Railway Accident Investigation Unit

Ireland

INVESTIGATION REPORT

Tram collision with a bus on O'Connell St

16th September 2009

RAIU Report No: R2013 – 001
Published: 28th February 2013

Report publication

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The original publication details are given below:

Title	Tram collision with a bus on the 16th September 2009
Document type	Investigation Report
Document number	2013-R001
Document issue date	28th February 2013

Where the report has been altered following its original publication, details on the changes are given below:

Revision number	Revision date	Summary of changes

Reader guide

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

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

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

Report preface

The RAIU is an independent investigation unit within the Railway Safety Commission (RSC) which conducts investigations into accidents and incidents on the national railway network, the DART network, the LUAS, heritage and industrial railways in Ireland. Investigations are carried out in accordance with the Railway Safety Directive 2004/49/EC and the Railway Safety Act 2005.

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 safety regulation or the management of safety.

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

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

Report summary

On Wednesday the 16th of September at approximately 14:55 hours a Luas tram, operating on the Red Line Service, travelling from Tallaght to Dublin Connolly collided with a Dublin Bus at the junction of O'Connell Street and Abbey Street.

Twenty-one people, including the driver of the tram, were injured as a result of the collision; three of which sustained serious injuries.

Tram 3002 proceeded through a stop signal at the junction of Abbey Street and O'Connell Street as a bus crossed through the junction on a green traffic signal which resulted in a collision. The immediate cause of this collision was as a result of a lapse in concentration by the tram driver.

The RAIU has made no new safety recommendations as a result of this investigation.

Contents

The occurrence

Summary of the occurrence

1 At approximately 14:55 hours (hrs) on the 16th of September 2009, a Luas Tram number (no.) 3002 travelling *inbound* on Abbey Street (St) from the direction of Tallaght to Connolly Station on the Luas Red Line collided with a Dublin Bus fleet number AV266 which was on the no. 16 service from Ballinteer to Santry. The bus was travelling northbound on O'Connell St at the junction of Abbey St and O'Connell St, see Figure 1.

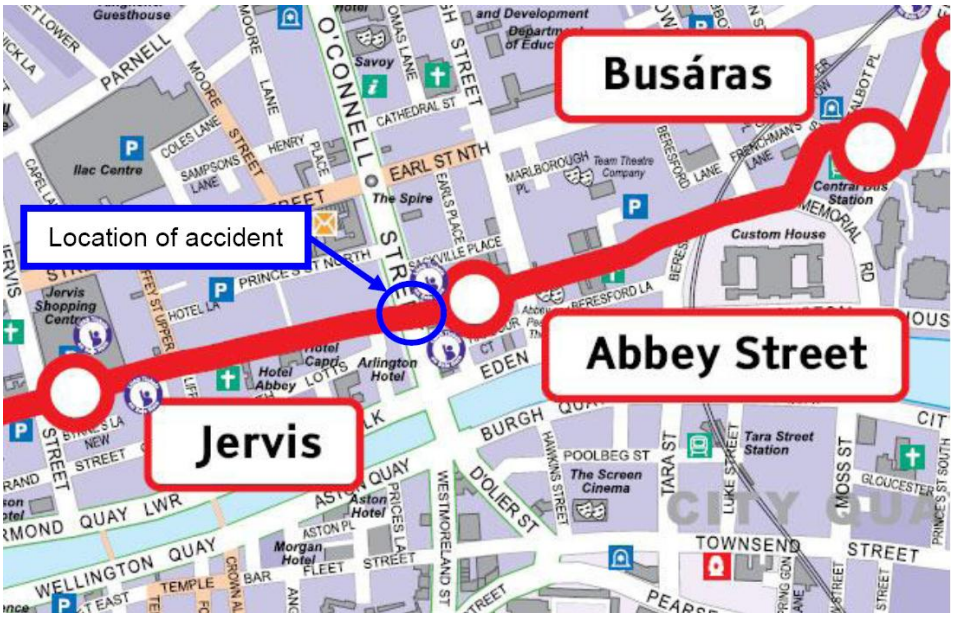

Figure 1 – Location Map

2 The tram had departed the Jervis stop and travelled along Abbey St (on the inbound track), stopping at the signal on the junction with O'Connell St. The tram then moved forward, 0.8 metres (m) before coming to a stop staying behind the tram stop line, and then moved forward again into the junction, see Figure 2 for the junction layout. The tram did not receive a proceed indication for the junction.

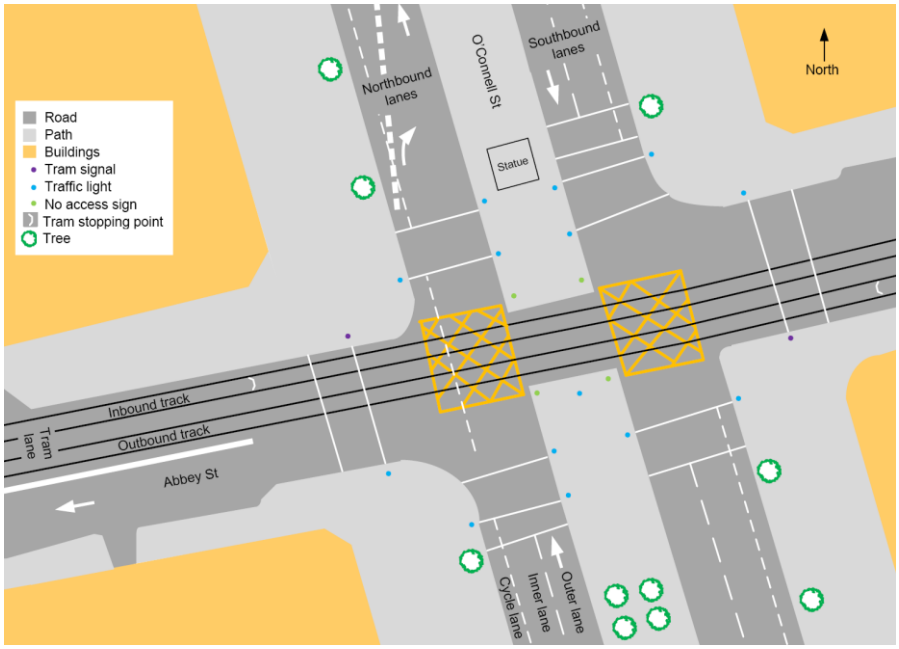

Figure 2 – Junction Layout (not to scale, for illustration only)

3 The bus was travelling along O'Connell St, in a northerly direction and entered the yellow box at the junction with Abbey St at the same time as the tram, see Figure 2. The bus had a green traffic signal displayed before it entered the junction. Another bus was travelling at a slower speed in the inside lane having picked up passengers.

4 The leading driver's cab of the tram impacted the side of the bus just behind the front wheels. The bus was then moved laterally to its right as the tram continued forward and derailed. The driver's cab of the tram penetrated the side of the bus. The front section of the tram bent to its left as the rear of the tram and the bus both continued forwards in their respective directions of travel. The bus mounted the central reservation. The front of the bus collided with a traffic light pole and the right side of the bus collided with a traffic sign pole. Both poles were knocked over. The front of the bus then made contact with a second traffic light pole.

5 The bus came to a stop with its leading right wheel and both rear wheels on the central reservation on the north side of the junction of O'Connell St and Abbey St. The tram came to a stop with the leading driver's cab of the tram protruding into the saloon of the bus. The first section of the tram was bent to the left relative to the rest of the tram at approximately a 15 degree angle to the direction of the tram tracks. The leading bogie was raised off the rails and the bogie under the second section of the tram was also derailed with its wheels resting on the road, see Figure 3 and Figure 4.

Figure 3 – Photograph of final position of vehicles

Figure 4 – Diagram of final position of vehicles

6 A total of twenty-one persons including the driver of the tram were injured. Three persons sustained serious injuries as a result of the crash.

7 There was substantial damage to both the tram and bus.

Description of the railway

Infrastructure

8 At the time of the accident the Luas Red Line was fifteen kilometres (km) in length running from Tallaght to Connolly Station with a total of thirty-five junctions including two pedestrian crossings controlled by traffic lights. The trams operate on a combination of *segregated track*, and *shared running* (where the trams share the road with other road users). Areas that are designated for segregated tram operation are indicated by a white line that separates the area for road vehicles and the area for trams and signs highlighting the tram lane.

9 Abbey St is divided into two sections by O'Connell St, with Abbey St Middle to the west and Abbey St Lower to the east. Trams operate on track segregated from road traffic by a tram lane, Figure 5. Abbey St Middle consists of a tram lane with two sets of tracks for tram operation in both directions and a single road traffic lane that permits travel in a westerly direction, accessing by a left turn from the northbound side of O'Connell St.

Figure 5 – Abbey Street Middle

10 In the city centre, and at Abbey Street Middle, the trams operate on embedded track that is level with the road surface, see Figure 5.

11 O'Connell St is a main arterial route and consists of a northbound and a southbound carriageway divided by a central reservation, each carriageway comprises of two traffic lanes and a cycle lane. There are yellow boxes marked on the road at the junction of Abbey St and O'Connell St to prevent road vehicles from stopping on the junction and blocking the tram route. Trams cross O'Connell St through a break in the central reservation. Signs are positioned at the central reservation prohibiting access for road vehicles across the central reservation.

Rolling Stock

12 Tram 3002 is an extended Citadis 301 light rail vehicle manufactured by Alstom Transport. It has a mass of 49,616 kilograms (kg) and is 40.813 m long. The tram is a bi-directional vehicle with driving cabs at both ends. This design was presented to the interim Railway Safety Commission for acceptance on the 14th October 2004 in accordance with the Transport (Railway Infrastructure) Act 2001 and the Railway Safety Bill 2001.

13 The maximum acceleration rate of the tram is 1.13 m/s^2. The full service braking rate of the tram between 1.61 and 1.7 m/s^2 with a brake response time of approximately 0.8 s. The emergency braking rate of the tram is between 3.08 and 3.33 m/s^2 with a brake response time of approximately 0.6 s.

14 The tram is fitted with a Tachometer which is an on board computer that monitors the state of certain functions and the time they occur, the speed of the tram in kilometres per hour (km/h) when they occur and the distance travelled by the tram within a tolerance of 2m. The Tachometer is used as an event recorder which primarily measures speed and driving behaviour in the event of an incident or accident.

15 The driving cab of the trams is primarily made up of non-structural elements, see Figure 6.

16 The upper part of the driving cab is designed to allow the tram driver visibility of the operating environment, to house the driving controls and to protect the driver as well as the equipment from the weather and road debris.

17 The lower part of the cab is primarily made up of a structural underframe and energy absorbing elements designed to withstand low speed collisions.

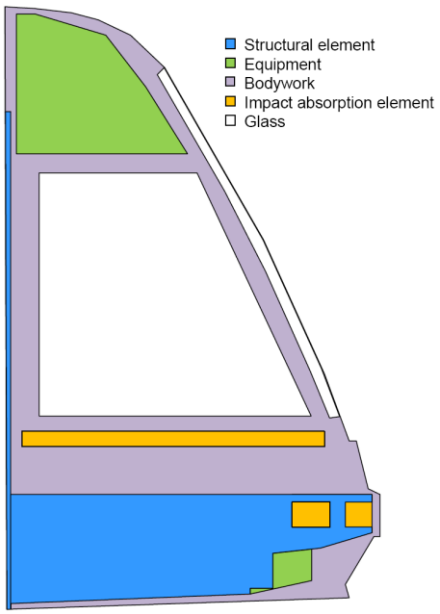

Figure 6 – Front end cab design

General operations

18 Trams are driven on track by 'line of sight driving', where the driver is responsible for maintaining "sufficient distance from trams ahead or any vehicles or pedestrians on the track so he can stop the tram without colliding" (Veolia, Tramway Safety Instruction Manual, 2007).

19 Tram operations are managed by the Central Control Room (CCR), which is located at the Red Cow Depot. It is equipped with a number of systems including, CCTV screens which monitor tram stops, road junctions and some other key areas and consoles to allow monitoring and control of the Automatic Vehicle Location System (AVLS) and the power supply for Luas. This allows for the safe monitoring and management of the system.

20 The maximum permitted speed for tram movements across O'Connell St at the time of the accident was 30 km/h. The speed of the tram is controlled by the tram driver through a master controller positioned on the left side of the driving cab console, see Figure 7.

Figure 7 – Driving console with close up of master controller

Signalling and communications

21 Tram movements 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 emitted diodes (LEDs) which are lit according to the type of signal to be displayed, this is either horizontal, vertical or diagonal lines or a central cluster (see Figure 8). These aspects are in line with Statutory Instrument no. 97/2003- Road Traffic (Signs Amendment) Regulations 2003.

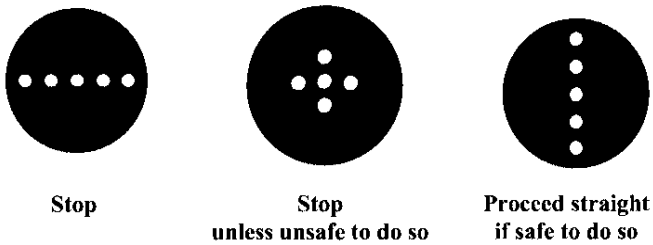

Figure 8 – Tram signal aspects

22 Communication between tram drivers and the CCR is over a secure digital radio system (Tetra) either via a portable handheld radio or in the cab. These allow one to one communication with CCR and also allow CCR to transmit messages to all drivers in a given area. In the event of an emergency tram drivers can press an emergency call button on the hand held radio. There is also an emergency radio foot-pedal in the cab that triggers an alarm in CCR and automatically opens a channel between CCR and the tram driver. A specific 'Emergency Protocol' is in place and all divers are trained in its use; these calls are given absolute priority in CCR.

Description of the bus

23 The bus involved in the collision was a Volvo B7LDD, Fleet number AV 266, the vehicle body was constructed by Walter Alexander (Belfast) Limited on a Volvo chassis and running gear. It has a mass of 12,000 kg and is 10.6m long.

24 The bus was fitted with eight internal and external CCTV cameras. The forward facing camera on the bus was not functioning at the time of the accident.

25 The bus was travelling in the outside lane, at a speed of 21.56 km/h.

26 The design of the bus is in accordance with European directive 2001/85/EC, the bus comprises of a Volvo chassis onto which an aluminium superstructure is fitted, the design of this is agreed by the customer Dublin Bus and manufacturer Walter Alexander Ltd.

27 This type of construction is the norm since the mid 1950s when first introduced on the London Routemaster bus. Aluminium superstructure buses were first introduced by Dublin Bus in 1990, all previous designs had a steel superstructure.

Fatalities, injuries and material damage

Fatalities and injuries

28 There were no fatalities as a result of this accident. On the tram, the tram driver was injured suffering concussion and abrasions, no passengers on the tram were hospitalised. Twenty-one people travelling on the bus were hospitalised, of which three people suffered serious injuries.

Material damage

29 The tram sustained severe frontal damage, with the cab and sub frame having to be replaced. Although the tram derailed, there was no significant damage to the infrastructure.

30 Substantial damage was caused to the middle nearside directly behind the wheel arch of the bus as a result of the front of the tram first making contact with the wheel arch, and as the bus moved forward, the tram penetrated the aluminium skin of the bus. The tram also slid up and over the side outrigger of the bus impacting into the passenger compartment of the bus.

31 Two traffic light poles and a road traffic directional sign pole were damaged as a result of the collision.

Parties and roles involved in the occurrence

Parties involved in the occurrence

32 Veolia Transport Dublin Light Rail Ltd. operates the Luas light rail tram system in Dublin, they are the Duty holder as defined in the Railway Safety Act 2005.

33 Alstom Ireland Limited are contracted to maintain the Luas vehicles and Alstrom Ireland Limited and Dalkia are jointly contracted to maintain the Infrastructure.

34 Dublin Bus is a licensed bus company that owns and operates public bus services in the greater Dublin area.

35 The roles involved in the occurrence are:

- Tram driver – A Veolia employed, passed as competent to drive trams on the 15th December 2005, who was driving the tram at the time of the accident;
- Bus driver – A Dublin Bus employee, fully licensed to drive the double decker bus, who was driving the bus at the time of the accident.

Other relevant parties

36 Railway Procurement Agency (RPA) is the Irish State body that provides the rolling stock and infrastructure required for the Luas light rail network.

37 Dublin City Council (DCC) is the Irish state body responsible for the management of local services within Dublin city centre, including the traffic light system.

External Circumstances

38 The weather at the time of the accident was bright, fine and sunny. Met Éireann recorded a dry day with maximum temperature of 11.4 degrees Celsius (°C).

RAIU Investigation

RAIU decision to investigate

39 In accordance with the Railway Safety Act 2005 the RAIU investigate all serious accidents. Given the number of injuries and extent of material damage as a result of this occurrence, the RAIU made the decision to investigate; as, under slightly different conditions this occurrence may have led to a fatality and more serious injuries resulting in a serious accident classification. Also, as a result of disruption to Dublin City Centre infrastructure, a decision to investigate was made under article 19 (2) of the European Railway Safety Directive (EC, 2004).

Scope of investigation

40 The RAIU must establish the scope of the investigation to ensure that only pertinent information is recovered and reviewed. Therefore, for this occurrence, the RAIU have defined the following scope:

- Establish the sequence of events;
- Establish the immediate cause, contributory factors and underlying causes;
- Examination of the relevant elements of the safety case;
- Examination of the pertinent information available from the relevant parties and third parties;
- Examination of any other significant safety deficiencies identified as a result of this investigation.

Investigation and evidence

41 The RAIU was notified of the accident at 15:15 hrs on 16th September 2009 and immediately mobilised to the site of the occurrence to conduct an on-site investigation. During the on-site and off-site investigation the RAIU collated and logged the following evidence:

- Photographic record of occurrence site;
- In-situ surveys for positioning of infrastructure and rolling stock;
- Witness testimonies from parties involved in the occurrence;
- Other testimonies from members of Veolia staff with information pertaining to the occurrence;
- Inspection and maintenance records for inspections carried out on the infrastructure;
- Veolia standards, procedures and other documentation;

- Standards, procedures and documentation from other relevant bodies (e.g. Road Traffic (Signs Amendment) Regulations 2003);
- DCC signal maintenance records,
- Data from the tachometer;
- Footage from various sources of closed circuit television (CCTV);
- Results from simulations conducted by the RAIU.

Delayed publication of the investigation report

42 On the 5th June 2010 the RAIU were informed that the driver of the tram was charged with driving offences under the Road Traffic Act (1961) and offences in contravention of the Railway Safety Act (2005).

43 The RAIU subsequently suspended their investigation until the conclusion of the Judicial Process so as not to potentially prejudice the ongoing prosecution.

44 It should be noted that although the RAIU suspended their investigation, an initial Preliminary Examination Report was conducted by the RAIU. This did not identify any safety deficiencies that required the issuing of interim safety recommendations.

45 On the 1st May 2012, after the Criminal proceedings the RAIU requested from the DPP any further evidence in possession of An Garda Síochána. This request was granted on the 27th September 2012 and the RAIU reopened their safety investigation.

Evidence

Automatic Vehicle Location System (AVLS)

46 Antennae positioned under the tram driving cabs transmit signals to AVLS loops embedded in the road. 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. The AVLS operates by electrical induction with the antenna transmitting requests to the AVLS loops.

47 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 tram driver by pressing the Ready To Start (RTS) button on the AVLS controls in the drivers cab;
- When requested by CCR via the AVLS system;
- When requested by the relevant Local Authority Traffic Control Centre.

48 Should a tram fail to receive a proceed aspect, either automatically or after manual RTS request by the driver, the tram 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.

49 AVLS in-track induction loops are used as tram detectors on approaching and clearing a junction. Typically there are three tram detection loops on the approach to a junction, Prepare, Demand and Stop, see Figure 9. Additionally, a clear detector is located on the exit of the junction activation of the clear loop by the tram indicates that the tram has passed through the junction and allows the signals move onto the next signal phase.

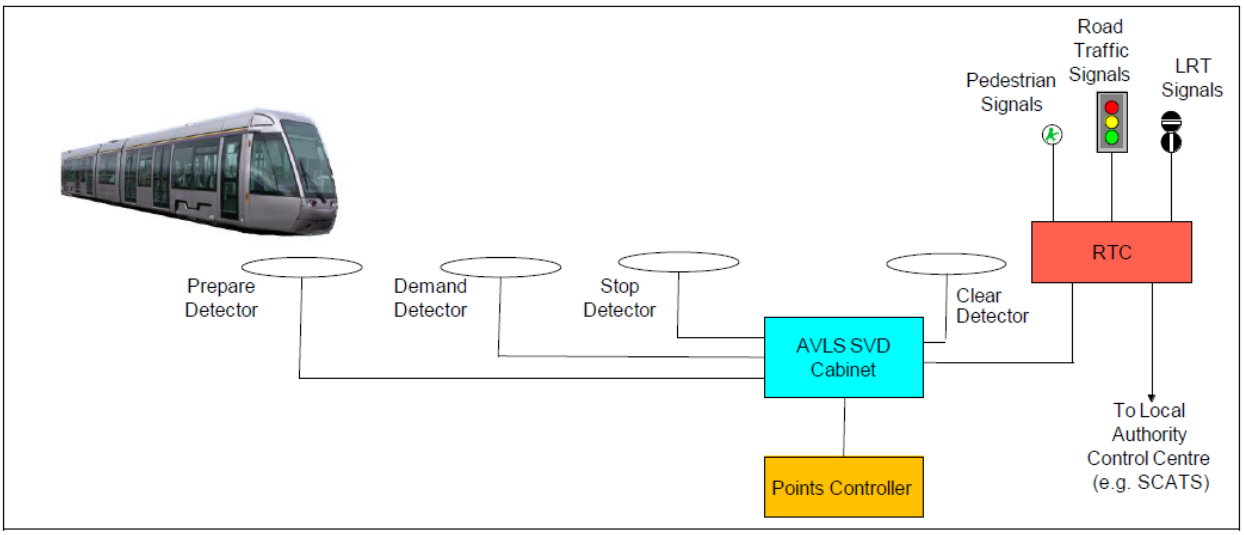

Figure 9 – Schematic of AVLS

50 The standard layout for tram signals is applied at the junction, a tram signal is provided 5m beyond the tram stop line, a detector loop is positioned 175m in advance of the tram stop line. This allows for the tram signal to be demanded in advance of the junction and allow a clear passage through the junction traffic permitting. During the RAIU investigation, no faults were found with the AVLS.

51 In a reconstruction done after the accident it was demonstrated the driver would have had a clear and unobstructed view of the signal at the junction both when the tram stopped initially and after moving forward before proceeding into the junction.

AVLS and road traffic light system interface

52 The AVLS is interfaced with the Local Authority's traffic light system at road junctions. This allows the presence of a tram to be detected by the traffic light system and the tram movement to be inserted into the traffic light sequence. The AVLS system communicates with a traffic light system junction controller notifying the traffic light system of the presence of the tram and the request for a proceed aspect.

53 Priority at junctions is negotiated with Local Authorities on a junction by junction basis and a default priority level is applied on a junction to junction basis by the relevant Local Authority Traffic Control Centre.

54 At high priority (Priority Level 3) junctions an AVLS loop positioned on the approach to the junction allows a tram be detected and inserted into the traffic light sequence in time for the tram

to receive a proceed aspect as it reaches the junction, allowing the tram to proceed across the junction without stopping.ie the junction allows the tram to be detected.

55 The junction of O'Connell St and Abbey St is controlled by DCC Urban Traffic Light System. A high priority level is applied to trams during overnight hours (7pm to 7am), and a medium priority level is applied during daytime hours (7am to 7pm). Trams do not have priority at the junction of O'Connell St. and Abbey St. And therefore do not cross the junction systematically without stopping, however depending on the signal timing phase and priority some trams may get a rolling proceed. This was not the case at the time of the accident. Trams are signalled across O'Connell St in the inbound and *outbound* directions separately. The traffic signal aspect sequence for O'Connell St junction when a tram is present is shown simplified in Figure 10.

Time (Duration of phase)	Tram	Road traffic	Pedestrians
47 s	Stop	Green then amber	Red
6 s	Stop	Red	Red
26 s	Proceed	Red	Red
25 s	Stop	Red	Green then amber

Figure 10 – O'Connell St junction traffic signal sequence

56 A typical Luas junction will run a 120 s cycle, this is divided to allocate time to each road, pedestrian and tram phase. The pedestrian and tram phase will only run if demanded, and when not running the time is divided between the road phases. Inbound and outbound trams are considered as separate movements by the Traffic Controller and only run in parallel if certain conditions are met.

57 When a tram is stationary at a junction, the tram driver's occasionally make a small movement to adjust the position of the tram over an AVLS loop to make sure the presence of the tram is detected due to slight variations in the sensitivity of the loops.

58 During the investigation no faults were found with the traffic light management system, or its interface with AVLS.

Tram Driver operation and competency

59 The tram driver has been fully qualified since 15th December 2005. After an extended period of nine months sick leave he was retrained in the basic driver training programme and was re-certified competent to drive on the 3rd of April 2007, which is standard Veolia procedure.

60 The driver's records show that he was assessed bi-annually, In addition, the driver was line monitored whilst on service eleven times since the start of 2008. In all assessments the driver was found to be competent to perform driving duties on the network.

61 The tram driver was previously involved in two minor road traffic accidents:

- 15th August 2008 – a car drove out of Arnott's car park onto Abbey St and collided with the tram, no blame was attributed to the tram driver;
- 5th March 2006 – a cyclist tried to cross a pedestrian crossing in front of the tram and struck the tram, no blame was attributed to the tram driver.

62 Veolia monitor and manage tram signals that are passed at stop, drivers and or Central Control are required to report any stop signals passed without authorisation; additionally any reports by other drivers or the public are investigated each of these incidents is investigated to establish the cause, and prevent a future occurrence if possible.

Events preceding the occurrence

63 The last scheduled 10,000 km examination, on Tram 3002, was undertaken on the 21st of August 2009 there were no problems encountered during either of this examination and no faults had been reported on the vehicle during its operation.

64 Trams undergo a pre-service check on a daily basis between midnight and entering service, which includes general functionality of the safety systems, traction system, driver aids and passenger comfort items. Tram 3002 was subject to a pre-service maintenance inspection on the evening of 15th September before entering service on the morning of the 16th.September 2009. No issues were found during this inspection. Pre service examinations are valid for 24 hrs.

65 Figure 11 illustrates the tram driver's shift pattern for the week prior to the accident.

Date	Duty periods
10th September 2009	Rest Day
11th September 2009	15:00 – 00:00 hrs
12th September 2009	12:07 – 20:12 hrs
13th September 2009	11:27 – 19:37 hrs
14th September 2009	Rest Day
15th September 2009	09:00 – 17:51 hrs
16th September 2009	07:26 – 15:43 hrs

Figure 11 – Tram driver's shift pattern

66 On the morning of 16th September 2009 the driver commenced duty at 07:26 hrs. The tram driver had his last refreshment break at 12:10 hrs for a period of 58 minutes (which was 2 hrs 45 minutes before the collision). The tram driver was due to finish duty at 15:43 hrs, with the Tallaght to Connolly return route was the final duty for the driver on the day.

Events during the occurrence

67 CCTV images taken, illustrated the events during the occurrence and aspect of signal at each stage, these are illustrated in Figure 12.

Tram stops at the stop line and remains at this point for 44 s. Tram aspect showing 'Stop'.

The tram moves forward a distance of 0.8m and remains here for a further 21 s. Tram aspect remains at 'Stop'.

The tram then moves across the junction. Tram aspect remains at 'Stop'.

Bus enters the junction as the tram moves through the signal. Tram aspect remains at 'Stop'.

Tram impacts with the bus as it travels through the junction. Tram aspect remains at 'Stop'.

Tram derails and bus is pushed across the junction. Tram aspect remains at 'Stop'.

Figure 12 – CCTV images of events during the occurrence

68 From the tachometer data it can be seen that the tram stopped before the junction for 44 s, then moved forwards 0.8 m before stopping for a further 21 s. The tram then moved forwards, entering the junction, sounded the horn for 1 s and applied the emergency brake at a speed of 19 km/h. It should be noted, that as the tram was reacting to the tram driver's brake application the speed briefly increased to a maximum of 20 km/h. The tram decelerated to a speed of 17 km/h prior to the collision. The distance travelled, after the brake application, was approximately 22m. The outputs from the tachometer are illustrated in Figure 13 (distances are approximate values).

Event	Time elapsed	Tram speed	Distance travelled
Tram stops, master controller in braking position	0 s	0 km/h	0 m
Master controller moved to neutral position	36 s	0 km/h	0 m
Master controller moved to acceleration position	41 s	0 km/h	0 m
Tram moves, master controller moved to neutral position	44 s	1 km/h	2 m
Tram stops	46 s	0 km/h	2 m
Master controller moved to acceleration position	64 s	0km/h	2 m
Tram moves	67 s	7 km/h	4 m
Master controller moved to braking position, horn sounded	70 s	19 km/h	14 m
Maximum speed reached	70 s	20 km/h	16 m
Master controller moved to neutral position	71 s	17 km/h	20 m
Emergency brake applied, master controller position undefined	72 s	-	20 m
Master controller in emergency braking position	72 s	11 km/h	22 m
Tram stops, master controller in emergency braking position	73 s	0 km/h	24 m
Master controller moved to acceleration position	73 s	0km/h	24 m
Master controller moved to neutral position	74 s	0km/h	24 m
Master controller moved to braking position	110 s	0km/h	24 m
Master controller moved to emergency braking position	110 s	0km/h	24 m
Master controller moved to braking position	131 s	0km/h	24 m
Driver's cab taken out of service	139 s	0km/h	24 m
Tram shut down	141 s	0km/h	24 m

Figure 13 – Tachometer download

Note: Although the tachometer recorded a forward movement of approximately 2m, this is not a precise measured distance as the tachometer is fitted with a memory system which is updated every 0.25m it is only recorded every 2 m this is due to the amount of memory available on this model of tram. In accident investigation the tachometer is primarily used as a record of speed and other functions and the exact location of a tram has to be corroborated by physical evidence. A scene reconstruction found that the actual distance covered by the tram in its initial movement was a distance of 0.8 m and a detailed examination of CCTV footage corroborates the tachometer timings.

69 At 14:55 the tram drove through the stop aspect and began to proceed into the junction; at the same time as the bus driver had a green traffic signal to enter the junction.

Events after the occurrence

70 The Emergency Services were contacted immediately by CCR and were on scene within a few minutes and the immediate area was cordoned off by An Garda Síochána to facilitate the rescue of injured and commence their investigation.

71 Full service was restored to the Luas Red line at 21:26 hrs on the 17th September 2009, following a comprehensive testing of the infrastructure and signalling.

Similar occurrences

72 The number of road traffic accidents involving trams has been monitored since the opening of the Green Line on the 30th of June 2004. The total number of road traffic accidents is 151, of these two occurred at the Junction of Abbey St and O'Connell St (less than 2%). There have been two previous collisions between trams and road vehicles at the junction of Abbey Street and O'Connell Street since the Luas Red Line opened in September 2004:

- 25th July 2005 – a car collided with the side of the leading cab of a tram, no blame was attributed to the tram driver as a result of this accident;
- 22nd May 2009 – a non articulated goods vehicle collided with a tram, no blame was attributed to the tram driver as a result of this accident.

Analysis

Rolling Stock

73 Tram 3002 was subject to a detailed examination of all safety critical components after the accident, with and no faults or defects were found.

AVLS

74 Paragraphs 46 to 50 describe the AVLS. The AVLS operated as expected. Paragraph 68 discusses the actions of the driver, according to the tachometer, showing the initial stopping of the tram, and the subsequent movement of the tram by 0.8 m. This suggests that the driver was attempting to activate the AVLS loop (discussed in paragraph 47), which was a driving practice adopted by drivers to activate a proceed signal. However the aspect did not change as the road traffic indication was already displaying a green indication for the bus.

AVLS and road traffic light system interface

75 Paragraphs 52 to 58 describe the interface of the AVLS and the road traffic light system. There were no faults found with the road traffic light system or its interface with the AVLS. All signal indications were correctly displayed in the proper sequence i.e. the tram aspect remained as 'Stop' when the road traffic signal displayed a green indication.

Tram driver operations and competency

76 Paragraphs 59 and 60 illustrate that the tram driver was competent to drive trams at the time of the accident and had been subject to routine assessment as per Veolia's standards.

77 Paragraphs 65 and 66 discusses the shift pattern and rest periods on the day of the accident. Analysis of this evidence indicates that fatigue did not contribute to the accident.

78 Paragraph 51 demonstrates that the driver had a clear and unobstructed view at the time of the accident.

Conclusions

AVLS

79 As there were no faults found in the AVLS and it operated as expected it can be concluded that the AVLS did not contribute to the occurrence (paragraph 74).

AVLS and road traffic light system interface

80 There were no faults found in the road traffic light system and its interface with the AVLS. The system operated as expected. The tram signal displayed a 'Stop' aspect when a green indication was displayed for road traffic (paragraph 75).

Tram Driver operation and competency

81 As a 'Stop' aspect was displayed for the tram and it was demonstrated during reconstruction that the tram driver had a clear and unobstructed view of the signal aspect, it can be concluded that the tram driver initiated the movement of the tram through the junction without a proceed signal (paragraph 78). There was no evidence to indicate that this was a premeditated action and therefore it has been concluded that this was as a result of lapse in concentration. This is also supported by the tram driver's actions in applying the emergency brake before the collision.

82 The Tram Drivers shift pattern did not contribute towards any issue of fatigue (paragraph 77).

Immediate cause, causal factors, contributory factors and underlying factors

83 Tram 3002 proceeded through a stop signal at the junction of Abbey Street and O'Connell Street as a bus crossed through the junction on a green traffic signal which resulted in a collision. The immediate cause of this collision was as a result of a lapse in concentration by the tram driver.

Relevant actions taken or in progress

Veolia

84 As of the 3rd December 2012, Veolia had advised that a number of actions have been taken since the accident.

85 In relation to training, the following actions were taken:

- Use of real case accidents to increase awareness and understanding of consequence were introduced to the drivers' training;
- A new training model has been built and is being used in Driver Refresher Training;
- The Tramway Safety Instruction Manual has been updated and revised;
- Retraining of drivers with key statistics and Luas accidents;
- The driver 'Route Knowledge DVD' has been updated.

86 In relation to monitoring, junction monitoring using CCTV and supervising personnel to measure compliance, has been increased.

87 In relation to design, the following actions were taken:

- Tram front facing cameras have been retrofitted to 401 (Red Line) trams to monitor SPAD and increase understanding and awareness of potential issues;
- All CCR operating systems have been upgraded;
- Smart Board technology has been installed in CCR.

88 In relation to post accident management, an Employee Assistance Program process has been enhanced with an increase of counselling days to manage post accident psychological trauma.

Railway Procurement Agency

89 After the accident the RPA established, with Veolia Transdev, a working group to carry out a review on the Luas systems. The Luas systems review included: the tram signalling system, the road crossing signalling system and the AVLS at the O'Connell St and Abbey St junction and the tram tachometer.

Safety recommendations

General description

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

91 As a result of the RAIU investigation, no safety recommendations have been made in relation to the occurrence.

Additional information

List of abbreviations

°C	Degrees Celcius
AVLS	Automatic Vehicle Location System
CCR	Central Control Room
CCTV	Closed Circuit Television
CoF	Contributory factor
DCC	Dublin City Council
Hrs	Hours
Kg	Kilogram
km/h	Kilometres per hour
LED	Light emitting diode
m	Metre
No.	Number
RAIU	Railway Accident Investigation Unit
RSC	Railway Safety Commission
s	Second
SI Units	International System of Units
St	Street
UF	Underlying factor

Glossary of terms

Accident	An unwanted or unintended sudden event or a specific chain of such events which have harmful consequences including collisions, derailments, level-crossing accidents, accidents to persons caused by rolling stock in motion, fires and others.
Causal factors	Any factor(s) necessary for an occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.
Contributory factor	Any factor(s) that affects, sustains or exacerbates the outcome of an occurrence. Eliminating one or more of these factor(s) would not have prevented the occurrence but their presence made it more likely, or changed the outcome.
Extensive damage	Damage that can be immediately assessed by the RAIU to cost at least €2,000,000 in total.

Immediate cause	The situation, event or behaviour that directly results in the occurrence.
Inbound	Travel of trams towards the city.
Incident	Any occurrence, other than an accident or serious accident, associated with the operation of trains and affecting the safety of operation.
Lapse	A temporary failure of concentration, memory or judgement.
On Train Data Recorder	A device fitted to trains to store key train parameters and train driver actions.
Segerated Running	Tram has a segregated right of way.
Shared Running	Where trams share the road with other road users
Outbound	Travel of trams away from city.
Serious accident	Any train collision or derailment of trains, resulting in the death of at least one person or serious injuries to 5 or more persons or extensive damage to rolling stock, the infrastructure or the environment, and any other similar accident with an obvious impact on railway safety regulation or the management of safety, where extensive damage means damage that can be immediately assessed by the RAIU to cost at least €2,000,000 in total.
Serious injury	Any injury requiring hospitalisation for over 24 hours.
Underlying factor	Any factor(s) associated with the overall management systems, organisational arrangements or the regulatory structure.

References

European Union (2004), Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004 on safety on the Community's railways and amending Council Directive 95/18/EC on the licensing of railway undertakings and Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification (Railway Safety Directive), 2004/49/EC, 29th April 2004.

Veolia Transport Ireland (2007), Tramway Safety Manual Instruction Manual.