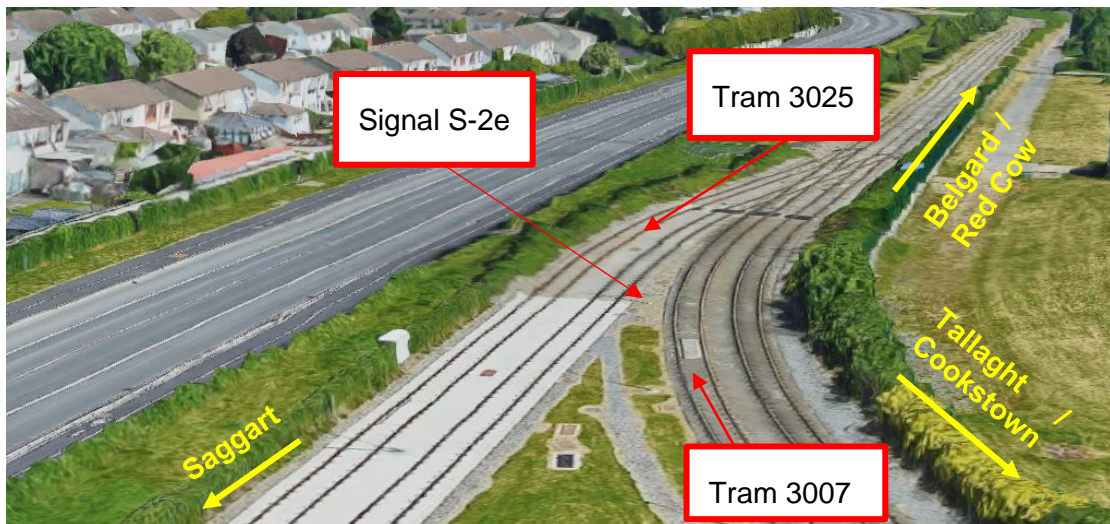


Figure 8 – Signalling at Cookstown LSS

112 At 15:08 hrs, Tram 3007 approached Signal S-2e at Stop, images in Figure 9 taken from the FFCCTV, both within a second, do not clearly indicate what aspect was being displayed due to sun glare, see Figure 9. Driver 3007 looked at the darkest part of the signal and thought that the top dot was lit (see inset in Figure 9) which would indicate a Proceed. Driver 3007 slowed his tram but proceeded towards the interchange.

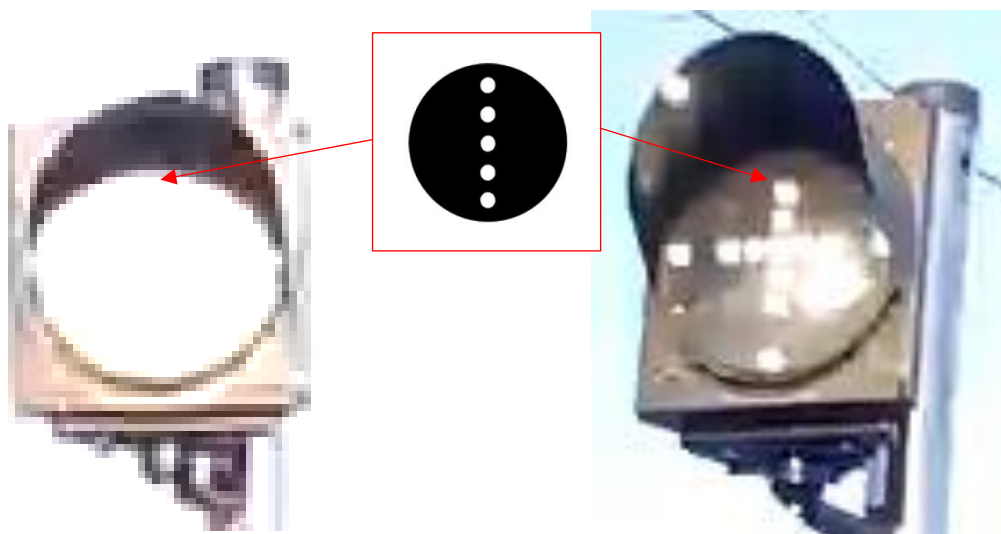


Figure 9 – Signal S-2e at the time of the incident

- 113 At the same time, Tram 3025, travelling outbound towards Saggart, entered Cookstown LSS on a “Proceed” aspect, see Figure 10.



Figure 10 – Tram 3025 approaches the Interchange (image from Tram 3007)

- 114 On seeing Tram 3025, Driver 3007 stopped Tram 3007, allowing Tram 3025 to travel over the interchange, see Figure 11 (FFCCTV image from Tram 3007 of Tram 3025). Had Tram 3007 not stopped, it would have collided with Tram 3025, see Figure 11 (FFCCTV image from Tram 3025 of Tram 3007).



Figure 11 – Tram 3025



Figure 12 –Tram 3007 stopped

- 115 After Tram 3025 travelled over the interchange; Tram 3007, progressed through the interchange; Driver 3007 had no signal indicating that it was safe to proceed, as Tram 3007 had already passed Signal S-2e, see Figure 13. Irrespective of whether Driver 3007 thought he had a proceed signal, Driver 3007 should have contacted LNMC to inform them that he did not have a signal to proceed through the interchange.



Figure 13 – Tram 3007 re-starting through Cookstown Interchange

- 116 At the same time, it was observed at LNMC that the tram signal at Cookstown LSS were displaying “Stop – Single Dot” aspects. LNMC contacted Driver 3007 to ask whether Signal S-2e was showing a “Proceed” aspect; and he confirmed it did. Driver 3007 continued to Red Cow, where he finished his rostered duty.

Cookstown Interchange, S-2e Inbound, 13th February 2020

117 On the 13th February 2020, Driver 3001 was operating the inbound Tallaght to Point passenger service. When Driver 3001 departed Cookstown, he approached Signal S-2e, at the Cookstown LSS, displaying a Stop aspect, as another tram (Tram 3008) was exiting Cookstown LSS in the outbound direction, see Figure 14. Driver 3001 assumed that the signal had upgraded for him and may have been distracted by Tram 3008 as he travelled past Signal S-2e at Stop.



Figure 14 – Signal S-2e at Stop and Tram 3008 travelling outbound

Cookstown Interchange, S-2a Outbound, 30th July 2020

118 On the 30th July 2020, Driver 3005 was driving the Red Cow to Tallaght service. Driver 3005 did not input the AVLS service file correctly (paragraphs 29 - 30), with the AVLS displaying Red Cow instead of Tallaght, Driver 3005 assumed it would auto-correct on arrival at Belgard; which caused a continuous distraction to Driver 3005. When Tram 3005 approached Signal S-2a at Cookstown LSS, it was displaying a Stop aspect (see Figure 15)¹⁴ as the AVLS had not been inputted correctly and automatic proceed could not be given. The PPI was set correctly for movements to Tallaght (see Figure 15). Tram 3005 was travelling at approximately 50 km/h in a 30 km/h speed limited area. Tram 3005 passed Signal S-2a at Stop and on realising, Driver 3005 applied the full service brakes and not the emergency brake; stopping the tram before the points and self-reporting the incident.

¹⁴ As part of the review of Cookstown Interchange, the RAIU found that, at the location of a signal (and PPI), there was a regulatory Stop sign where drivers are not required to stop in accordance with the TSI Manual, which is contradictory to the Road Traffic Act (see Figure 15). TII have replaced the sign (see Figure 16) and conducted a review off all signage on the network to ensure all signage is correct.



Figure 15 – Signal S-2a displaying a Stop aspect

Cookstown Interchange, Outbound C-1, 16th February 2021

119 On Tuesday 16th February 2021, Driver 4011 was scheduled to operate the Sweep Tram (Red Cow to Tallaght). At 05:09 hrs, as Driver 4011 approached Cookstown LSS, Signal S-2a, was displaying a Stop aspect see Figure 16. The points were set in the default position for Tallaght as indicated by the PPI, Driver 4011 had inputted the incorrect trip code on the AVLS.

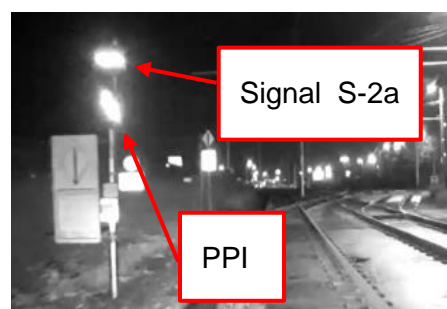


Figure 16 – Signal S-2a at Stop

120 Tram 4011 travelled past Signal S-2a at Stop and continued to Tallaght. At Tallaght, Driver 4011 contacted LNMC to report that he may have been involved in a SPAS event.

121 On the day of the incident, Driver 4011 was suffering with a dental issue which may have caused a distraction.

SPAS incidents at Sandyford Stop

Introduction

122 At Sandyford Stop, there are three tracks and a number of points. The service dictates the track to be used, which is set out in the timetable or LNMC instruction.

123 In terms of similar occurrences at these locations prior to 2019 (from 2012-2018), there had been thirteen previous occurrences of SPAS in the Sandyford Stop location.



Figure 17 – Sandyford

TSI Manual requirements

124 In terms of Sandyford Stop, the TSI Manual states that authorised tram movements are controlled by PPI and tram signals; the maximum speed is 15 km/h; wrong directional movements are not permitted except under instructions from the LNMC; and, not to input RTS or route select while moving. The TSI Manual requires drivers to:

- Stop on the control loop and select route according to timetable;
- If a proceed is not given immediately, repeat route selection until a proceed is obtained;
- Check that the platform is available and clear of a tram;
- Check that your route is clear before moving - proceed if safe to do so.

Sandyford Stop, S-1 Southbound, 18th January 2019

125 On Friday 18th January, Driver 5025, was travelling to Sandyford Stop; he was going to serve Sandyford Stop and to enter Sandyford Depot to take his meal break. At the same time, there were two trams at Sandyford Stop (on the southbound and central tracks), Tram 5025 was waiting on the loop on the northbound track, at Signal S-1, which was displaying a Stop aspect (see Figure 18).

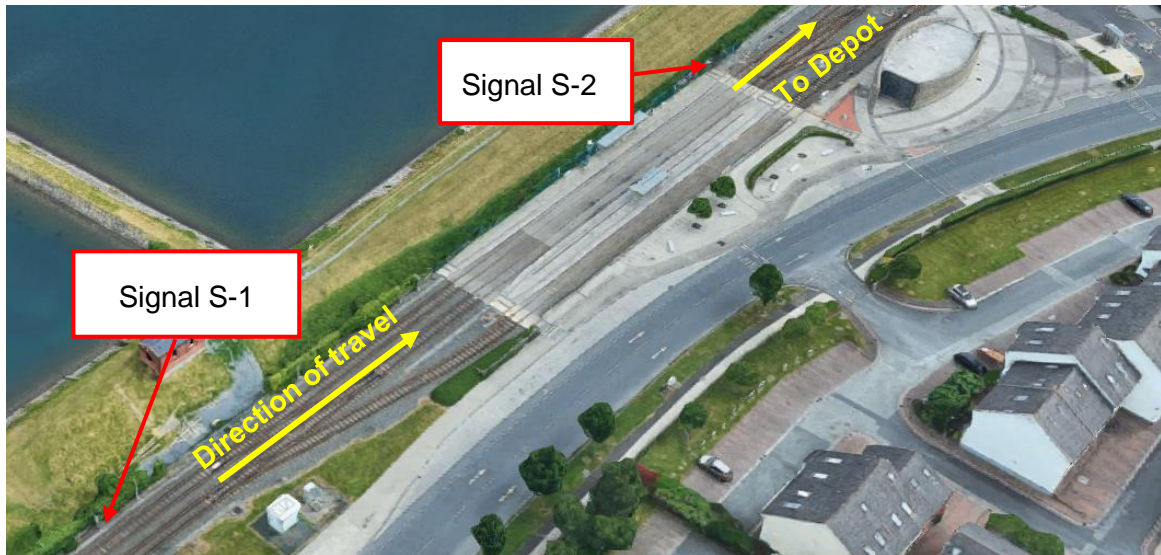


Figure 18 – Location of the incident

126 After approximately a minute, when the other tram on the southbound track cleared the Sandyford Stop, Driver 5025 did not input the RTS request and proceeded towards Sandyford Stop, passing Signal S-1 at Stop (see Figure 19), assuming the signal has cleared.



Figure 19 – Tram 5025 stopped at Signal S-1

127 On approaching Signal S-2, Driver 5025 saw the signal was displaying a “Stop – Single Dot” aspect. Driver 5025 stopped his tram and contacted LNMU.

Sandyford Stop, S-2 Southbound, 25th July 2019

128 On the Thursday 25th July 2019, there were significant delays on the Green Line due to a non-Luas related issue which LNMC were regulating; this resulted in a number of tram swaps and a large amount of radio communications. As a result, when Driver 4012 arrived at Sandyford Central, LNMC requested that Driver 4012, to swap trams with the driver stopped on the southbound track (Tram 4012). Driver 4012 was then to drive Tram 4012 into Sandyford Depot, out-of-service (Figure 17). An announcement was made that Tram 4012 was being taken out of service and there was a request for passengers to exit Tram 4012, resulting in passengers/pedestrians walking around on the platform areas.

129 Tram 4012 was stopped at Signal S-2 Southbound (Figure 17)¹⁵; points were set for the depot movement. Driver 4012 did not input an RTS request to for a proceed aspect from Signal S-2. Driver 4012's focus was on the passengers/pedestrians (Figure 20 shows two pedestrians in the area of Signal S-2 at the time of the incident).

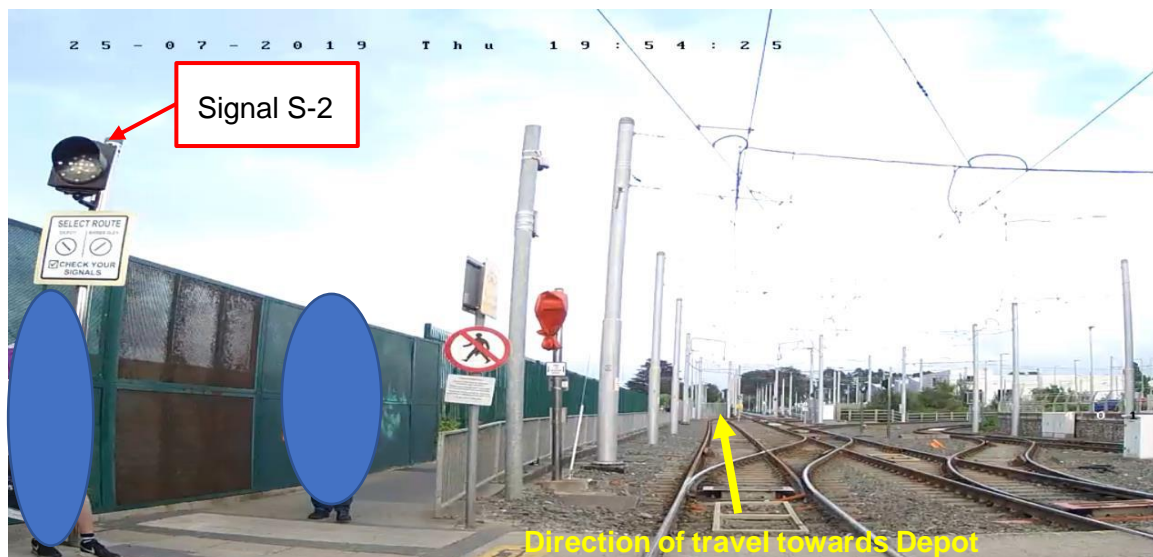


Figure 20 – Stopped position at Sandyford Stop at 19:54:25 hrs

130 Driver 4012 proceeded towards Sandyford Depot and travelled past Signal S-2 at Stop.

131 On travelling into Sandyford Delta, Driver 4012 saw that the signals ahead of him were displaying “Stop – Single Dot” aspects; he then stopped the tram and contacted LNMC.

¹⁵ This is the signal that an internal recommendation by Transdev, recommended the signal to be lowered (paragraph 36).

Sandyford Stop, S-2 Southbound, 25th August 2019

132 While operating the northbound service (Brides Glen to Sandyford), Driver 5006 left his sunglasses in the rear cab and did not have easy access to them operating the southbound service from the leading cab.

133 During the operation of the Beechwood to Brides Glen service, southbound, Driver 5006 was stopped at Sandyford Stop at 10:53 hrs (see Figure 21).



Figure 21 – Stopped position at Sandyford Stop

134 Driver 5006 checked the points, they were set for his route; he also was checking his mirrors. Driver 5006 did not select input an RTS request for a proceed aspect from Signal S-2 (see Figure 17), and departed Sandyford Stop, passing Signal S-2 at Stop. Driver 5006 thought that he did check Signal S-2 before departing; although, Driver 5006 said there was glare due to the sun and his sunglasses were in the trailing cab.

135 On travelling into Sandyford Delta, Driver 5006 saw that the signals ahead of him were displaying “Stop – Single Dot” aspects; he then stopped the tram and contacted LNMC.

Sandyford Stop, S-4 Northbound, 26th January 2020

- 136 On the 26th January 2020, Driver 5031 was operating the Brides Glen to Broombridge passenger service. On approach to Sandyford northbound platform, Signal S-4 (see Figure 22 for location of signal) was displaying a Stop aspect (Figure 23).

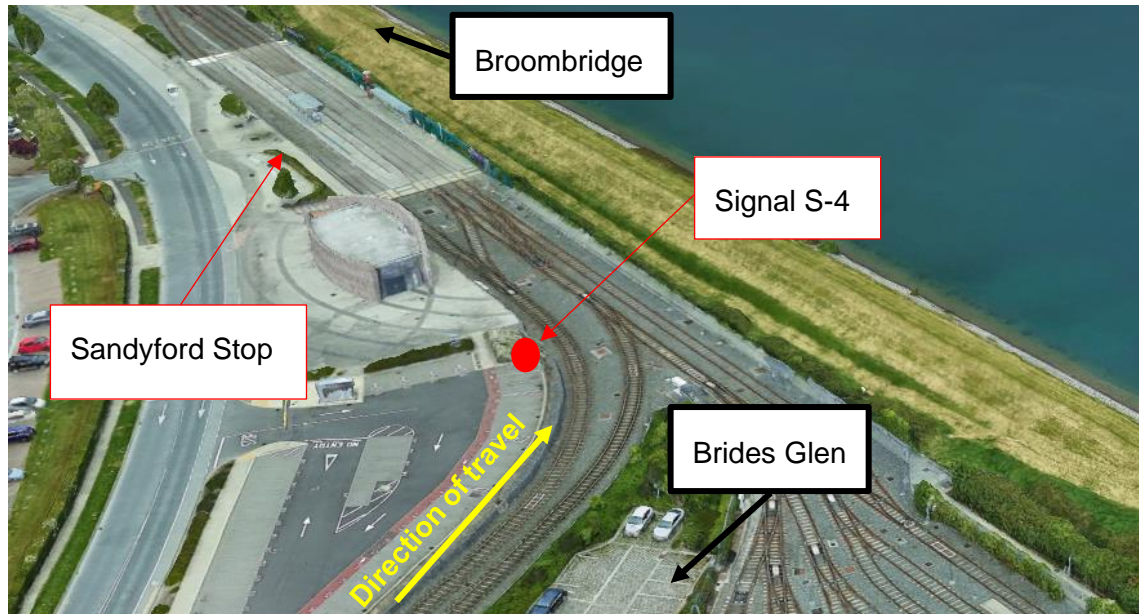


Figure 22 – Signal S-4 Northbound

- 137 Driver 5031 did not look at the signal and instead looked at the PPI (Figure 23) to see if his route was set for the northbound platform, which it was. Driver 5031 did reduce the speed of the tram, but did not stop, passing the signal at Stop.



Figure 23 – Signal S-4 at Stop and PPI indicating route set for northbound platform

- 138 When Driver 5031 saw the next signals were displaying “Stop – Single Dot” aspects, he contacted LNMCC.

Sandyford Stop, S-4 Northbound, 28th January 2020

139 On the 28th January 2020, Driver 5031¹⁶ was operating the Brides Glen to Parnell passenger service. On approach to Sandyford northbound platform (Route 5 in Figure 24), Signal S-4 (see Figure 22 for location of signal) was displaying a Stop aspect (Figure 24) and the PPI was set for the northbound platform (Figure 24).

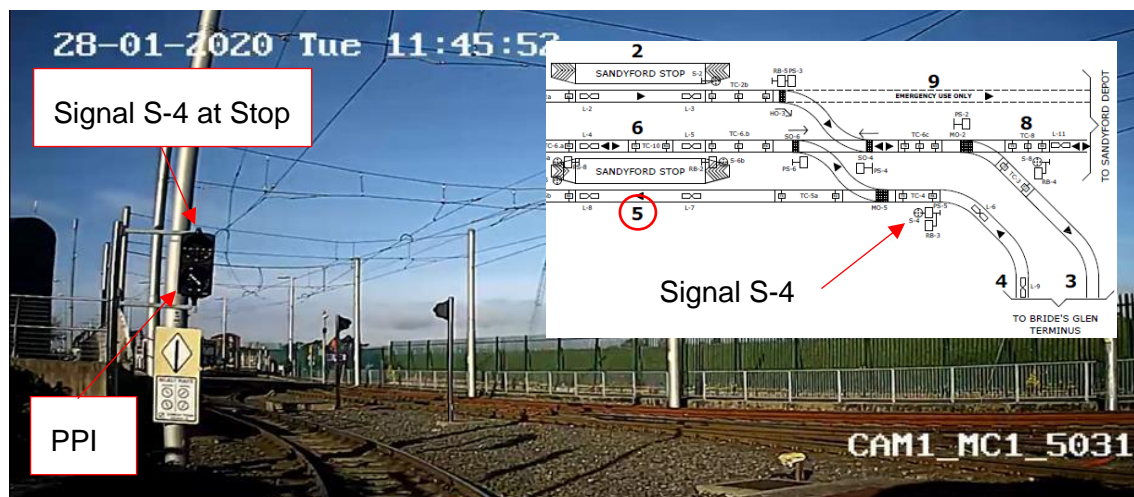


Figure 24 – Signal S-4 at Stop and PPI indicating route set for northbound platform

140 Driver 5031 stopped the tram at the signal and did not make an RTS request for the proceed signal; he then proceeded against the Stop aspect and passed the signal at Stop, thinking he had a proceed signal; the PPI may have been contributory to this assumption.

¹⁶ This was the same driver as the previous SPAS at the same location, two days earlier on the 26th January 2020.

Sandyford Stop, S-5 Northbound, 28th May 2020

- 141 On the 28th May 2020, Driver 5016 was operating the Brides Glen to Broombridge northbound passenger service. Tram 5016 stopped on Sandyford northbound platform to allow passengers to exit and enter the tram.
- 142 While stopped at Sandyford Stop (route 5 in Figure 25), Signal S-5 was displaying a Stop aspect. Driver 5016 did not input an RTS request and proceeded against Signal S-5 at Stop, see Figure 25; Driver 5016 thought he may have pressed the wrong button instead of the RTS request button.

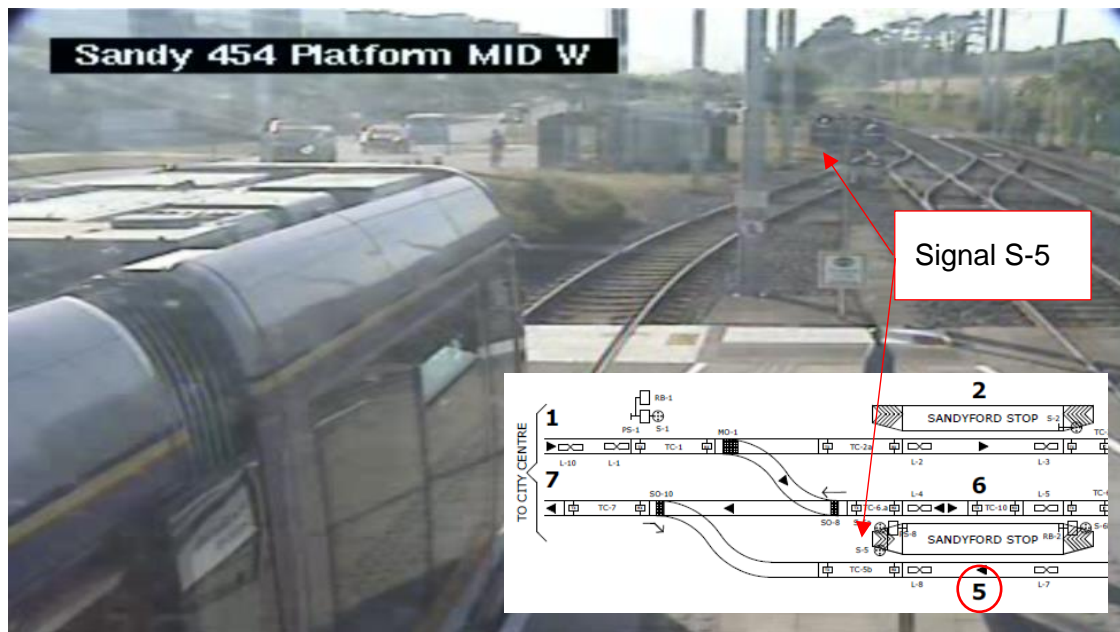


Figure 25 – Signal S-5

- 143 A southbound tram driver, entering the Sandyford LSS location, saw “Stop – Single Dot” aspects and contact LNMCC who saw the SPAS indication on the LSS mimic.

Sandyford Stop, S-4 Northbound, 7th June 2020

144 On the 7th June 2020, Driver 5029 was operating the Brides Glen to Sandyford northbound passenger service. On approach to the northbound platform (Route 5 in inset of Figure 26), Signal S-4 was displaying a Stop aspect (see Figure 26); this was due to the AVLS not being set correctly, meaning that Signal S-4 did not give an automatic proceed on the approach of Tram 5029, as a result Driver 5029 was required to input make an RTS request.

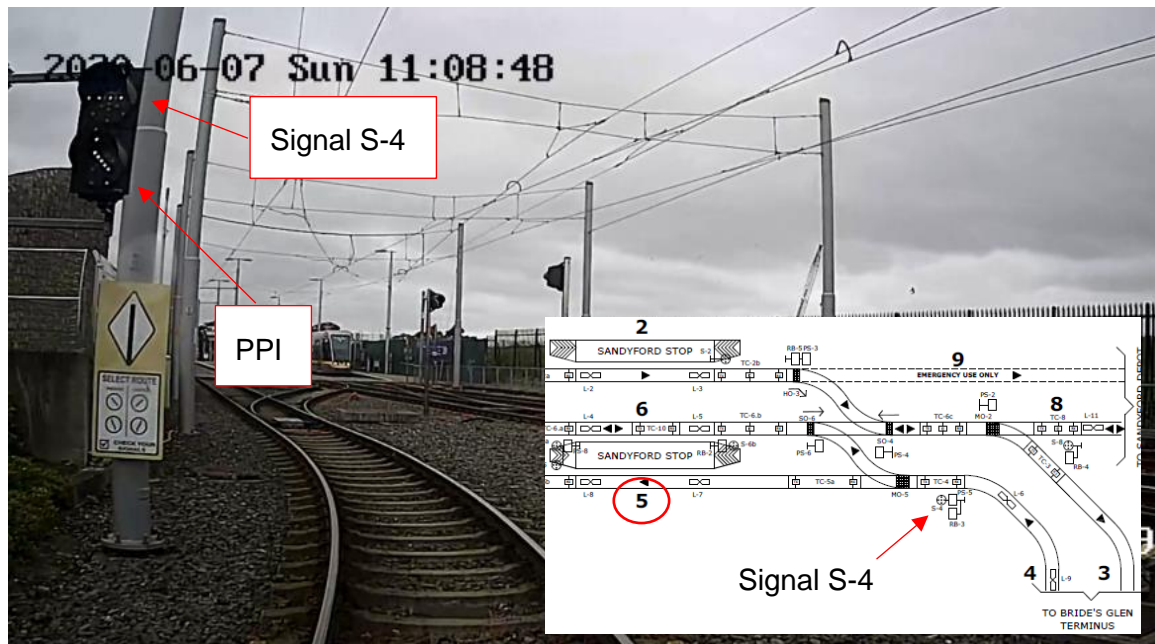


Figure 26 – Signal S-4 and Sandyford layout

145 Driver 5029 did stop but saw that the PPI was set correctly and proceeded past Signal S-4 at Stop.

Sandyford Stop, S-5 Northbound, 21st October 2020

146 On Wednesday 21st October 2020, Driver 5003 was operating the Brides Glen to Parnell passenger service. Driver 5003 entered the Sandyford northbound platform and stopped to allow passengers to enter and exit the tram.

147 The signal to proceed northbound is Signal S-5, which was displaying a Stop aspect. There were a number of pedestrians crossing in front of the tram and Driver 5003 thought he inputted the RTS but may have pressed the chimes button; however, Driver 5003 did not input an RTS command and proceeded past Signal S-5 at Stop, see Figure 27, and continued northbound.



Figure 27 – Signal S-5 at Stop

148 The next tram to enter the Sandyford LSS area heading southbound saw the tram signals displaying “Stop – Single Dot” aspects and this driver notified LNMCC.

Sandyford Stop, S-1 Southbound, 24th May 2021

149 On the 24th May 2021, Driver 5031 was operating the Broombridge to Sandyford service. As Tram 5031 approached Signal S-1 (Figure 18) into Sandyford Southbound Platform, the signal was displaying a Stop aspect; and, the points were set for the required movement (note: Driver 5031 had not inputted the AVLS correctly, with the wrong route set, although, it is noted that this does not guarantee a Proceed signal). Driver 5031 stopped his tram on the control loop for the signal; however, four seconds later took traction and passed Signal S-1 at Stop without inputted an RTS request. The FFCCTV of Tram 5031 (Figure 28) stopped at Signal S-1 shows that, from the perspective of the FFCCTV, the aspect cannot be determined due to sun glare.



Figure 28 – Signal S-1 with sun glare

150 On arrival at Sandyford Stop, Driver 5031 disembarked passenger and was required to enter Sandyford Depot, Driver 5031 could not determine the aspect of Signal S-2 (Figure 18) due to sun glare so contacted LNMCC, who saw on the LSS mimic that there was a suspected SPAS.

Sandyford Stop, S-2 Southbound, 9th June 2021

151 At 19:44 hrs On the 9th June 2021, Driver 5017 took over the operation of the Sandyford (Southbound Platform) to Brides Glen passenger service.

152 At 19:45 hrs, Driver 5017 inputted the RTS command at the control loop at tram signal S-2 (see Figure 29) to request the tram proceed signal aspect and correct route setting for destination, Brides Glen (Route No.2 to No.3, see Figure 29); however, as another tram was still occupying the track circuit (Route No. 8), the Sandyford LSS system disregarded Driver 5017's RTS command and the proceed signal aspect was not given.

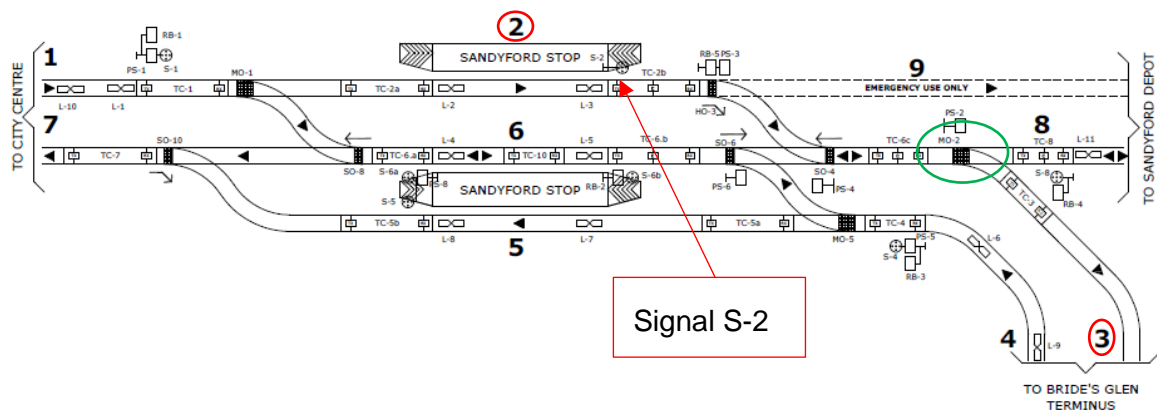


Figure 29 – Sandyford layout, see Signal S-2, and Routes No. 2 and No.3 circled

153 Driver 5017 did not realise that the proceed aspect was not displaying of Signal S-2 and proceeded past Signal S-2 displaying a Stop aspect.

154 As Driver 5017 approached the points, he saw that the points were not set for Brides Glen, but for entry back into Sandyford Depot, see Figure 30. Driver 5017 stopped the tram and contacted LNMCC.

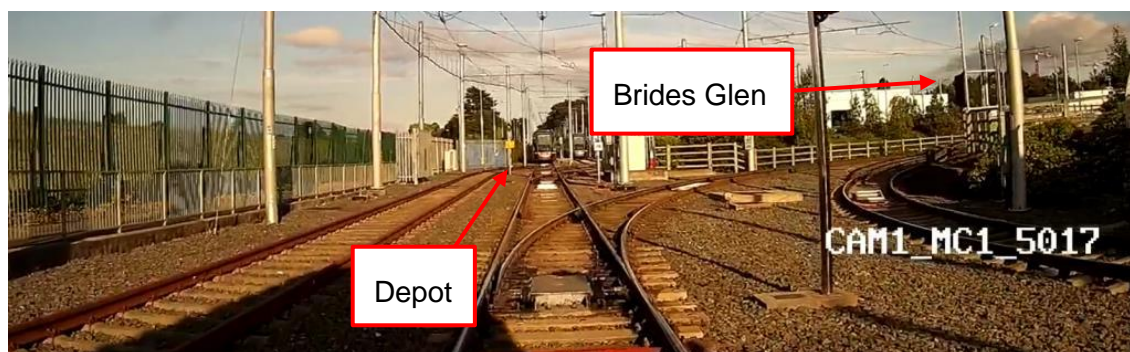


Figure 30 – Points set for Depot entry

155 Driver 5017 appears to have had an incorrect expectation that Signal S-2 would upgrade once the RTS command and route setting was inputted, which may have caused him not to check the signal aspect.

SPAS incidents in Sandyford Depot

Introduction

156 There is no automatic routing in Sandyford Depot.

157 There is signage through-out the depot such as those set out in Figure 3, at the signal locations e.g. at the depot gates exit there is a sign that says, “Radio for Depot Exit, RTS, Check your signal”, can be seen in Figure 33.

Sandyford TSI Manual Instructions

158 In terms of Sandyford Depot, there are general rules in relation to the tram movements in the depot, workshop and sanding shed; mainly requiring permissions to be sought from LNMC for movements. Other movements are carried out under the general rules in the TSI Manual.

159 In terms of entering the depot, the TSI Manual outlines which track to use for the different services and requires route to be selected e.g. from Brides Glen must enter from the central track.

160 Exiting the depot, trams must use the central track but must stop on the loop at the depot gate and input an RTS before commencing the movement to main line.

Sandyford Depot, S-8 Northbound, 9th October 2019

161 On the 9th October 2019, Alstom Vehicle Maintenance¹⁷ requested LNMC to move Tram 5002 from Storage Road 5 to Sandyford Central Platform (Figure 35) in order to move another tram (Tram 5001) into the depot. In turn, LNMC requested Driver 5002 to move the tram.

162 When Driver 5002 powered up Tram 5002, the service file on the AVLS failed. Driver 5002 made the decision to fix it when stopped at the gates.

163 LNMC authorised Driver 5002 to move Tram 5002 from Storage Road 5 to the depot gates. Driver 5002 carried out this movement without issue. While stopped at the depot gates, Driver 5002 began programming the AVLS on the driver's console.

164 At approximately 22:47 hrs, LNMC authorised the movement of Tram 5002 from the depot gates (see Figure 31 for CCTV image of Tram 5002 stopped at the depot gates with Signal S-8 displaying a "Stop" aspect) to Sandyford Central Platform, "on signals".



Figure 31 – Tram 5002 stopped at the depot gates

165 Driver 5002 continued to programme the AVLS and did not input the RTS request and proceeded to drive past Signal S-8 displaying a "Stop" aspect.

166 Driver 5002 continued to Sandyford Central Platform, unaware he had passed Signal S-8 at "Stop".

167 At Sandyford Central Platform, Driver 5002 saw all the "Stop, PPI not detected, call CCR" and "Stop – Single Dot" aspects and contacted LNMC.

¹⁷ At the time of the incident Alstom Ireland Limited were the Vehicle Maintenance Contractor.

Sandyford Depot, S-8 Northbound and Signal S-6b Southbound, 12th March 2020

168 On the 12th March 2020, Driver 4014¹⁸ was rostered to do a preparation of Tram 4014 and take it into service (Sandyford to Broombridge), departing from Sandyford Central Platform. Tram 4014 was required to travel past Signal S-8 to arrive at the Central Platform, see Figure 32 (travelling from 8 to 6 (circled)). During preparation, Driver 4014 noticed that the battery was flat for the hand-held radio, which required replacement, this made Driver 4014 feel under pressure as he thought he was going to be late entering service.

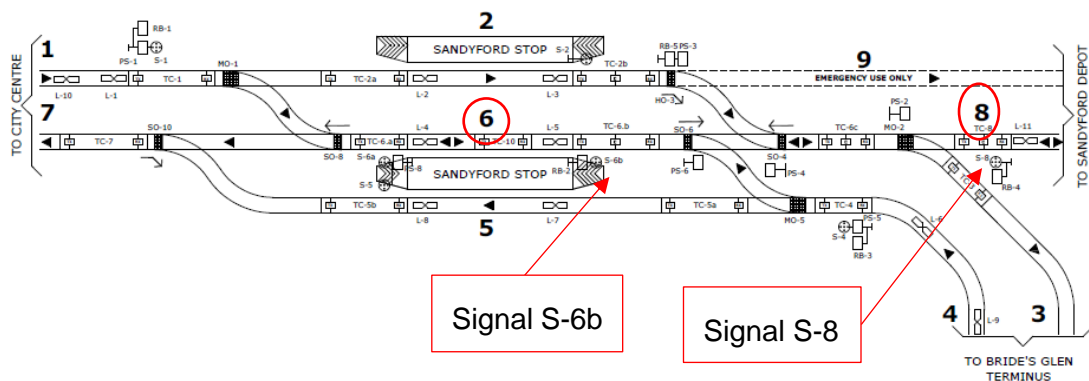


Figure 32 – Sandyford layout

169 At 06:30 hrs, Driver 4014 requested permission to travel from Storage Road 6 to the Depot Gates, which was granted, and Tram 4014 travelled to the Depot Gates and stopped at Signal S-8, which was displaying a Stop aspect, see Figure 33.



Figure 33 – Signal S-8

170 At 06:31 hrs, Driver 4014 requested permission from LNMC to exit the depot, which was granted. Driver 4014 did not input the RTS command to request the tram proceed signal for Signal S-8, the signal remained at Stop, and Tram 4014 travelled past Signal S-8 at Stop.

¹⁸ Driver 4014 was also the driver involved in the SPAS at Cookstown on the 3rd January 2020. Driver 4014 no longer works for Transdev.

- 171 Driver 4014 continued onto the Central Platform, where he saw “Stop – Single Dot” aspects and contacted LNMC who suspected a SPAS had occurred and requested that Driver 4014 return Tram 4014 to the depot.
- 172 At 06:40 hrs, Driver 4014 was now required to input an RTS command for Signal S-6b (see Figure 32), to re-enter the depot, however he did not and proceeded past Signal S-6b at Stop, see Figure 34.



Figure 34 – Signal S-6b at Stop

Sandyford Depot, S-8 Northbound, 13th April 2020

173 On the 13th April 2020, Driver 5016 was required to prepare and operate Tram 5016 for the Sandyford to Broombridge service. Tram 5016 was located on Storage Road 6, which required movements onto Storage Road 8, to allow exit from the Depot (similar to movements in paragraph 168 and Figure 32). At the Depot Gates, Driver 5016 was required to request permission to exit the depot from LNMCC, he did not do this, passing Signal S-8 at Stop and entered onto the mainline. Driver 5016 had been distracted by a family bereavement and issues related to Covid-19; which also resulted in other events incidents (wrong door selection and unauthorised shunting).

Sandyford Depot, S-8 Northbound, 7th October 2020

174 On the 7th October 2020, Driver 5014 was required to prepare Tram 5014, located on Storage Road 5 Sandyford Depot, for service. Driver 5014 was given permission, by LNMCC, to move Tram 5014 from Storage Road 5 to the Depot Gates (see Figure 35).

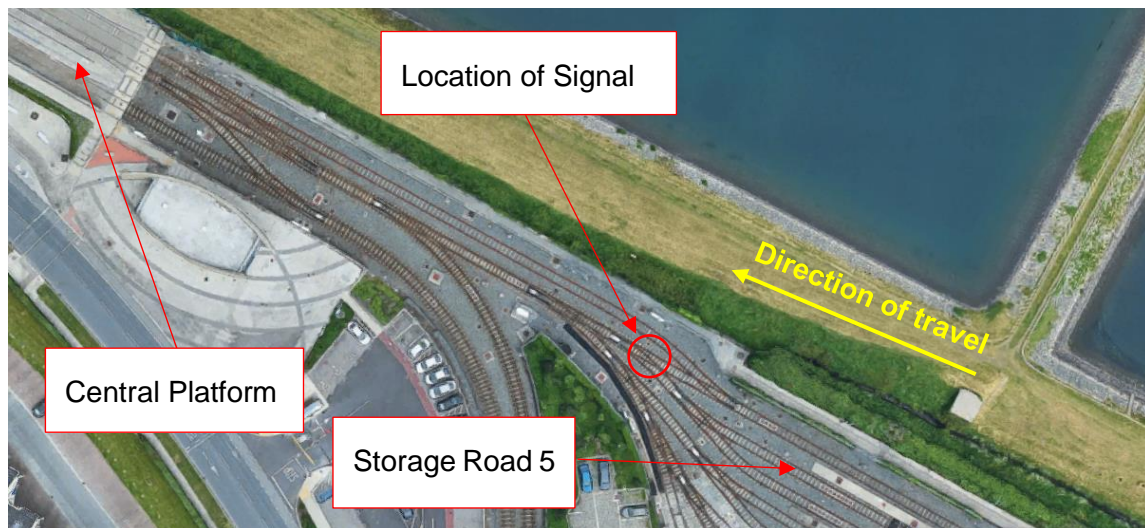


Figure 35 – Locations relevant to the incident

175 At the Depot Gates, Driver 5014 requested permission, from LNMCC, to exit the Depot onto the mainline (movement 8 to 6 inset Figure 36). Signal S-8 was displaying a Stop aspect (see Figure 36).

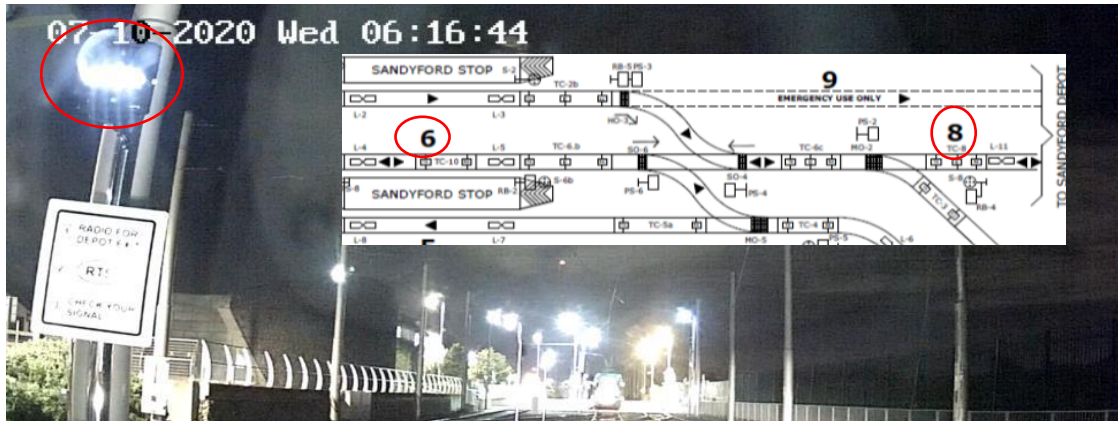


Figure 36 – Tram at Depot Gates, Signal S-8 displaying a Stop aspect (circled)

- 176 LNMCC granted permission for the movement. Driver 5014 was then required to input the RTS but failed to do so; and exited the Depot, passing Signal S-8 at Stop. Driver 5014 continued onto Sandyford Central Platform, where he saw the signals displaying “Stop – Single Dot” aspects and notified LNMCC. Driver 5014 was returned to Depot.
- 177 Driver 5014 thought he had inputted the RTS, however, stated that there were ongoing personal issues which may have caused a distraction.

Sandyford Depot, S-6b Northbound, 16th October 2020

178 On the 16th October 2020, Driver 5006 was requested by LNMCI to carry out a test run of Tram 5006 which had its camera recently repaired. The test run was from Sandyford to Brides Glen and then back to Sandyford.

179 Driver 5006 carried out the test run, without incident. On return to Sandyford, Tram 5006 arrived at Central Platform; Driver 5006 changed ends to return the tram to the depot. At 12:34 hrs, while Tram 5006 was stopped at Signal S-6b, Driver 5006 received permission from LNMCI to enter the depot. Signal S-6b was displaying a Stop aspect and the PPI was displaying that the points were set for the tram to enter the depot.

180 Driver 5006 observed the PPI and not the signal and did not enter an RTS request and proceeded past Signal S-6b displaying a Stop aspect, see Figure 37.

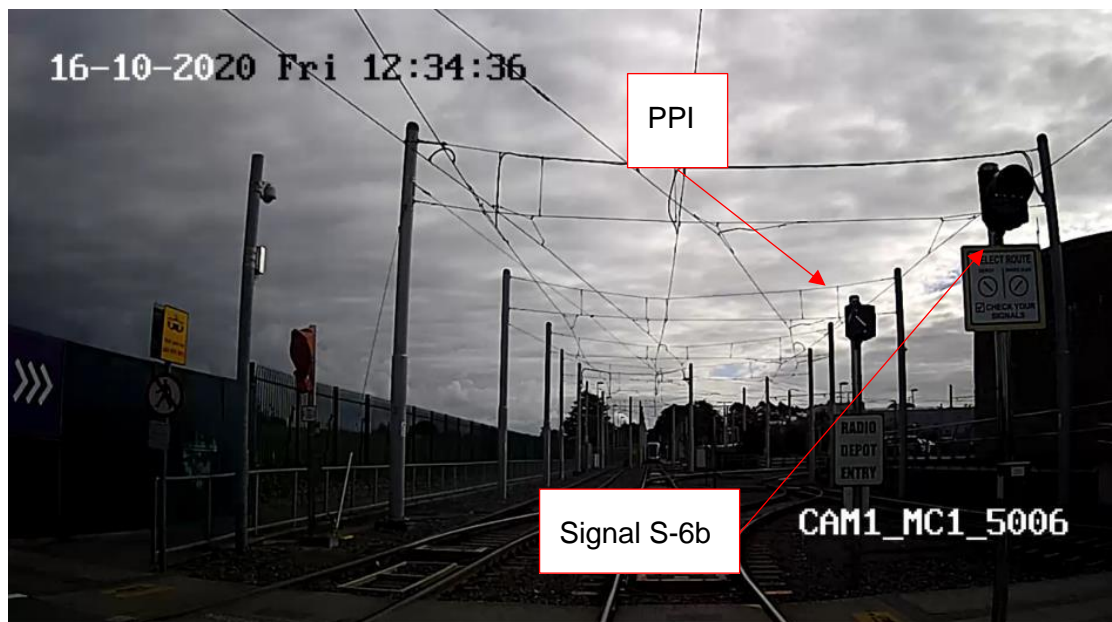


Figure 37 – PPI and Signal S-6b

181 Driver 5006 was aware he was involved in the SPAS, and slowed the tram, but did not stop as he did not want to delay tram services, which is a violation to the correct procedures.

182 LNMCI observed the suspected SPAS on the LSS mimic and contacted Driver 5006.

Sandyford Depot, S-6b Northbound, 14th April 2021

- 183 On the night of the incident, Driver 5034 was scheduled to work at Sandyford Depot (the shift involves any operational requirements including tram depot movements).
- 184 At approximately 22:00 hrs, LNMCC requested that Driver 5034 move Tram 5034 from Storage Road No. 1 to Sandyford Central Platform and back into the Depot onto North Apron No. 3.
- 185 Driver 5034 proceeded to Sandyford Central Platform without issue. At Signal S-6b, Driver 5034 was granted permission to re-enter the depot. Driver 5034 did input the RTS but did not request the left route; but observed the correct route was set for the movement (left direction on the PPI), see Figure 38.
- 186 Driver 5034 did not check the aspect of Signal S-6b and travelled past Signal S-6b at Stop.

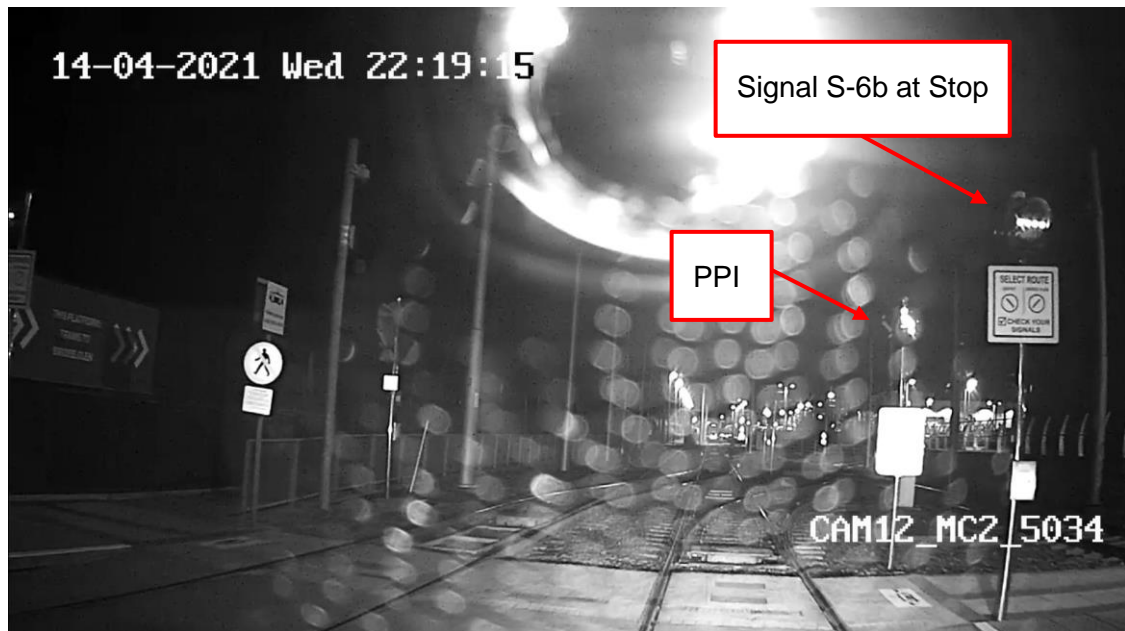


Figure 38 – Tram 5034 at Sandyford Central Platform

- 187 On the day on the incident, Driver 5034 was distracted by his upcoming retirement (8 days after the incident). It appears that Driver 5034 was reliant on the PPI, set for his route, rather than the signal.

SPAS incidents at Broombridge

General information

188 Broombridge is an LSS Location.

189 The speed approaching the Broombridge east-gate area is 20 km/h temporary speed restriction which was introduced in 2015; the speed was reduced from 35 km/h¹⁹.

190 There were three previous SPAS incidents at Signal S-1 NB, Broombridge prior to the incidents outlined below.

TSI Manual requirements

191 The maximum permitted line speed in the Broombridge “Crossing Area” and Depot is 10 km/h; according to the TSI Manual, the Crossing Area is before the platform tram stops and comprises of all tracks (northbound, southbound and crossover area).

192 The TSI Manual sets out general principles in relation to Broombridge Stop, this is mainly in relation to passenger trams arriving and departing the Stop. The TSI Manual states that the “Stopping Position is on the loop at the PPI Signal”. There are no specific instructions in relation to entering or exiting Broombridge Depot.

¹⁹ The RAIU queried as to why there was a temporary speed restriction for seven years; TII and TDLR are now in the process of making the 20 km/h a permanent speed restriction.

Broombridge, S-1, 27th September 2019

193 On the 27th September 2019 Driver 5001 could hear over the radio that one of the other tram drivers was having issues with their tram.

194 At approximately 17:19 hrs, Driver 5001 departed Sandyford Central, to service all stops to Broombridge on the Green Line. While at Broadstone Stop (four stops ahead of Broombridge), Driver 5001 heard, over the radio communications system, that there was a problem with signals at Broombridge Stop. Tram 5001 was held at Cabra Stop for a few minutes, as there was a problem with points.

195 As Driver 5001 travelled towards Signal S-1 on the approach Broombridge (see Figure 39) at approximately 18:22 hrs, he was hoping not to run into issues like the other drivers which would delay his meal break.

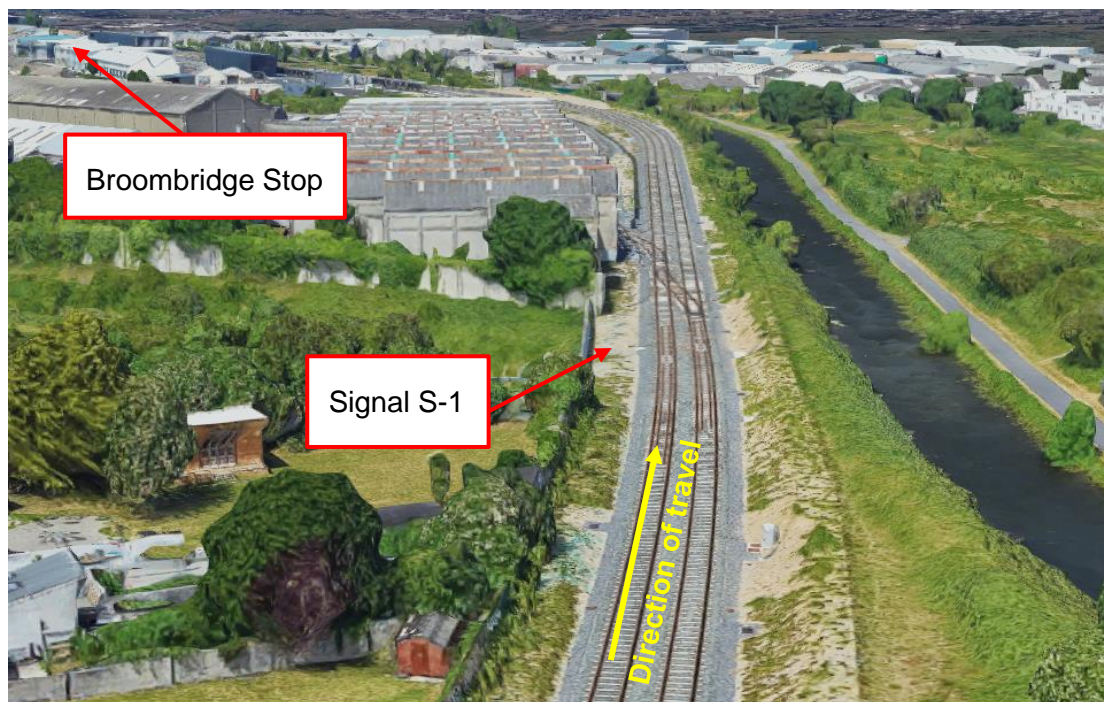


Figure 39 – Location of the incident

196 As a result, Driver 5001 was looking at the PPI at Broombridge Depot (see inset Figure 40) and was not looking at Signal S-1 and passed it displaying a “Stop” aspect; he had an incorrect expectation that Signal S-1 would be displaying a “Proceed” as he normally received a proceed at this signal. Driver 5001 normally approaches Signal S-1 on a “Proceed” aspect. Driver 5001 was unaware that he passed Signal S-1 at Stop, therefore, continued onto Broombridge Stop.

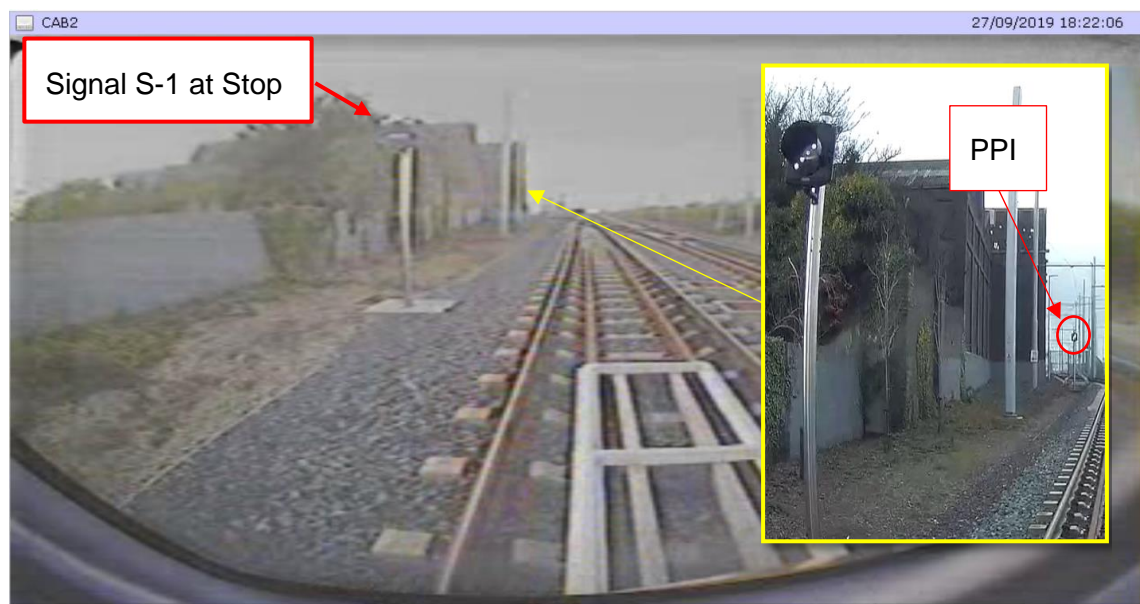


Figure 40 – Signal S-1 at Stop at Broombridge East Gate (Northbound)

PPI PAS, Broombridge Depot, 21st February 2019

197 On Thursday 21st February, the last tram movement over Points MO 37 was Tram 5005 at 17:41 hrs (an hour before the accident). The driver of Tram 5005 reported to LNMCC that the PPI were displaying a “Stop – Single Dot” aspect, Figure 41. No actions were taken; the radio communication was not recording; and, there was no TED report for the fault.



Figure 41 – PPI displaying a “Stop – Single Dot” aspect

198 At approximately 18:39 hrs when Tram 5032 arrived at Broombridge Stop and disembarked passengers and service driver, Driver 5032, was at the end of its timetabled service, as was required to be returned to Broombridge Depot for preparation-out by Driver 5032, see Figure 42.

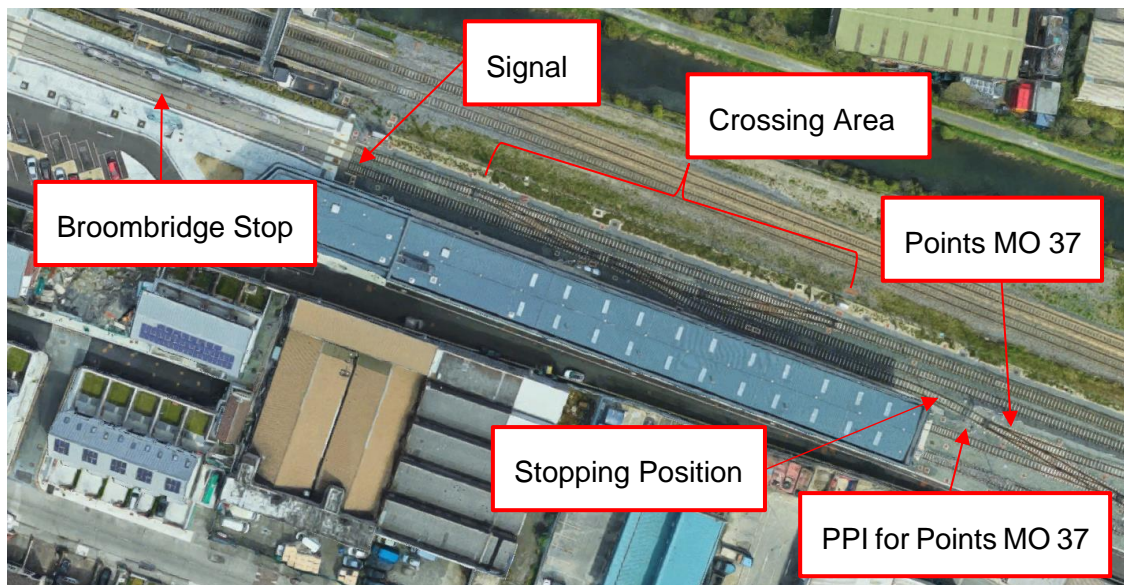


Figure 42 – Location of the incident

199 Driver 5032, boarded Tram 5032, activated the cab; and as the signal was displaying a Proceed (Tram Proceed to Right) aspect, Driver 5032 took traction and began travelling over the Crossing Area and towards the depot at a speed of 10 km/h.

200 Tram 5032 then approaches the PPI (the TSI Manual states that this is the Stopping Point for drivers). The PPI is displaying a “Stop – Single Dot” aspect, see Figure 43; this aspect indicates “the point position is not detected. Contact CCR. Danger of Derailment. Visual Check of Point Required”, see inset Figure 43. Points MO 37 were not set for the movement.



Figure 43 – PPI displaying a “Stop – Single Dot” aspect (circled red)

201 At the time, Driver 5032 was looking down onto the driver’s duty sheet and did not see and stop at the PPI; instead Tram 5032 continued onto Points MO 37, which resulted in the leading M1 bogie becoming derailed.

202 Driver 5032 applied the normal brake and then the emergency brake and the tram came to a stop in the derailed position.

203 A post-accident inspection of Points MO 37 found no faults with the points i.e. the track gauge at the switch tip was 1445 mm (maximum tolerance allowed is 1445 mm); and, the cross level throughout the unit was 10 mm (maximum tolerance allowed in 12 mm). However, the inspection found that the last gauge stop bolt on the left-hand switch blade had a gap of 18 mm when in the closed position, see Figure 44.



Figure 44 – Points MO 37

204 There was some damage to Tram 5032, mainly to the body-catcher and transversal damper, costing approximately €4,300 to repair.

Broombridge East Gate, S-1 Northbound, 23rd December 2019

205 On Monday 23rd December, Driver 5029 was operating the Sandyford Central to Broombridge passenger service which was late as a result of a signal fault at O'Connell Street.

206 As Driver 5029 was driving to Broombridge Stop he was watching the AVLS screen on the driver's console.



Figure 45 – Location of the incident

207 As Driver 5029 approached Signal S-1 at Broombridge East Gate, he slowed the tram to approximately 15 km/h (the permitted speed is 20 km/h). Signal S-1 was displaying a “Stop” aspect, see Figure 46. Tram 5029 continues to travel past Signal S-1 at “Stop”.



Figure 46 – Tram 5029 approaching Signal S-1 (circled red) at “Stop”

208 Driver 5029 continued to Broombridge Stop, without realising he had passed Signal S-1 at “Stop”. LNMU saw that a SPAS had occurred on the LSS and contacted the driver.

Broombridge East Gate, S-1 Northbound, 3rd September 2020

209 On Thursday 3rd September 2020, Tram 5023 was operating the Sandyford Central to Broombridge service. The AVLS was not set correctly (although, this would not guarantee the prevention of the SPAS).

210 At 20:32 hrs, on route to Broombridge terminus, Tram 5023 approached and passed Signal S-1 at Broombridge East Gate displaying a “Stop” aspect, see Figure 47. It should be noted that Driver 5023’s mobile phone vibrated (mobile phone should have been off, paragraph 44) around the same time as Driver 5023 approached Signal S-1, which may have been a distraction to the driver.



Figure 47 – Signal S-1 a Stop aspect

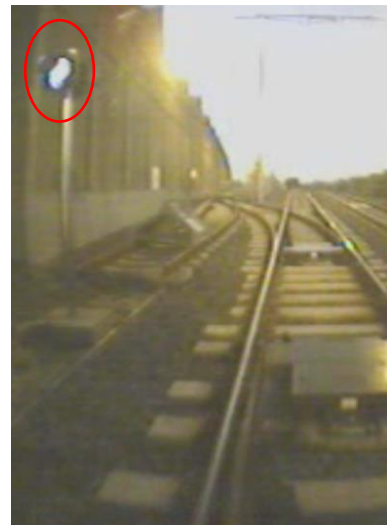


Figure 48 - PPI

211 The PPI was set correctly for mainline movements (see Figure 48) and Driver 5023 continued to the Broombridge terminus platform.

212 Driver 5023 was unaware he had been involved in a SPAS event and continued his duty until 01:47 hrs; LNMC were not immediately aware of the incident. As a result, Driver 5023 was not subject to drugs and alcohol testing.

Broombridge East Gate, S-1 Northbound, 8th January 2021

213 On Friday 8th January 2021, Driver 5029 was scheduled to operate the Sandyford Central to Broombridge passenger service, the tram departed Sandyford seven minutes late at 14:19 hrs.

214 At 15:01 hrs, on approach to Signal S-1 Broombridge, Tram 5029 was travelling at 27 km/h (7 km/h over the authorised speed). Signal S-1 was displaying a Stop aspect, see Figure 49. The sun was in Driver 5029's eyes, however, he was wearing prescription sunglasses. Driver 5029 considers he had a lapse of concentration on approach to Signal S-1.



Figure 49 – Signal S-1 displaying a Stop aspect

215 On seeing the Stop aspect, Driver 5029 applied the emergency brake; Tram 5029 came to a stop past the signal. Driver 5029 contact LNMC to report the emergency brake application and possible SPAS.

SPAS incidents at the Red Cow

General description

- 216 The Red Cow is on the Red Line and is the location of one of the Depots for tram maintenance and driver sign-on/ meal break locations.
- 217 Located outside the Red Cow Stop and Depot, is the Red Cow Delta, see Figure 50.
- 218 There were six previous SPAS events at Signal A08b Outbound: two in 2013; three in 2017; and, one in 2018.



Figure 50 – Red Cow Stop, Delta & Outbound Signals

TSI Manual operations

- 219 There are no specific instructions in relation to the Red Cow Delta or approaches to the Red Cow in the TSI Manual, drivers should follow normal operations passenger service requirements.

Red Cow Delta, Signal A08a Outbound, 30th March 2019

220 At 18:50 hrs, on Saturday March 30th Driver 4011 collected Tram 4011 at the Red Cow outbound platform; Driver 4011 was to travel to Saggart. Driver 4011 departed the Red Cow Stop, displaying a proceed aspect (Signal A08b), see Figure 51.

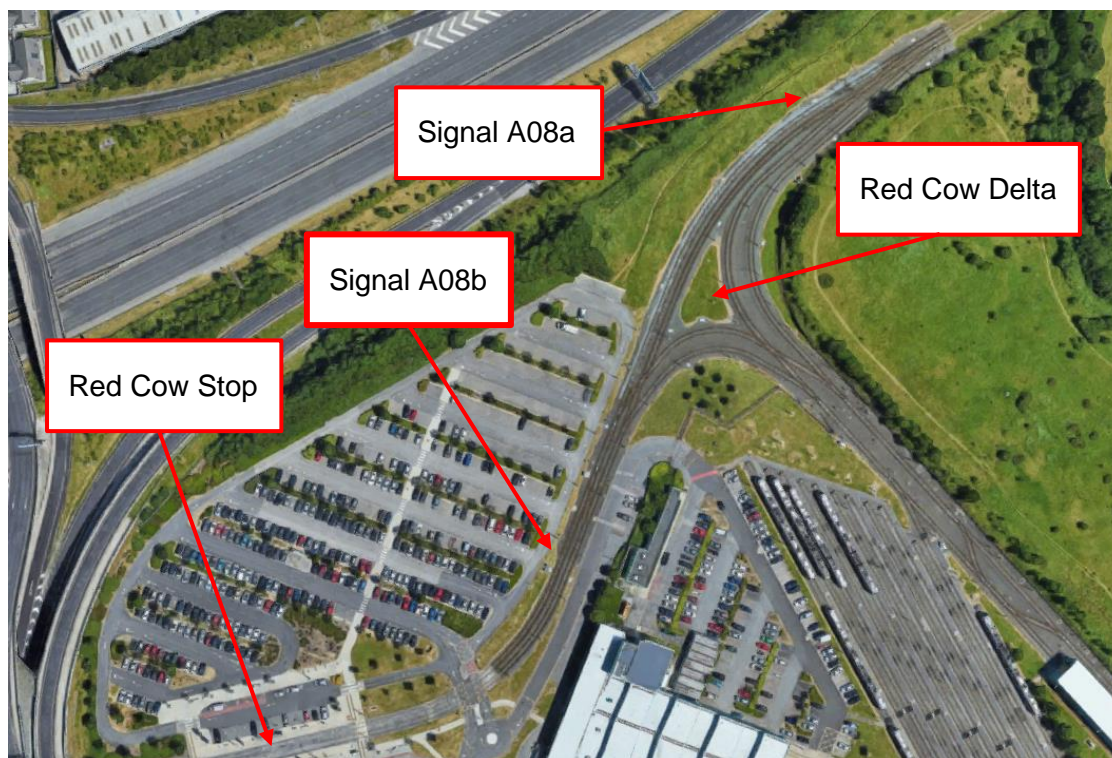


Figure 51 – Red Cow Stop, Delta & Outbound Signals

221 Shortly after Tram 4011 approached Signal A08a (Figure 51) displaying a Stop aspect, see Figure 52. Driver 4011 saw the Stop aspect and applied the normal service brake; however, Tram 4011 passed Signal A08a at Stop. Driver 4011 had momentarily forgotten there was a second signal, after Signal A08b.



Figure 52 – Signal A08b displaying a Stop aspect

222 Driver 4011 attempted to contact LNMU, by radio, without success, and continued to Tallaght, where he contacted LNMU to self-report the incident; in this instance, the driver could have used his mobile phone (paragraph 38).

Red Cow Delta, A08b Inbound, 3rd July 2019

223 On Wednesday 3rd July 2019, Driver 3010, was operating the inbound Tallaght to Point service. At the time of the incident, trams travelling outbound, were all terminating at the Red Cow, due to an earlier occurrence at Cookstown LSS.

224 On arrival at the Red Cow Delta, Tram 3010 stopped at the first signal, Signal A08a, (see Figure 53 for location of signal) displaying a Stop aspect; and proceeded once the signal changed to Proceed.

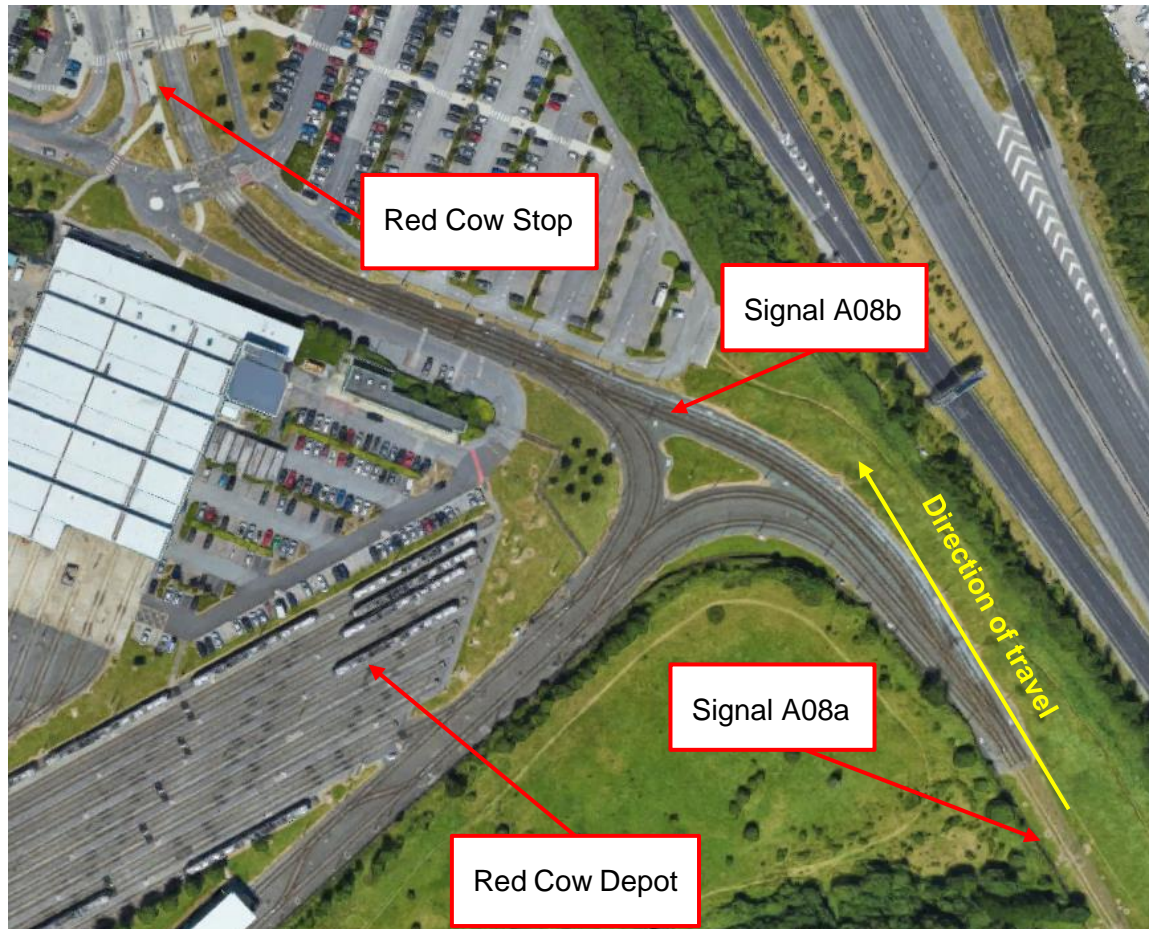


Figure 53 – Red Cow Delta

225 On approach to the second signal, Signal A08b, this was displaying a Stop aspect. Driver 3010 looked to his left, into the Red Cow Depot, to see the outbound trams terminating. Driver 3010 was not looking for Signal A08b. When Driver 3010 looked forward, he saw Signal A08b was displaying a Stop aspect and applied the normal brakes and not the emergency brakes as he thought he would stop in time.



Figure 54 – Signal A08b displaying a Stop aspect (red circled) at Red Cow Delta

226 Tram 3010 came to a stop and Driver 3010 contacts LNMC.

Red Cow Delta, A08b Outbound, 6th December 2019

227 On Friday 6th December 2019, Driver 3010 was operating the Outbound Red Cow to Kingswood passenger service.

228 At Red Cow Outbound Platform, Driver 3010 did not input the RTS.

229 At 08:45:39 hrs Tram 3010 approached Signal A08b (see Figure 51 for location), Signal A08b was displaying a “Stop” aspect, see Figure 55. Driver 3010 had an incorrect expectation that Signal A08b would upgrade to a “Proceed” aspect.



Figure 55 – Signal A08b displaying a “Stop” aspect

230 Driver 3010 saw the “Stop” aspect and applied the emergency brake but passed Signal A08b at “Stop”. When Tram 3010 came to a stop, Driver 3010 notified the LNMC.

SPAS incidents at Sylvan Drive/Embankment Road

General description

231 Sylvan Drive/Embankment Road Junction is on the Luas Red Line and is adjacent to Kingswood Stop; which in turn is one stop away from the Red Cow, see Figure 56 and Figure 57.

232 Road traffic runs parallel to the Luas line and there is a road junction (Junction A07) close to Kingswood Stop, see green dot in Figure 57.

233 There were two previous SPAS incidents at Signal A07 Outbound.

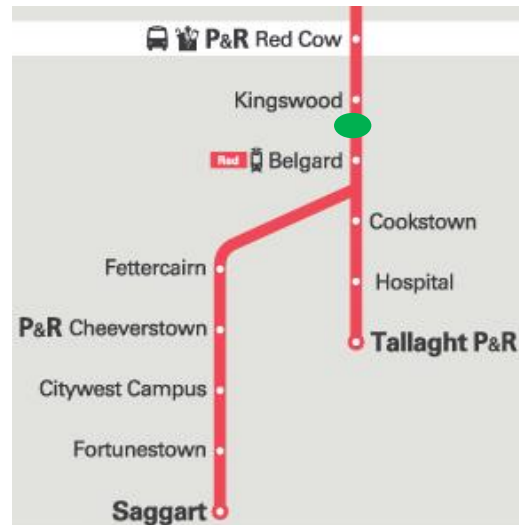


Figure 56 – Sylvan Road (green circle)

Sylvan Drive/Embankment Road, Signal A07 Outbound, 17th May 2019

234 On Monday 20th May, after his scheduled meal break at the Red Cow, Driver 3023 took over the outbound Red Cow to Tallaght service at the Red Cow Stop; the relieved driver remained in the cab i.e. there were two drivers in the cab. Three minutes later, Tram 3023 arrived at the Kingswood Stop at 22:22:05 hrs, see Figure 57.



Figure 57 – Location of the incident (images taken from Google)

235 At Kingswood with the other driver exited the cab. Signal A07 was displaying a Stop aspect, see Figure 58. At 21:22:49 hrs (45 seconds after arriving at the stop) Signal A07 upgraded to a Proceed aspect (see Figure 59) due to the set signalling sequencing at Signal A07 which is unique to this junction²⁰ i.e. Driver 3023 had not inputted the RTS. At this stage, Driver 3023 saw the Proceed aspect.

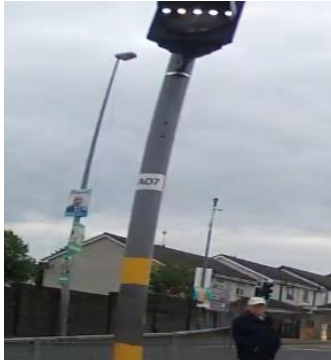


Figure 58 – Stop



Figure 59 – Proceed



Figure 60 – Stop

236 At 21:23:22 hrs (seventy-seven seconds after arriving at the Stop; thirty-three seconds after the upgrade) Signal A07 downgraded to a Stop aspect (to allow movement of road traffic), see Figure 60, this means Driver 3023 now has to input an RTS request to get a proceed.

237 Driver 3023 did not input the RTS request and proceeded against Signal A07 at Stop at 21:23:23 hrs (one second after the downgrade). Tram 3023 proceeded through the junction with no conflicts with road traffic (see Figure 61). Driver 3023 noted that a car to the driver's left sounded a horn but was not in the junction.

²⁰ At the time of the incident, there was a unique signalling sequencing at Signal A07, which was introduced by South Dublin County Council as a result of road traffic issues with junction timings of the road traffic signals (managed by South Dublin County Council). South Dublin City Council did not consult with TDLR in relation to the changes. The change resulted in Signal A07 being able to upgrade to a Proceed aspect without drivers inputting an RTS request button; the proceed aspect can therefore be displayed even if a tram is not ready to go; in addition, the signal can then downgrade to Stop if the tram's departure is further delayed, in this instance the driver must input an RTS request. When TII and TDLR became aware of the issue, the signalling sequence was changed. TII and TDLR met with South Dublin City Council and now have a process in place for making changes to signalling sequences; this will be further enhanced through the formal introduction of a SCC.



Figure 61 – Tram 3023 travelling through Junction A07

238 Driver 3023 did not realise he was involved in a SPAS incident and finished his rostered duty, it was notified to LNMC by a member of the public.

Sylvan Drive/Embankment Road, Signal A07 Inbound, 21st May 2020

239 On the 21st May 2020, Driver 4007 was operating the Tallaght to Red Cow Inbound passenger service. At 12:08 hrs, Driver 4007 departed Belgard on route to Kingswood, when he approached Signal A07 Inbound displaying a Stop aspect, see Figure 62.



Figure 62 – Signal A07 at Stop

240 Driver 4007 was looking at the road traffic signal on his right which was displaying a green light (Figure 62) and not looking at the tram signal on his approach. When Driver 4007 did look at the signal, it was displaying a Stop. Driver 4007 applied the emergency brakes, and stopped the tram, past the signal, but did not breach the road junction. Driver 4007 reported the incident to LNMC.

Sylvan Drive/Embankment Road, Signal A07 Inbound, 12th May 2021

241 On the 12th May 2021, Driver 3012 was operating the Saggart to Red Cow passenger service. At 08:23 hrs, Driver 3012 departed Belgard on route to Kingswood; as Driver 3012 approached Signal A07, below the permissible speed limit, the signal was displaying a Stop aspect, see Figure 63.



Figure 63 – Signal A07 at Junction A07 (Sylvan Drive / Embankment Road)

242 There were pedestrians at the *uncontrolled pedestrian crossing* on Tram 3012's approach, see Figure 64.



Figure 64 – Pedestrians approaching the uncontrolled pedestrian crossing

243 On seeing the Stop aspect, Driver 3012 applied the brakes (normal service brake), however, he did not apply sufficient braking to prevent the tram passing Signal A07 at Stop and despite seeing that the tram was going to SPAS, Driver 3012 did not apply the emergency brake, and passed the signal, stopping on the, but did not enter the road junction (Junction A07).

244 Driver 3012 then self-reported the incident to LNMC. Tram 3012 was braking for approximately 260 m over a period of thirty-two seconds.

SPAS incidents at Belgard Road Inbound & Outbound

Belgard Road, Signal A05 Outbound, 4th January 2019

245 At 07:18 hrs on Friday 4th January 2019, Tram 3012 was operating the outbound Red Cow Depot to Saggart service passenger service when it approached the Main Belgard Road Junction, Junction A05 (Figure 65).

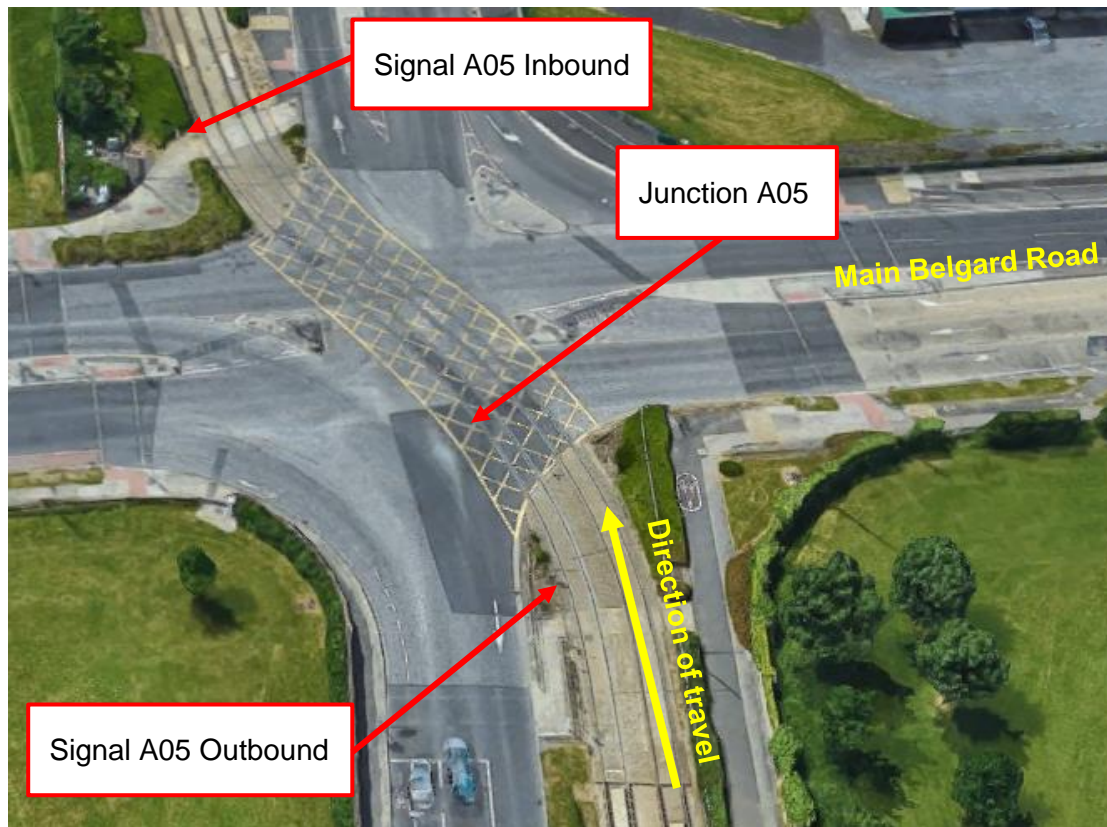


Figure 65 – Belgard Road

246 Signal A05²¹ was initially displaying a Proceed aspect. Signal A05 then changed to a “Stop, Unless too close to Stop Safely” aspect, see Figure 66.



Figure 66 – Signal A05 displaying a “Stop, Unless too close to Stop Safely” aspect

²¹ Signal A05 Outbound is a multi-SPAS signal, which has been involved in four previous SPAS events prior to this occurrence.

247 Signal A05 then downgraded to Stop aspect, see Figure 67. Driver 3012, saw Signal A05 change to Stop but appears to have had an incorrect expectation that the signal would upgrade. On realising the signal would not upgrade he applied the maximum service brake, thinking that this would stop the tram in front of the signal (he did not apply the emergency brake as he thought it may injure passengers).



Figure 67 – Signal A05 displaying a Stop aspect (circled red)

248 However, Tram 3012 travelled past Signal A05 at Stop, and stopped before the uncontrolled pedestrian crossing. Driver 3012 contacted LNMC to report the SPAS.

Belgard Road, Signal A05 Inbound, 15th July 2019

249 On the 15th July 2019, Driver 4003 was operating the Saggart to Red Cow passenger service. As Tram 4003 travelling inbound, approached Junction A05, see Figure 65. Signal A05²² was displaying a Stop aspect, see Figure 68.



Figure 68 – Signal A05 at Stop

250 Tram 4003 continued towards Junction A05. When Driver 4003 saw a car driving over the Main Belgard Road (Driver 4003 thought the car had breached the lights), he applied the brake (Driver 4003 is unsure if he applied the emergency brake or the maximum service brake – the OTDR was not downloaded (OTDR previously discussed in paragraphs 55 - 59). Tram 4003 came to a stop, ahead of the junction and contacted LNMC. Driver 4003 requested a wrong directional movement back to Signal A05, which was granted by LNMC.

251 Post-incident, it was discovered that Driver 4003²³ was distracted by on-going personal issues, for which TDLR were providing support.

²² It was the second SPAS event at this signal prior to this incident.

²³ The driver was subject to a disciplinary hearing as a result of this incident and his previous SPAS incidents; which resulted in his termination from driving duties.

Blackhorse, Signal A19 Outbound, 4th October 2019

252 On the 4th October 2019, Driver 4013 was operating the Point to Red Cow passenger service. At 10:38 hrs, Driver 4013 arrived at the Blackhorse Stop (Figure 69).

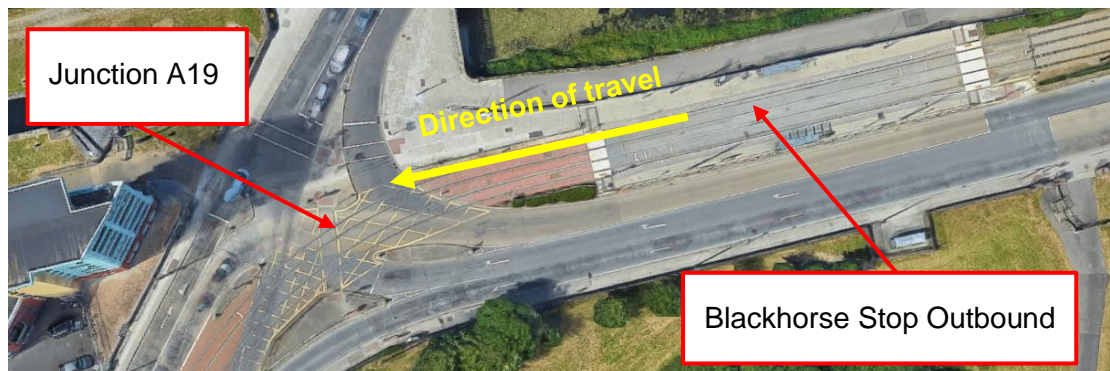


Figure 69 – Blackhorse Stop

253 When Driver 4013 was ready to depart the platform, he inputted his RTS command to request the tram proceed signal, from Signal A19; however, Signal A19²⁴ remained at Stop (there were issues with some other signals near the location of Signal A19), see Figure 70. Driver 4013 reported the issue to LNMCC. LNMCC informed Driver 4013 that they would contact Dublin City Council to input the signal and to await further instructions.



Figure 70 – Signal A19 at Stop

254 At 10:45:12 hrs (Tram 4013 was now stopped at Blackhorse Stop for approximately seven minutes), an inbound tram approached onto Junction A19, travelling inbound towards Blackhorse Stop, see Figure 71.

²⁴ No previous SPAS events at this signal prior to this incident.



Figure 71 – Inbound tram, travelling towards Blackhorse Stop

255 Four seconds later, Tram 4013 departs Blackhorse Stop, with Signal A19 still displaying a Stop aspect. Driver 4013 had not received any instructions from LNMC.

256 Driver 4013 was looking at the junction and not the signal prior to departure. Driver 4013 was inexperienced in relation to the events surrounding the incident, with Signals A16, A17 and A18 being blank; he was also waiting for close to seven minutes for Signal A19 to change; when he saw the inbound tram proceeding, he incorrectly assumed that he should proceed. Driver 4013 was a newly qualified driver and did not appear to appreciate the importance of not travelling past a Stop aspect, this maybe as a result of the fact that he had not been subject to any practical monitoring prior to the incident.

257 LNMC were monitoring the junction, as a result of Driver 4013's fault report; and saw Tram 4013 travel past Signal A19 at Stop. LNMC contacted the driver requesting he stop.

Blackhall Place/ Benburb Street, Signal A28, 20th May 2019

258 On Monday 20th May 2019, Tram 3021, was operating the Tallaght to Connolly inbound passenger service, when it stopped at the signalised junction of Blackhall Place and Benburb Street (Junction A28), located between Museum and Smithfield Stops. As Signal A28 (inbound) was displaying a Stop aspect (Figure 72); the pedestrian signal was also displaying a stop aspect (see Figure 72).



Figure 72 – Tram 3021 stopped at Signal A28

259 A few seconds later, the pedestrian signal changed to green (Figure 73), Driver 3021 applied traction and passed Signal A28 on a “Stop” aspect. On realising the signal was at “Stop”, Driver 3021 applied the brake, he did not apply the emergency brake and stopped approximately ten metres past Signal A28 and contacted the LNMC.



Figure 73 – Pedestrian signal displaying a green figure

260 It was noted that Driver 3021 normally used error prevention techniques during his normal driving duties to prevent SAS SPASs, whereby he would look at a signal, look away and look back again to ensure he had a “Proceed” aspect; however, in this case it was a pedestrian signal that appears to have triggered the movement.

261 There was one previous SPAS at Signal A28 where a driver proceeded on a green pedestrian aspect in 2013.

Dawson Street/ Stephen's Green, Signal D02 Outbound, 17th March 2019

262 On Sunday 17th March 2019 Tram 5030 was operating the Parnell to Brides Glen outbound passenger service. At Dawson Street, LNMC requested Driver 5030 hold at the platform due to anti-social behaviour at the Stephen's Green Stop (see Figure 74).

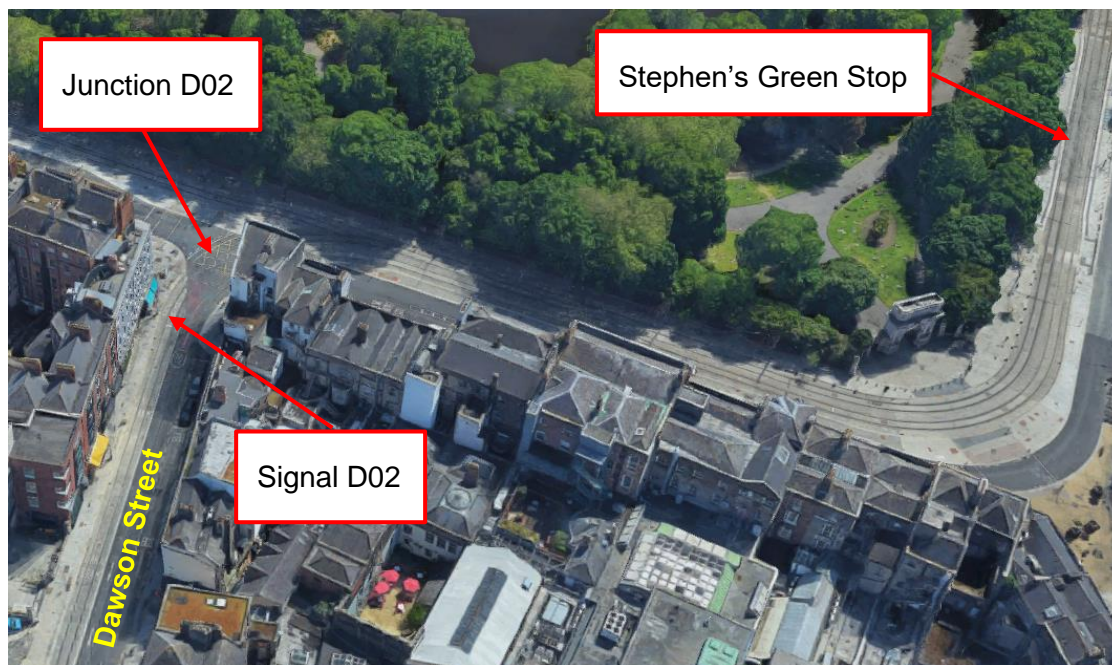


Figure 74 – Location of the incident (images taken from Google)

263 A few minutes later, LNMC requested Driver 5003 to depart Dawson Stop and continue the service. On approach to Dawson Street/Stephen's Green Junction, Junction D02, tram signal, Signal D02 was displaying a Stop aspect (see Figure 75 and Figure 76).



Figure 75 – Signal D02 & Junction D02



Figure 76 – Signal D02 displaying a Stop

- 264 Driver 5030 was focused on two pedestrians of the footpath next to Junction D02 and was concerned they were going to walk out in front of the tram (Figure 77 show two pedestrians at the junction).



Figure 77 – Travelling onto Junction D02, two pedestrians circled

- 265 At 21:54:49 hrs, Tram 5030 proceeds onto Junction D02, after passing Signal D02 at Stop. A car travelled into the junction in front of the tram causing Driver 5030 to sound the tram horn. Car horns were also sounding. Driver 5030 saw that cars were still travelling through the junction and realised they had been involved in a SPAS and self-reported the incident to LNMC.
- 266 Driver 5030 continued onto St Stephen's Green Stop and contacted LNMC and requested a relief driver to drive the tram back to the depot.

Section 11 – Events after a SPAS incident

Driver actions

267 According to the TSI Manual if a signal is passed at stop, the driver must: stop as soon as possible when it is safe to do so; put on hazard lights; contact LNMC and confirm service number, staff identification, exact location, junction number and direction of travel; and, await further instructions from LNMC.

Key events after a SPAS

268 A number of events normally occurred after a SPAS event, namely:

- LNMC request drivers to make a number of controlled movements in order to de-tram passengers and return the tram to the depot²⁵;
- Drivers are required to undergo drugs and alcohol testing²⁶;
- The OTDR and FFCCTV is downloaded and reviewed;
- The driver is interviewed by TDLR's safety team;
- Drivers are briefed on the incident, the rules are re-enforced and re-coached;
- Accompanied by a Team Leader / Driver Trainer on their first duty post incident;
- An internal investigation is carried out by the safety team.

²⁵ Staff Management Procedure "Signal Passed at Stop", TTI Luas SM 007 ISS sets out criteria under which drivers should be immediately removed from duty e.g. drugs and alcohol; unfit, shock, gross negligence.

²⁶ The RAIU made a safety recommendation on the 4th March 2020 in "Passenger trap-and-drag occurrence on Luas tram at Heuston Stop, 26th March 2019" report, namely "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". Transdev re-drafted and published their "Drugs and Alcohol Policy" on the 10th September 2020, and the recommendation was closed by the CRR on the 21st October 2020. As a result, the RAIU are not going to conduct a further review on the management of driver testing post incident.

Driver driving post-incident

269 In general, drivers are normally back to full driving duties, without sanction or extra monitoring, within a week of the SPAS event. For example, the driver involved in the SPAS at Signal S-4 Northbound, Sandyford Stop on the 26th January 2020, was involved in another SPAS incident at the same signal two days after the first incident on the 28th January 2020 (paragraphs 136 - 140). On rare occasions, drivers are terminated from driving duties; this is normally as a result of previous incidents.

270 The RAIU note, that drivers can be subject to disciplinary reviews as a result of SPAS incidents (normally related to drivers with a number of incidents); which can result in removal from the driving grade.

271 By way of comparison, drivers in heavy rail, drivers are normally subjected to additional monitoring, assessment and on-train data recorder download reviews over a fixed period of time, which can be in some cases up to two years.

Internal investigation process

272 TDLR's management of SPAS incidents, is through "Signal Passed at Stop" document (TTI Luas SM 007 ISS). This four-page document is mainly related to the management of internal investigations into SPAS incidents, it sets out the procedures of investigation as:

- Establish the full facts;
- Establish the immediate cause;
- Establish any non-compliance with procedures and approved methods of working;
- Identify any human factors issues that may have contributed;
- Establish the effectiveness of the tram brakes;
- Assess the suitability of training and staff briefing arrangements.

273 Factors for consideration include:

- Distraction of the driver for whatever reason;
- Fitness for duty of the driver concerned;
- Communications failures;
- Adequacy of driver training;
- Any other contributory factors.

274 As part of the RAIU investigation, the RAIU reviewed the completed TDLR investigation reports. The RAIU found that TDLR's immediate cause is consistently that "Driver (insert number here) passed a "Do not proceed" aspect at tram signal (insert signal number here) at (insert location here)", or similar.

275 In terms of the underlying causes, there is some variations, such as:

- Drivers' anticipation that the tram signal would change to "Proceed" aspect, and therefore not braking sufficiently on the approach to the signal;
- Drivers looking at or programming the AVLS when approaching the signal;
- Looking at surroundings or tram mirrors (e.g. crossings/ junctions, depots, pedestrians) when approaching signals
- Drivers not inputting the RTS before taking traction;
- Drivers not looking at the signal or poor visibility of the signal (glare);
- Drivers looking at points or PPI instead of signal;
- Driver looking at pedestrian lights instead of tram signals.

276 The root cause consistently being that "The tram driver did not adhere to the line-of-sight principle of checking that his signal aspect was displaying a proceed signal before engaging the junction and as a result the incident "Signal Passed at Danger" occurred", that he did not apply the emergency brake to stop the tram before the tram signal as per driver training". or similar.

277 In the reports, there is little or no commentary on the signal history (i.e. is it a multi-SPAS signal); and therefore there are instances where there is a high level of SPASs at a particular signal, but no suggested recommendations to make improvements.

278 Some of the internal investigation reports state that "reviews" have been carried out in terms of the daily and six-weekly rosters; and, that no "indication or concern relating to driver fatigue" has been identified. However, the reports never include a driver fatigue / risk index scores (a means of calculating whether cumulative fatigue, time-of-day, shift length, the effect of breaks and the recovery from a sequence of shifts are areas of concern in terms of driving).

279 The actions taken, is normally that the drivers are briefed on the incident.

280 There are generally no safety recommendations unless a recommendation can be made in relation to the physical signal head (e.g. the upgrade of the signal to LED), however, this has happened only once in the thirty-six reports; and this was directed at TII.

281 Therefore there is little self-directed recommendations for TDLR in terms of operations, resulting in no apparent improvements in terms of reducing the number of SPAS incidents. The RAIU consider this to be an additional observation, AO-08 (paragraph 317) and have made an appropriate safety recommendation, Safety Recommendation 2022003-15 (paragraph 341).

Section 12 – Analysis

Introduction

282 This section of the report, examines the causation of SPAS incidents and analyses the TDLR training, supporting documentation and operating instructions to determine if these contribute to the identified causations.

Causation of SPAS incidents

Introduction

283 Below are some of the main causations of the SPAS incidents reviewed; it should be noted, that one or more of these can apply to an individual occurrence.

LSS Locations

284 The majority (69%) of SPAS incidents occurred at LSS locations (Sandyford (44%), Broombridge (14%) and Cookstown Interchange (11%).

285 It should be noted that these locations are the only locations where the LNMC can see a suspected SPAS event through a visual representation on the LSS mimic (paragraph 88).

286 Unlike, with some depot movements (paragraphs 70 - 71), there is no specific training through LSS locations Cookstown and Broombridge and there is no minimum activity criteria drivers have to carry out the driving through Cookstown as set out in Figure 7.

287 The RAIU have also linked the Sandyford and Broombridge LSS locations SPAS incidents to driver meal break times, see paragraphs 291 and 292. Also, reviewing the depot movements at Sandyford, see paragraphs 295 and 296.

SAS SPAS incidents

288 A SAS SPAS is a SPAS where a stationary tram starts against a signal at stop. This may be at a platform starting signal, or at any other signal at which a tram is stopped.

289 Of the thirty-six SPAS incidents reviewed by the RAIU, seventeen incidents²⁷ (47%) were SAS SPAS incidents. Of these seventeen, eleven (69%) involved drivers not inputting the RTS request; with the majority (82%) occurring in Sandyford.

290 In heavy rail, a Driver's Reminder Appliance (DRA) is used, in the prevention of SAS SPADs. The DRA is a device in a driving cab to enable the driver to set a reminder that the signal ahead is at danger. Whilst set, the DRA prevents the driver being able to take power. The main objectives of the DRA are to indicate to the driver, whilst the device is set, that the signal ahead may still be at danger; and to prevent the driver from starting away when the device is set. The DRA must be set when: entering/leaving the driving cab; and, when stopped at any signal at danger (which helps prevent SAS SPADs).

²⁷ Sandyford on the 18/01/19, 25/07/19, 25/08/19, 28/01/20, 28/05/20, 07/06/20, 21/10/20, 24/05/21, 09/06/21, 09/10/19, 12/03/20, 07/10/20, 16/10/20, 14/04/21, Sylvan Drive on the 17/05/19; Blackhorse on the 04/10/2019, Blackhall Place on the 20/05/19.

SPAS timings & locations

291 The RAIU reviewed the timings of SPAS incidents and the scheduled meal breaks, see Figure 78.

SPAS Event	Driver Roster	Scheduled breaks	SPAS time	Note
Sandyford, 09/06/2021	16:16 – 01:05	19:10 & 22:37	19:45	SPAS occurred five minutes after break
Sandyford, 24/05/2021	16:43 – 01:43	19:46 & 22:06	19:28	Driver was due to take his break on arrival at Sandyford
Kingswood, 12/05/2021	06:04 – 12:25	08:22	08:25	Driver was late for his break which was due to occur on arrival at the Red Cow
Broombridge, 08/01/2021	14:03 – 22:12	15:04	15:01	Driver was scheduled his break on arrival at Broombridge
Sandyford, 07/06/2020	08:39 – 16:45	11:21 & 15:04	11:08	Driver was due to take his break at arrival at Sandyford
Sylvan Drive, 21/05/2020	06:16 – 15:00	09:41 & 12:16	12:08	Driver was scheduled a meal break on arrival at the Red Cow
Sandyford, 13/04/2020	08:09 – 16:46	10:16 & 14:16	11:01	SPAS occurred after scheduled break
Cookstown, 03/01/2020	06:30 – 15:25	10:10 & 10:40	15:08	Driver was due to finish when he arrived at Red Cow
Broombridge, 23/12/2019	04:32 – 10:40	05:52	05:52 hrs	Due to take first break at Broombridge
Blackhorse, 04/10/19	05:57 – 14:12	08:15 & 10:45	10:45	Was late for second break which was due on arrival at the Red Cow
Broombridge, 27/09/2019	15:01 – 23:41	18:14 & 19:58	18:22	Was late for second break which was due on arrival at Broombridge
Belgard Road, 15/17/2019	16:46 – 01:37	19:46 & 22:23	19:21	Was late for first break which was due on arrival at the Red Cow
Sylvan Drive, 17/05/2019	14:27 – 23:18	18:05 & 20:46	21:23	Break finished at 21:16 at the Red Cow with the SPAS occurring 7 minutes later
Red Cow, 30/03/2019	16:21 – 01:10	18:18 & 21:38	18:51	Break finished at 18:48 at the Red Cow with the SPAS occurring 3 minutes later
Sandyford, 18/01/2019	06:07 – 12:10	07:33 & 09:51	09:37	Break was due on arrival at Sandyford.

Figure 78 – Timings of SPAS incidents versus meal break times

292 Of the thirty-six incidents reviewed by the RAIU, fifteen (approximately 42%) occur around the time of scheduled meal breaks; there is some correlation between the meal breaks and the locations where drivers are taking their breaks i.e. Broombridge, Red Cow and Sandyford, this can be clearly seen in Figure 79.

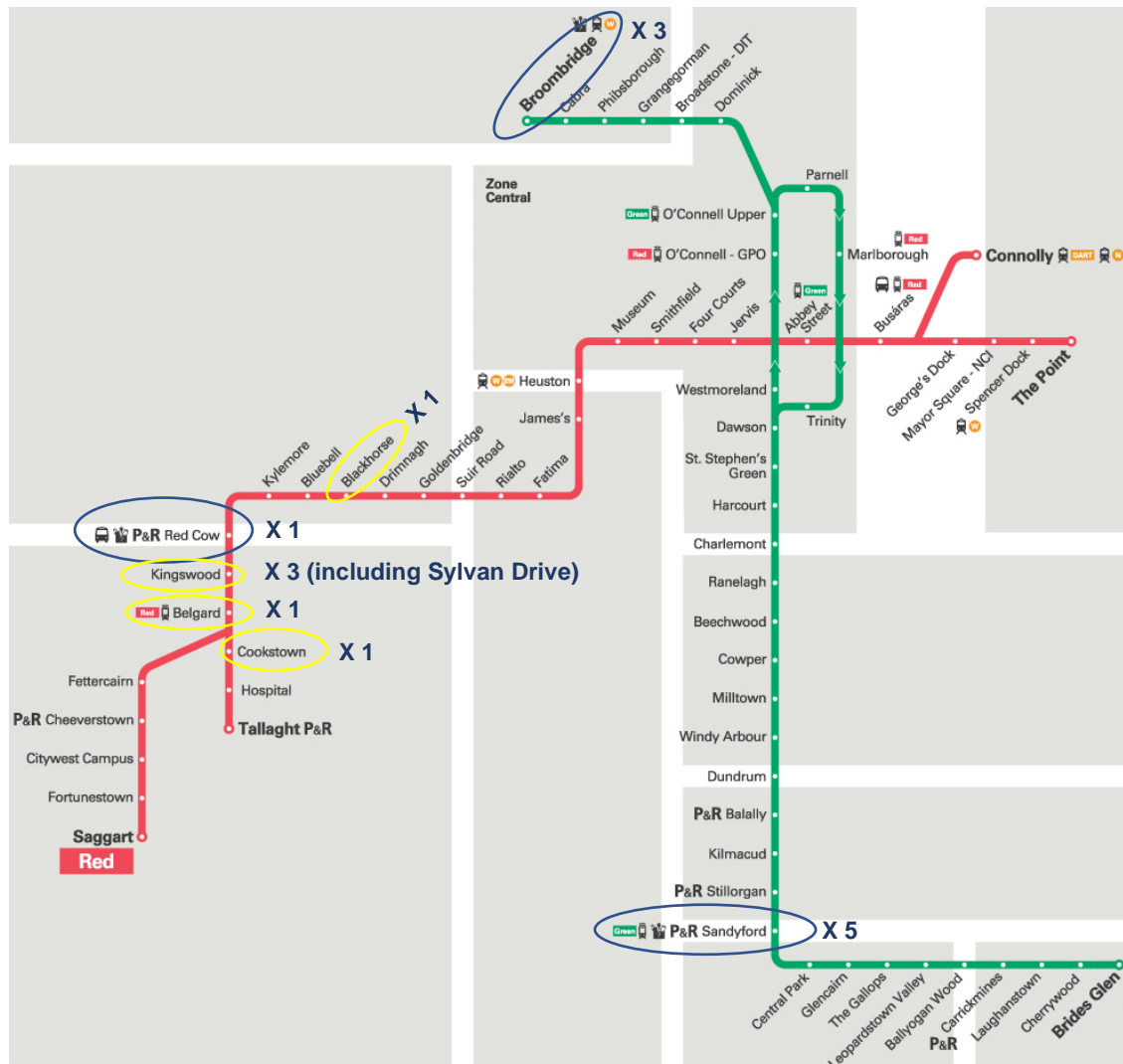


Figure 79 – Locations of SPAS incidents close to meal break locations

293 As mentioned previously, some of the internal investigation reports state that “reviews” have been carried out in terms of the daily and six-weekly rosters; and, that no “indication or concern relating to driver fatigue” has been identified; however, the reports never include a driver fatigue / risk index scores (paragraph 278).

PPI & Points

294 In twelve²⁸ of the incidents (33%), the drivers were looking at the PPI or the position of the points to see if their route was set, rather than looking at the signal to see if they had a Proceed aspect. The majority (83%) of these incidents occurred in the Sandyford area.

Sandyford Depot

295 Nine²⁹ (25%) of the thirty-six SPAS incidents, involved tram movements entering and exiting the depot. The TSI Manual gives very brief notes in relation to these movements, paragraphs 124 - 158. With the driver training, minimum activity criteria only requiring four generic depot entry and exit movements, see Figure 7.

296 It was also noted, that in four of the incidents, the drivers, on hearing that permission was granted by LNMC for the movement, proceeded without inputting the RTS request³⁰; indicating that the verbal LNMC permission prompted the driver to proceed without checking the signal.

AVLS

297 In six³¹ (17%) of the thirty-six incidents, the tram service number had not been inputted correctly in the tram's onboard AVLS. At certain points on the network, the AVLS enables the auto-routing (whereby the tram automatically selects the route, based on the service file information which includes information related to the timetable and route of the tram), paragraphs 29 - 31.

298 If the AVLS is not entered correctly, the signals at certain location will not automatically upgrade i.e. in the case of the incidents reviewed by the RAIU, had the correct tram service number been entered, the signals would likely have upgraded to proceed if there was no conflicting movement.

²⁸ Cookstown on the 30/07/20, 16/02/20; Sandyford on the 18/01/19, 25/07/19, 25/08/19, 26/01/20, 28/01/20, 07/06/20, 24/05/21, 16/10/20, 14/04/21, Broombridge on the 27/09/19.

²⁹ Sandyford 18/01/19, 25/07/19, 09/10/19, 12/03/20, 13/04/20, 07/10/20, 16/10/20, 14/04/21, 24/05/21.

³⁰ Sandyford on the 09/10/19, 12/03/20, 07/10/20, 16/10/20.

³¹ Cookstown on the 30/07/20, 16/02/20, Sandyford on the 07/06/20, 24/05/21, 09/10/19, Broombridge on the 03/09/20.

299 When the AVLS is set correctly, signals upgrade to Proceed when there are no conflicting movements, in this case, drivers may have an incorrect expectation that signals will upgrade for them; compounding the causation of the SPAS in these types of SPAS incidents.

Incorrect expectation of Proceed aspect

300 In nine (25%) of the incidents, drivers had an incorrect expectation that the signal would upgrade, either as a result of:

- Drivers normally having a Proceed aspect at a certain signal (and may not due to AVLS not being inputted correctly); or,
- Inputting the RTS request, expecting a Proceed, which wasn't granted due to conflicting movement, and proceeding without looking at the signal³²;
- The automatic Proceed at Sylvan Drive (paragraphs 234 - 238) upgraded and downgraded while the tram was at the Stop, leaving the driver thinking he had a Proceed;
- Reading the road traffic signals instead of the tram signals and expecting a proceed;
- Seeing other trams making a movement.

Distraction/ Preoccupation

301 There were ten (28%) incidents related to general distraction and pre-occupation, due to: Driver personal issues (retirement, bereavement, dental, COVID-19); In-cab distractions such as sun glare, duty sheets and AVLS; Late running of trams / disruption on the network; Pedestrians close to the line.

Operating in degraded conditions

302 Seven³³ (almost 20%) of the incidents could be considered as driving in "degraded mode" e.g. passenger service delays, issues with points and signals and anti-social behaviour. There is a "minimum activity criteria" of just three in the driver training (paragraph 72).

³² Sandyford on the 09/06/21.

³³ Sandyford on the 25/07/19; Broombridge on the 21/02/19 and 27/09/19; Red Cow Delta on the 03/07/19; Blackhorse on the 04/10/19 and Dawson Street on the 17/03/19.

Loss of situational awareness

303 In some instances (17%), there was a *loss of situational awareness*, where driver forgot about second signals³⁴; looking at traffic / pedestrian signals³⁵ or, driving against a Stop signal without authorisation³⁶.

³⁴ Red Cow on the 30/03/19, 03/07/19.

³⁵ Blackhall on the 20/05/19 and Sylvan Drive on the 21/05/20.

³⁶ Sandyford 13/04/20 and Blackhorse on the 04/10/19.

Operations

Introduction

304 This report has previously discussed the application of the emergency brake (paragraphs 73 - 77), with conclusions (paragraph 317) and associated safety recommendation (paragraphs 336). This section of the report will discuss the onboard AVLS, inputting the RTS request, LSS & Depot movements.

Onboard AVLS

305 As previously discussed, when a driver is taking a tram into service, the driver must enter the tram service number on the tram's onboard ALVS (paragraph 29) which in turn allows proceed aspects to be given automatically where applicable (paragraphs 28, 30). The driver training includes the inputting of the AVLS as part of the tram preparation task, with a minimum of ten times a driver has to carry out the task prior to being passed competent (paragraph 65 and Figure 7). The driver's competency management does re-enforce that the AVLS should only be programmed when stopped (paragraph 81). The TSI Manual also outlines that the AVLS should be inputting when stationary (paragraph 42). However, this report indicates that drivers are not inputting the AVLS correctly and when moving (paragraph 297).

Inputting the RTS Request

306 Almost a third of the incidents reviewed in this report were incidents of SAS SPAS where the driver had not inputted the RTS request (paragraph 289). There is no DRA, or similar, in the driving cab for the prevention of SAS SPAS incidents (paragraph 290). The TSI Manual repeatedly states that the RTS request must be inputted, while stationary, and, prior to taking traction. There are also information signs throughout the Luas network requesting the RTS to be inputted (paragraph 20), in particular at depot locations (paragraph 157).

LSS & Depot Movements

307 The majority of SPAS incidents occurred at LSS locations (paragraph 284); with Sandyford and Broombridge also being depot locations, along with the Red Cow Depot (not an LSS Location). The TSI Manual, does indicate some generic depot movements (paragraph 47) and movements to be carried out in Sandyford (paragraphs 124, 158 - 160), Broombridge (paragraphs 191 - 192) and Cookstown (paragraph 109), with no specific instructions for the Red Cow Delta (paragraph 219). It appears, the instructions are not robust enough for the movements that are to be carried out at these locations.

Training, competency management & monitoring

308 It has been identified that the majority of SPAS incidents occur at the LSS and depot locations (paragraph 284). In terms of minimum activity criteria, drivers have to perform tram movements (depot moves (10 times) and depot entry and exit (4 times)) i.e. Broombridge, Red Cow and Sandyford Depots; there is no minimum activity criteria for the other LSS locations of Cookstown Interchange and Red Cow Delta.

309 The competency management does include checks for the avoidance of SPAS incidents, such as signal and distraction management (paragraph 81); however, there are no specific requirement for the adoption of error prevention techniques in the management of SPAS incidents.

Post-SPAS incident management

310 The TSI Manual does outline the actions to be taken after a SPAS incident, and where the driver is aware they have been involved in a SPAS, these, as a majority have been carried out (paragraph 267).

311 In terms of the RAIU findings, the RAIU have already identified the need for an SSC (paragraphs 32 - 37, 96); there are two additional key areas for consideration.

312 Firstly in terms of the management of drivers, post-incident, there is a dearth of processes and supervision of drivers, post-incident; drivers can return to driving duties, almost immediately, without any form of ongoing monitoring (paragraph 269 - 271). The RAIU consider this to be an additional observation, AO-07 (paragraph 317) and have made a safety recommendation, Safety Recommendation 2022003-14 (paragraph 340). Although the RAIU note, that drivers can be subject to disciplinary reviews as a result of SPAS incidents (normally related to drivers with a number of incidents).

313 Secondly, the internal investigation process appears to be too generic and a form of “tick-box exercise”, with no real investigation into why the incident occurrences and no review as to why some signals are multi-SPAS signals or a true indication of driver fatigue. TDLR’s primary “blame” is on the driver with no focus on external circumstances (paragraph 272 - 280). The RAIU consider this to be an additional observation, AO-07 (paragraph 317) and have made an additional observation (paragraph 341).

Section 13 – Conclusion

Causal, contributing & systemic factors

314 The RAIU identified three causal factors (i.e. any action, omission, event or condition, or a combination thereof that if corrected, eliminated, or avoided would have prevented the occurrence, in all likelihood) which were applicable to some of these SPAS incidents, namely:

- CaF-01 – Drivers did not input the RTS request for the call for a Proceed aspect (paragraph 306).
- CaF-02 – Drivers, on seeing a Stop signal, did not apply the emergency brake, which may have prevented the tram passing the signal (paragraphs 73 - 77).
- CaF-03 – There is no DRA, or similar, in the driving cab for the avoidance of SAS SPAS incidents (paragraph 290).

315 In terms of contributing factors to why there are SPAS incident, the RAIU found the following in terms of the occurrences of **some** SPAS incidents:

- CoF-01 – There appears to be a link between the occurrence of a SPAS and the LSS (paragraphs 284 - 287) and depot locations (paragraphs 295 - 296), these may be the result of more complex movements which involve approval from LNMC, in particular in Sandyford Depot (paragraph 296); and, being the locations where drivers take their meal breaks (paragraphs 291 - 292).
- CoF-02 – Drivers did not check signals prior to taking traction from a stationary position, resulting in SAS SPAS incidents (paragraphs 288 - 290).
- CoF-03 – Drivers checked the Points Position Indicator (PPI)/ Points instead of the signal aspect (paragraphs 294).
- CoF-04 – Drivers did not input the service files into the AVLS correctly or were inputting while the tram is in motion; resulting in distraction and automatic proceeds not being given, which further resulted in an incorrect expectation of a Proceed aspect (paragraph 297 - 299).

- CoF-05 – Drivers had an incorrect expectation of signals upgrading to proceed on approach (paragraph 300) as a result of:
 - Normally having a proceed at certain locations;
 - Inputting an RTS request and assuming the signal has upgraded (but hasn't);
 - Reading road traffic signals in error;
 - Looking at the movements of other trams.
- CoF-06 – Drivers operating in degraded mode (paragraph 302).
- CoF-07 – Drivers being distracted, preoccupied or losing situational awareness as a result of personal issues, pedestrians, in-cab distractions (AVLS, sun glare), and forgetting signals (paragraphs 301 - 303).

316 Systemic factors to the SPAS incidents were:

- SF-01 – Driver training is deficient in terms of the:
 - Minimum activity criteria related to the LSS Locations (paragraph 286);
 - Training criterion for depot movements (paragraph 308);
 - Understanding of the importance of RTS requests, emergency brake applications and the correct input of the AVLS.
- SF-02 – The TSI Manual is not robust enough in terms of some of the movements to be carried out around depots and LSS locations (paragraph 307); and, the application of emergency brake (paragraphs 73 - 77).
- SF-03 – There were number of instances of driving rule breaks in terms of non-application of the emergency brake (paragraph 73 - 77) and not inputting of the AVLS (paragraphs 297 - 299).

Section 14 – Additional observations

317 The RAIU made eight additional observations, as a result of this investigation, namely:

- AO-01 – TDLR do not refer to the “Stop” aspect as a “Stop” aspect and instead it is referred to as a “Do not Proceed” aspect in the TSI Manual, internal investigation reports, TED recordings, etc. In addition, it does not refer to the “Stop, unless too close to Stop Safely” aspect as a “Stop” aspect, instead it is referred to as a “cluster” in investigation reports, TED recordings and a safety notice. Also, the “Stop, single dot, contact CCR for instruction” aspect is not referred to as a “Stop” aspect, but instead as a “Single dot aspect” (paragraph 72).
- AO-02 – TDLR do not have a formalised SSC; where the positioning of the signal can be examined to see if it was contributory to a SPAS event and where this is the case changes to the asset or its operational context would reduce the likelihood of a further accident or incident occurring, the SSC should recommend what retrospective action is appropriate (paragraphs 32 - 36).
- AO-03 – Drivers are regularly not applying the emergency brake and making a normal braking application on the approach to a Stop aspect, resulting in trams passing the signals; this is mainly as a result of drivers being concerned about possible injuries to passengers as a result of emergency brake applications. The RAIU consider that drivers are over-reliant on the line-of-sight principles rather than obeying the controlling signals. The TSI Manual does not specifically state that drivers should apply the emergency brake to prevent SPAS incidents (paragraphs 73 - 77).
- AO-04 – TDLR do not currently score any of the SPAS events in terms of severity (they are currently classified by type only), therefore there is no means of calculating the likelihood of an accident, its potential consequences or as an indication to the variations of SPAS risk over time (paragraph 86).
- AO-05 – Presently, suspected SPAS incidents can only be detected at LSS locations; resulting in a reliance on driver self-reporting SPAS incidents (paragraph 88).
- AO-06 – Presently, LNMC can see a suspected SPAS event at LSS locations through a visual representation on the LSS mimic; however, there is no audible alarm (paragraphs 88 -89).

Trend investigation into SPAS incidents on the Luas Network

- AO-07 – After a SPAS event, drivers are coached/ re-trained and permitted back to full driving duties, without support (e.g. additional monitoring for a fixed period of time) within days of the incident (paragraph 334).
- AO-08 – The current internal investigation process produces generic reports which do not capture the trends around SPAS incidents, in particular, at multi-SPAS signals; or other specific conditions which may prevent the re-occurrence of a similar SPAS incident (paragraph 313).

Section 15 – Measures taken since the commencement of the RAIU investigation

Measures taken by TII

318 The OTDR on the Luas 402 has a memory capacity corresponding to 350 km. The Luas 401 fleet has recently been upgraded whereby it now records data for a total of 171 km before the memory capacity has reached its maximum. At this point it will then overwrite the data stored on the Personal Computer Memory Card International Association (PCMCIA), thus erasing old data, and replacing it with new. TII conducted carried out a risk assessment “Risk Assessment of the Memory Capacity of the On Tram Data Recorder (OTDR)”, published in September 2022, related to memory capacity of the 401 fleet, in summary, the findings found that the sufficiency of 171 km with respect to the potential for SPAS-related data to not be overwritten is deemed more than adequate in consideration of:

- A tram never being more than circa 20 km from a depot
- A subsequent tram (always within 15 minutes) will note the single-dot signal and report the SPAS;
- A technician to download the data will always be available at the depot;
- The occurrence of unreported SPAS in areas without vehicle detection is low. Luas tram can only proceed through junctions by calling a phase. This can only be done prior to the stop line [at the stop loop or demand loop] or by contacting the LNMC by radio.

319 Speed limits have been adjusted between Belgard Stop to Cookstown Interchange (Outbound) and a further review of speed limits on the network resulting in a limited number speed changes at certain locations, mainly at uncontrolled pedestrian crossing locations (footnote 12, paragraph 106).

320 Contradictory signage has been removed at Cookstown Interchange a full review of signage on the network has been carried out to ensure all signage is correct (footnote 13, paragraph 118).

321 The enhancement of the tram signal in Sandyford and Cookstown LSS has been previously agreed by TII and is a work in progress for TDLR; and involves the change out to improved LEDs.

Measures taken by TDLR

- 322 The TSI Manual is currently under review, with a view to addressing the safety recommendation made in this RAIU report, namely, related to: references to “Stop2 aspects, operating instructions for LSS and depot locations and emergency brake applications.
- 323 Training and competency management processes are in the review process in terms of changes to the TSI Manual and the post-incident management of drivers.
- 324 TDLR reviewing the SRR process.
- 325 TDLR are working with stakeholders for the formalisation of the SCC.
- 326 TDLE have stated that a monthly internal SPAS review meeting now being held to “identify any potential trends and actions to be taken”.

Section 16 – Safety Recommendations

Introduction to safety recommendation

327 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

328 As a result of a number of measures being undertaken by TII and TDLR, there is no requirement for safety recommendations related to:

- OTDRs – as a result of enhanced memory capacity upgrades (paragraphs 318);
- Speed limits – as a result of speed limit adjustments based on a review of speed limits on the network (paragraph 319);
- Signage – as a result of a review of signage on the network (paragraph 320).

Safety recommendations as a result of SPAS incidents

SAS SPAS incidents

329 There is no DRA, or similar, in the driving cab for the avoidance of SAS SPAS incidents, which accounts for almost half the incidents reviewed by the RAIU. As a result, the RAIU make the following safety recommendation to address CaF-03 and CoF-02:

Safety Recommendation 2022003-01

TII should determine if in-cab technological and/or mechanised systems could be introduced to assist drivers with the prevention of SAS SPAS incidents, taking into account requirements for ensuring safety risk is ALARP. Analysis should include an appraisal of available systems and the effect they may have on mitigating sub-standard driver performance.

Depots and LSS Locations

330 In relation to SPAS incidents in depots and LSS locations; consideration should also be given to how verbal instructions are given to drivers from the LNMC, the RAIU make the following safety recommendation to address CoF-01 and SF-02:

Safety Recommendation 2022003-02

TDLR should enhance the TSI Manual operating instructions for all depot and LSS locations based off site-specific risk assessments for the different locations. These enhancements should include step-by-step guidance on how trams are moved at these locations; this should include how verbal permissions are granted by LNMC.

Technical factors

331 In terms of inputting the AVLS, the RAIU also make this safety recommendation in terms of a technical solution to the inputting the AVLS while in motion to address CoF-04, CoF-07, SF-01 and SF-03:

Safety Recommendation 2022003-03

TII should review the technical specification of the onboard AVLS console to see if it is possible to limit the inputting of the AVLS service files to when the tram is stationary; and if so, implement this change.

Human Factors

332 There is a definitive link between SPAS events on the Luas and the timings of scheduled meal breaks; in particular, SPAS events are occurring where drivers are due to take their meal breaks (paragraphs 291 - 292); these may be related to driver fatigue (paragraph 293). In terms of human factors, there are also issues related to incorrect expectation (including reading the PPI and Signal together), distractions and pre-occupation, and, operating in degraded mode. As a result the RAIU make the following safety recommendations to address CaF-02, CoF-01, CoF-03, CoF-05, CoF-07, CoF-06 and AO-07:

Safety Recommendation 2022003-04

TDLR should, with the assistance of a qualified human factors expert, review the timings and locations of SPAS incidents to establish reasons as to why drivers are involved in SPAS incidents at certain times and locations.

Safety Recommendation 2022003-05

TDLR should, with the assistance of a qualified human factors expert, introduce training in relation to error prevention techniques as a tool for drivers to manage distraction, pre-occupation and incorrect expectation.

Driver training

333 In terms of driver training, there is no minimum activity criteria at LSS locations and a very low minimum activity criteria for depot entry and exit (four times), depot moves (ten times) and operating in degraded mode. There are also issues related to checking signals, reading of PPIs, inputting the AVLS and RTS requests. As a result, the RAIU make the following safety recommendation to address CaF-01, CoF-02, CoF-03, CoF-04, CoF-06 and SF-01:

Safety Recommendation 2022003-06

TDLR should review its current training regime with a view to increasing training and competency assessment of drivers, in particular in terms of driving in depots and LSS locations and in degraded mode.

Safety Recommendation 2022003-07

TII should, as part of the increased driver training and competency assessment, consider the introduction of a driver training simulator which would assist in driving training in depots, LSS locations and in degraded mode.

Safety recommendations as a result of additional observations

“Stop” Signal

334 TDLR do not refer to the “Stop” aspect as a “Stop” aspect and instead it is referred to as a “Do not Proceed” aspect in the TSI Manual, internal investigation reports, TED recordings, etc. In addition, it does not refer to the “Stop, unless too close to Stop Safely” aspect as a “Stop” aspect, instead it is referred to as a “cluster” in investigation reports, TED recordings and a safety notice. Also, the “Stop, single dot, contact CCR for instruction” aspect is not referred to as a “Stop” aspect, but instead as a “Single dot aspect” (paragraph 72). As a result, the RAIU make the following safety recommendation to address AO-01 (paragraph 317):

Safety Recommendation 2022003-08

TDLR should ensure that tram signals are referenced correctly in the TDLR suite of documents, this in turn should reinforce, to the drivers, which signals are Stop signals.

Signal Sighting Committee

335 TDLR do not have a formal SSC presently. In terms of SPAS, an SSC can conduct a post-incident Signal Sighting Assessment and make changes to the asset or operational context to reduce the likelihood of a further accident or incident occurring. The RAIU consider that signals should be assessed after a SPAS event and as such make the following safety recommendation to address AO-02 (paragraph 317):

Safety Recommendation 2022003-09

TDLR should establish a formalised SSC, to include stakeholders from the relevant internal and external departments (e.g. TII and local authorities) to ensure that:

- **In the event of a SPAS event an SSC is convened, where appropriate, to determine if any immediate actions can be taken at the signal location which may prevent a SPAS re-occurrence;**
- **Any changes to signalling sequencing (including the introduction of new signals) are carried out as per the relevant SMS procedure to ensure that risks are not inadvertently introduced at signals;**
- **Multi-SPAS signals are reviewed to see if there are any trend to the SPAS incidents;**
- **Previous recommendations, related to SPAS events, from internal investigations have been addressed.**

Emergency Brake Applications

336 One of the causations of SPAS incidents is drivers not applying the emergency brake and making a normal braking application, resulting the tram passing the signal; this is mainly as a result of drivers being concerned about possible injury to passengers as a result of emergency brake applications. The RAIU consider that drivers are over-reliant on the line-of-sight principles rather than obeying the controlling signals. Although, the TSI Manual does not specifically state that drivers should apply the emergency brake to prevent SPAS incidents; the Team Leaders have instructed drivers to apply the emergency brake at all times; meaning the non-application of the emergency brake is a violation of driver instructions (paragraphs 73 - 77). As a result the RAIU make the following safety recommendation to address CaF-02, AO-03, SF-02 and SF-03:

Safety Recommendation 2022003-10

TDLR should update the TSI Manual and training and competency management suite of documents to include clear instructions on when emergency brake applications should be made in relation to the prevention of SPAS incidents; these instructions should be properly communicated to the drivers.

SPAS Risk Ranking

337 Despite the SPAS events being categorised by TDLR, they are not “ranked” in terms of their risk severity. The RAIU consider that risk ranking the SPAS events on the Luas network would give a clearer indication on the severity of the SPAS (likelihood of an accident and its potential consequences) and an indication as to the variations of SPAS risk over time; which, in turn, could be used to allocate resources for investigations. As a result, the RAIU make the following safety recommendation based on AO-04 (paragraph 317):

Safety Recommendation 2022003-11

TDLR should introduced a SPAS risk scoring process for high-risk SPAS events on the Luas network, to ensure that the severity of a SPAS can be measured (best-practice should be applied if available). This scoring process can be used to assess if risks associated with the SPAS conform to TDLR risk acceptance criteria and are ALARP. The scoring process will also ensure that correct system interventions are applied, where required.

SPAS detection

338 Suspected SPAS incidents can only be detected at LSS locations, as a result, the RAIU consider the following safety recommendation is warranted to address additional observation, AO-05 (paragraph 317):

Safety Recommendation 2022003-12

TII should research if technological and/or mechanised systems could be implemented for the entire Luas network to ensure SPAS events are immediately detected, taking into account requirements for ensuring safety risk is ALARP. Analysis should include appraisal of available systems, including systems that report detection of SPAS events to LNMC and to the driver in the cab.

339 In addition, LNMC can see a suspected SPAS event at LSS locations through a visual representation on the LSS mimic; however, there is no audible alarm. The RAIU consider that, given the possible severity of a SPAS events, the following safety recommendation is warranted to address AO-06 (paragraph 317):

Safety Recommendation 2022003-13

TII should evaluate if it is possible to introduce an audible alarm for suspected SPAS incidents at LNMC.

Driver re-training post SPAS

340 After a SPAS incident has been confirmed, drivers are re-training over a period of one-to-two days which normally involves the driver trainer accompanying the driver through the location of the SPAS. Drivers are normally back to full driving duties, without sanction or extra monitoring, within a week of the SPAS event; the RAIU consider that this may be, in part, a reason for drivers being involved in multiple SPAS events (paragraph 312). Therefore, the RAIU consider the following safety recommendation is warranted to address additional observation, AO-07:

Safety Recommendation 2022003-14

TDLR to review and strengthen the current process for the management of drivers post SPAS incident, to ensure drivers skills are further developed (through adequate re-training) and they are supported (through increased monitoring) post SPAS incident.

Internal investigation process

341 The current internal investigation process is ineffective in the prevention of SPAS incidents, with the current system being too generic to capture the trends around SPAS incidents (paragraph 313). The RAIU make the following safety recommendation to address AO-07:

Safety Recommendation 2022003-15

TDLR should develop their internal investigation processes, to develop a:

- **Training and competency management system for internal investigators;**
- **Manual, or similar, outlining internal investigation processes and report writing.**

Section 17 – Additional Information

List of abbreviations

AO	Additional Observation
ALARP	As low as reasonably practicable
AVLS	Automatic Vehicle Location System
CaF	Causal Factor
CCR	Central Control Room
CCTV	Closed Circuit Television
CI	Chief Investigator
CoF	Contributory Factor
CRR	Commission for Railway Regulation
DART	Dublin Area Rapid Transport
DC	Direct Current
DoT	Department of Transport
FFCCTV	Forward-facing closed circuit television
hr	hour
IB	Inbound
km	kilometre
LED	Light emitted detector
LNMC	Luas Network Management Centre
LRT	Light rapid transit
LRV	Light rail vehicle
LSS	Line Signalling System
m	metre
OB	Outbound
OCS	Overhead Catenary System
OTDR	On tram data recorder
PPI	Points Position Indicator
RAIU	Railway Accident Investigation Unit
RTS	Ready to Start
SAS	Start Against Signal
SF	Systemic Factor
SPAD	Signal Passed at Danger
SPAS	Signal Passed at Stop
SMS	Safety Management System
SRR	SPAD risk ranking

SSC	Signal Sighting Committee
TED	Traffic Event Database
TDLR	Transdev Dublin Light Rail
TII	Transport Infrastructure Ireland
TSI	Tramway Safety Instruction
USAN	Urgent Safety Advice Notice
V	Volt

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.
Additional observations	Safety issues identified during the investigation, but without relevance to the conclusions on causes (causal, contributing and systemic) and consequences of the occurrence being investigated.
Article 20 of Directive (EU) 2016/798, Obligation to investigation	<p>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.</p> <p>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:</p> <ul style="list-style-type: none"> (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.
Auto Routing	Automatic route selection whereby the points position change automatically when a tram with a recognised destination code passes over a pre-loop.
Body-catcher	Devices used under the front of the tram to deflect obstacles from the tram tracks.

Brake blending	When two (or more) systems of braking are required to attain a specified level of retardation.
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.
Cascaded speed	Controlled step downs to the permitted speeds to reduce the risk of an over speeding train running onto a portion of line where a considerably lower speed applies.
Central Control Room	Place from which tram operations are managed and monitored.
Closed safety recommendation	The CRR has reviewed a submission (or further submission) and is satisfied that the safety recommendation has been addressed.
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.
Degraded	Anything that disrupts, deviates from, or affects the normal service, including system failure, tram failure, degraded operation, incidents and accidents.
Double Track	Double track where one track is normally used for trams going to the city centre, and the other track for trams going from the city centre.
Electro-dynamic brake	Use of an electric traction motor as a generator when slowing a vehicle.
Emergency Brake	Maximum brake available including the electro-dynamic brake. The emergency brake is applied by the driver when driver puts the master controller to the emergency brake, or automatically when a safety critical function is not met (vigilance device failure, door open/fault, and Emergency Exit handle activation).
Error prevention techniques	Techniques to be used by drivers to manage distraction, refocus their attention and become aware of their surroundings and situation.
Extensive damage	Damage that can be immediately assessed by the RAIU to cost at least EUR 2 million in total.

In advance	An alternative to “beyond”.
Inbound	Trams travelling towards Dublin City.
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.
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
Line-of-sight	A tram should be able to stop, before a reasonably visible stationary obstruction ahead, from the intended speed of operation using the service brake. Taken from SM019Drive at a speed that you always are able to stop your tram comfortably before any hazard that is present or expected, take into consideration weather conditions and visibility.
Load compensation	The function of load compensation adjusts the braking force in accordance with the load, with the objective of maintaining the deceleration rate demand irrespective of load.
Loss of situational awareness	Occurs when inappropriate mental representations are activated in spite of real world evidence.
Master controller	Used to provide traction in the traction zone, apply parking brake in the neutral zone, and apply normal service, maximum service, and emergency brake in the braking zone. This is achieved by moving the device forward or backwards in a horizontal movement. This lever incorporates the vigilance device which is operated by means of a clicking motion.
Northbound	Green Lines trams operating from Brides Glen or Sandyford to Parnell or Broombridge.
Outbound	Trams travelling away from Dublin City.
Points Position Indicator	Shows the positional layout of the points.

SAS SPAS	A SPAS where a stationary train starts against a signal at Stop. This may be at a platform starting signal, or at any other signal at which a train is stopped.
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.
Service brake	The operation of the service brake system shall be under the control of the driver with the following functions: brake the tram in normal service; brake the tram to address line speeds; and, brake the tram to bring the tram to a standstill.
Simulator	A full sized replica of a tram cab which uses computer generated imagery to mimic real-life driving experience, where normal, abnormal and emergency situation can be generated for drivers experience.
Southbound	Green Line trams operating from Broombridge or Parnell to Sandyford or Brides Glen.
Sweep tram	A tram used to validate the line (i.e. which is to check the line is free from obstacles / obstructions) prior to passenger services operating, travelling at a maximum speed of 25 miles kilometres per hour.
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.
Uncontrolled Pedestrian Crossing	Pedestrian crossing locations intersecting the tram line where no traffic control (i.e. traffic signal or stop signs) is present. Tram drivers are not obliged to stop when a proceed tram aspect is displayed, so pedestrians are recommended to wait for a gap in tram traffic and cross only when it is safe to do so.

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Vigilance device	Button operated by holding and releasing for periods of time; if the driver exceeds the times, an alarm will sound and driver must respond, or the emergency brake will be activated.
Westbound	Red Line trams operating from The Point or Connolly to Saggart or Tallaght.

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