Office of Transport Safety Investigations

BUS SAFETY REPORT

BUS FIRES IN NEW SOUTH WALES IN 2020

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THE OFFICE OF TRANSPORT SAFETY INVESTIGATIONS

The Office of Transport Safety Investigations (OTSI) is an independent NSW agency whose purpose is to improve transport safety through the investigation of incidents and accidents in the rail, bus and ferry industries. OTSI investigations are independent of regulatory, operator or other external entities.

Established on 1 January 2004 by the *Transport Administration Act 1988 (NSW)*, and confirmed by amending legislation as an independent statutory office on 1 July 2005, OTSI is responsible for determining the contributing factors of accidents and to make recommendations for the implementation of remedial safety action to prevent recurrence. Importantly, however, OTSI does not confine itself to the consideration of just those matters that contributed to a particular accident; it also seeks to identify any transport safety matters which, if left unaddressed, might contribute to other accidents.

OTSI's investigations are conducted under powers conferred by the *Transport Administration Act 1988 (NSW)* and *Passenger Transport Act 2014 (NSW).* Additionally, all OTSI publications that are considered investigation reports are also conferred by these Acts. OTSI investigators normally seek to obtain information cooperatively when conducting an accident investigation. However, where it is necessary to do so, OTSI investigators may exercise statutory powers to interview persons, enter premises and examine and retain physical and documentary evidence.

It is not within OTSI's jurisdiction, nor an object of its investigations, to apportion blame or determine liability. At all times, OTSI's investigation reports strive to reflect our balanced approach to the investigation, in a manner that properly explains what happened, and why, in a fair and unbiased manner.

Once OTSI has completed an investigation, its report is provided to the NSW Minister for Transport and Roads for tabling in Parliament. The Minister is required to table the report in both Houses of the NSW Parliament within seven days of receiving it. Following tabling, the report is published on OTSI's website at www.otsi.nsw.gov.au.

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There were 73 fire and thermal incidents reported to OTSI in 2020. This represented a 34% decrease from 2019. There were seven fire incidents in 2020.

There was a significant decrease in thermal events from 110 in 2019 to 66 in 2020. In 2020 no passengers or staff were injured resulting from bus fires or related events.

There was a significant decrease in the severity of damage to vehicles, with no buses destroyed in 2020 compared to four in 2019. The number of buses with major damage, one incident, has remained the same as 2019. It was likely that one bus was saved from major damage by the activation of the engine bay fire suppression (EBFS) system.

All NSW buses under Transport for New South Wales (TfNSW) metropolitan and outer metropolitan contract are now fitted with engine bay fire suppression systems. All future buses supplied under these contracts will be delivered with EBFS systems. Non-contracted buses are not required to be fitted with EBFS systems; these buses are also accredited by TfNSW.

BUS FIRES IN NEW SOUTH WALES IN 2020

Introduction

In June 2013, the Office of Transport Safety Investigations (OTSI) released an investigation report into common safety-related issues revealed through the examination of the nature and circumstances of bus fires from 2005 to 2012.[1] This was followed by annual reports from 2013 to the present.[2] This is the eighth such annual report.

Monitoring of the extent, origins and causes of bus fires reported to OTSI continued through 2020 and resulted in the publication of this report in January 2021.

In line with previous years, all reported fires were documented and included incidents which did not progress to a fire but had involved excessive heat and the generation of smoke. The reports were assessed and grouped into two categories: fire incidents and thermal incidents.[3]

In most cases, the origin and cause of the incident was readily identifiable and did not require an in-depth investigation.

This report contains a summary of the information gathered in 2020 and provides commentary on comparisons with the information reported in previous years. The report also summarises the implementation progress of recommendations made in previous reports.

Data for this report originated from information provided by operators and Transport for New South Wales (TfNSW), using the same methodology used for recording occurrences in the previous years.

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1 OTSI Bus Safety Investigation Report, *An Investigation into Bus Fires in NSW 2005 – 2012*.

2 All OTSI investigation reports are available at www.otsi.nsw.gov.au

3 Fire incident: Visible fire seen by driver, passengers or witnesses. Fire or flames are reported and flaming combustion has occurred (Rapid oxidation of gases and vapours that generate detectable heat and light). The level of damage was such that it was likely that an actual fire occurred.
Thermal incident: No mention of fire or flames seen by driver, passengers or witnesses. An excessive heat event, possibly accompanied by smoke. A likely precursor to a fire.

Data analysis

In 2020 there were a total of 73 reported incidents: seven fire incidents and 66 thermal incidents. This was a 34% decrease in total incidents from 2019 (Figure 1).

There was a significant decrease in thermal events, destroyed buses and reduction in the risk of injury to passengers.

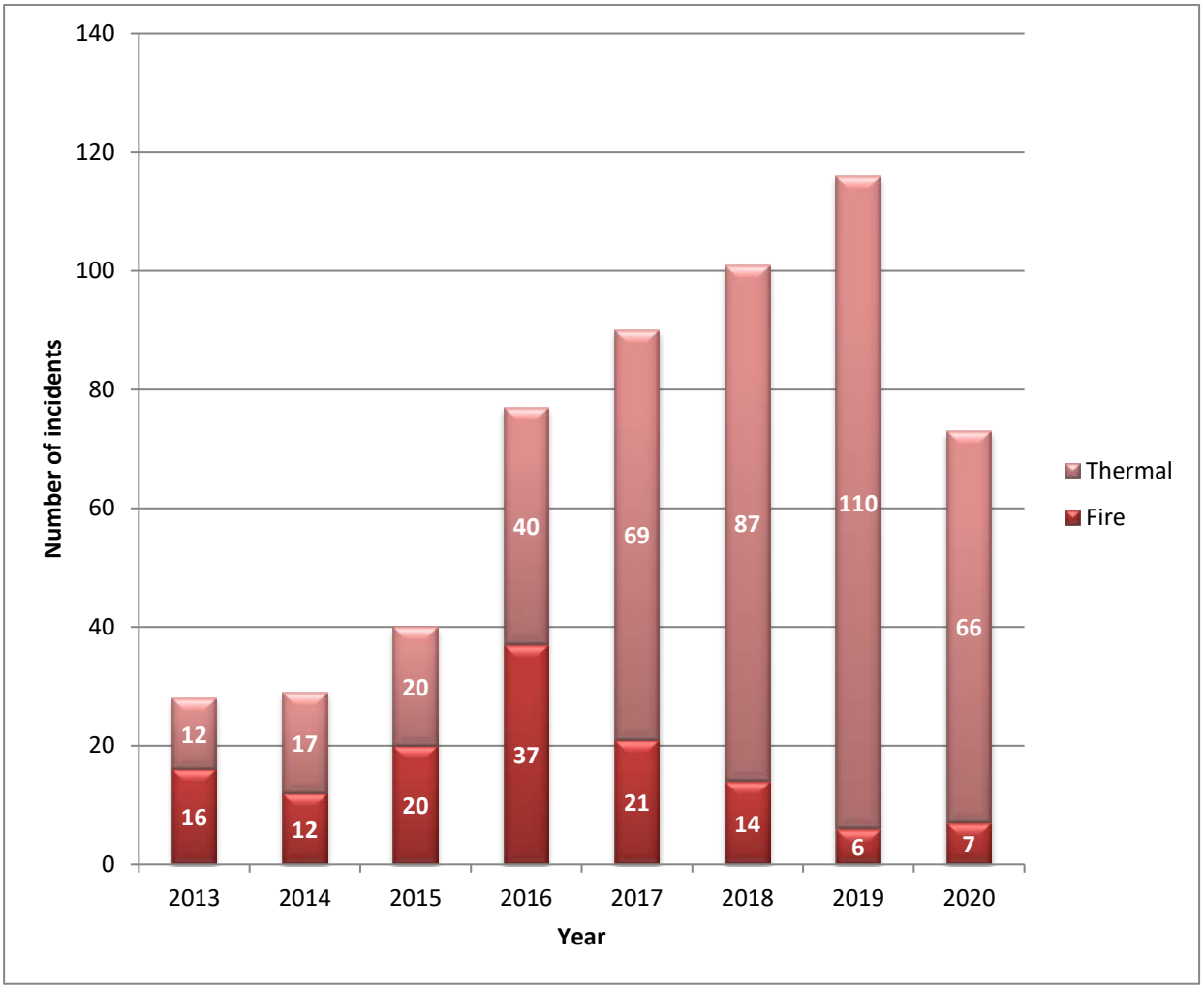

Figure 1: Number of fire and thermal incidents 2013-2020

Of the seven fire incidents in 2020, the majority of these were minor in nature.

The 73 incidents reported in 2020 were distributed throughout the year, as shown in Figure 2. On average there was a fire or thermal incident reported approximately every 5 days. Brief details of each incident are recorded in Appendix A.

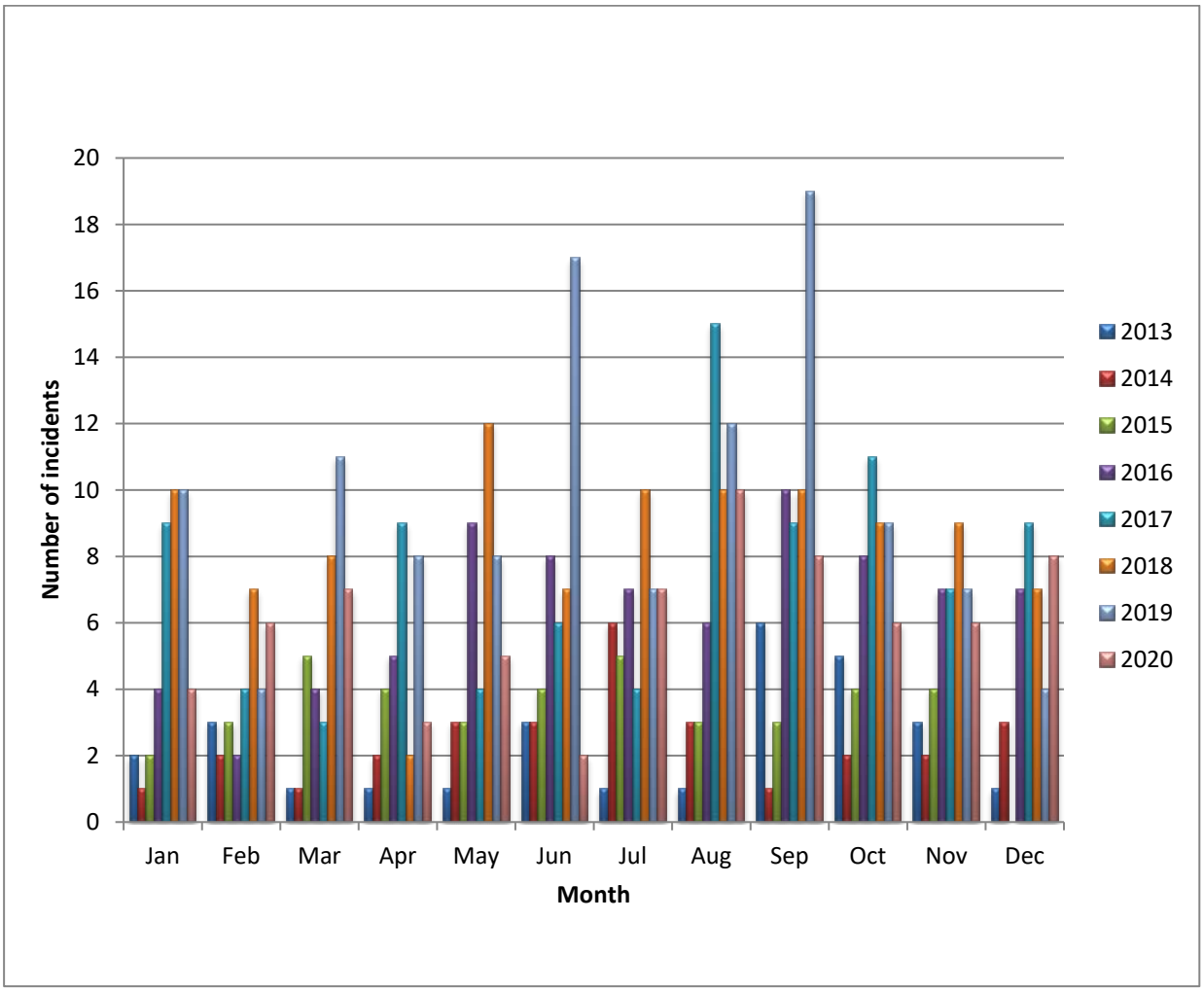

Figure 2: Incidents by month 2013-2020

The number of incidents per month in 2020 ranged from two incidents (in June) to 10 incidents (in August). There was no apparent trend in the month by month incidents.

Damage levels of incidents

Incidents were classified into the following levels:

- Destroyed
- Major
- Minor
- Smoke damage
- Nil damage (see Appendix B for a more detailed description).

Based on OTSI assessment and operator reports, nil buses were destroyed, one suffered major damage, 30 had minor damage, 37 had smoke damage and five buses had nil damage (Figure 3).

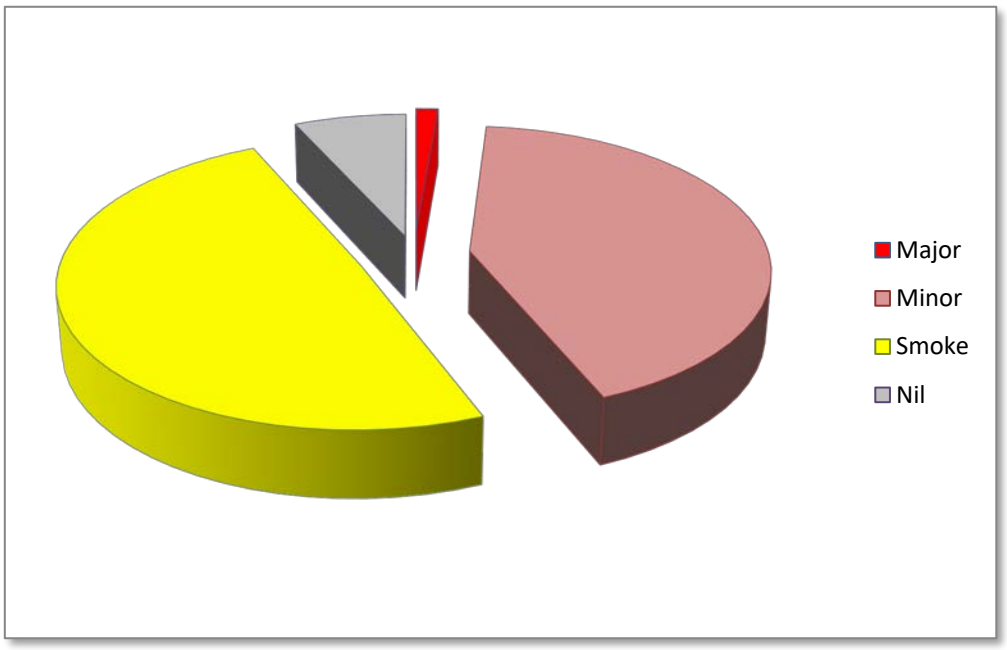

Figure 3: Severity level of incidents 2020

One important area is the category of highest severity, in which a bus or coach is destroyed by fire. It would be expected that this is an area where the number of reports is likely to be accurate. This is an event that is highly likely to be reported.

The numbers of destroyed buses have steadily declined following a peak in 2016 with the exception of a minor rise in 2019. Figure 4 indicates that in 2020 there were nil buses destroyed compared to four in 2019, three in 2018, five in 2017 and seven in 2016.

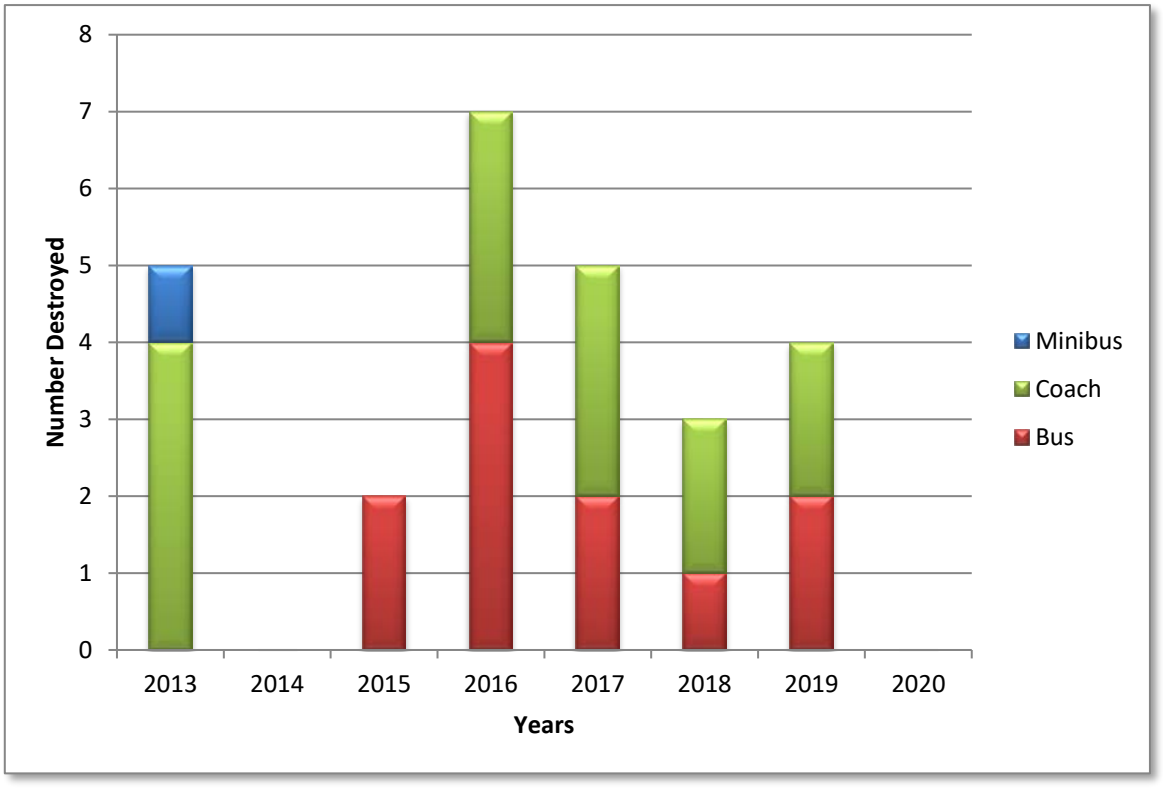

Figure 4: Destroyed 2013-2020

The number of incidents resulting in major damage have decreased following a peak in 2016. The major damage levels were: 2013 (two), 2014 (two), 2015 (two), 2016 (seven), 2017 (two), 2018 (one), 2019 (one) and 2020 (one).

Injuries

There were no reported injuries to any person as a result of a bus fire or thermal event in 2020.

Age of buses and number of incidents

The ages of the buses involved ranged from almost new to 25 years. An analysis of bus fleets in the current year showed that highest frequency of bus thermal incidents and fires occurred in 2010 buses (Figure 5). This coincided with the highest number of buses of this year of manufacture on the road in the TfNSW contracted bus fleet.

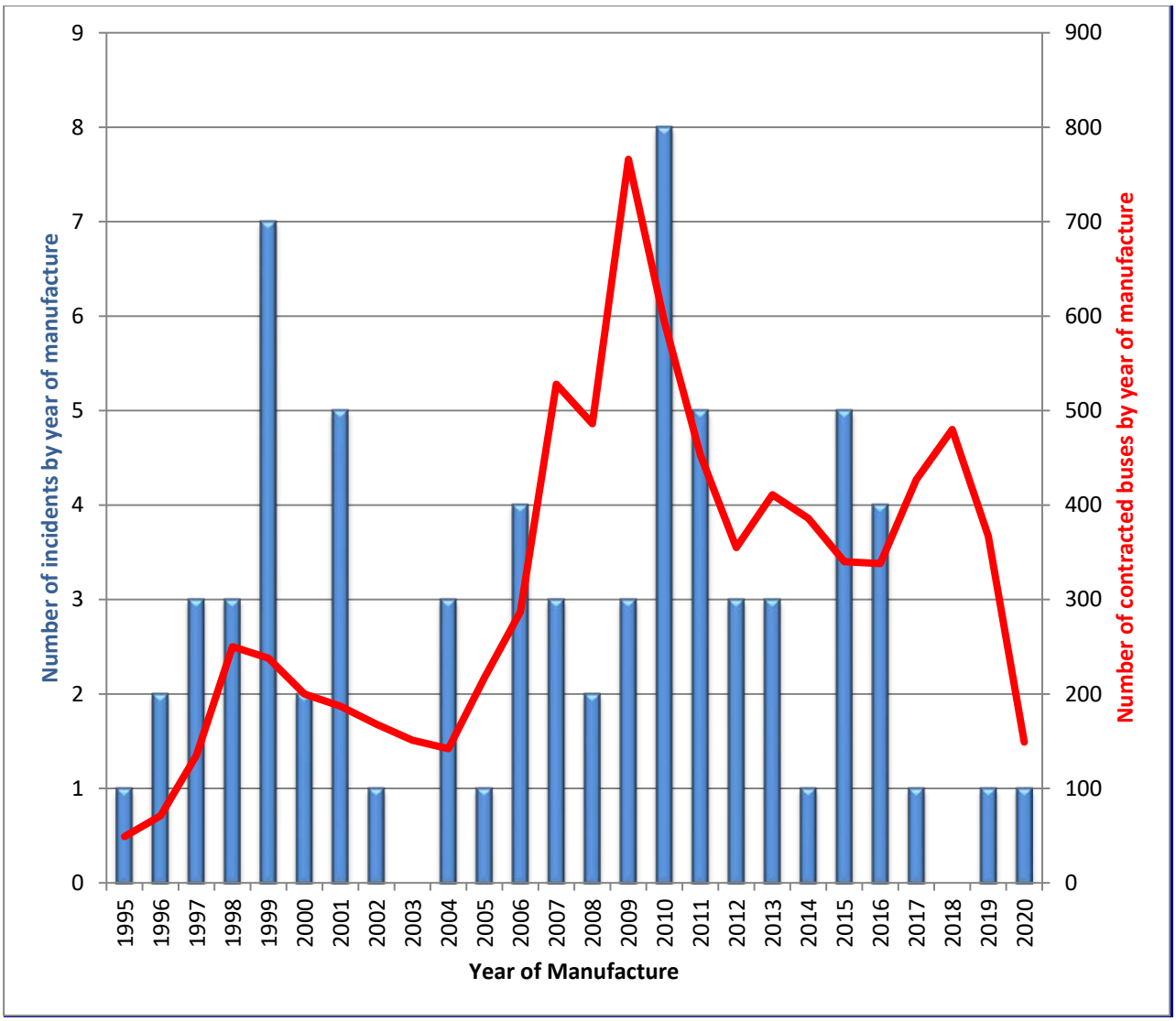

Figure 5: Year of manufacture and incidents in 2020

Severity level and age of buses

From 2016 to 2020 the average age of destroyed buses was 16.6 years, major damage 15.2 years, minor damage 11 years and smoke damage 10.3 years. The severity level and the average age of buses involved in incidents between 2016 and 2020 are shown below in Figure 6.

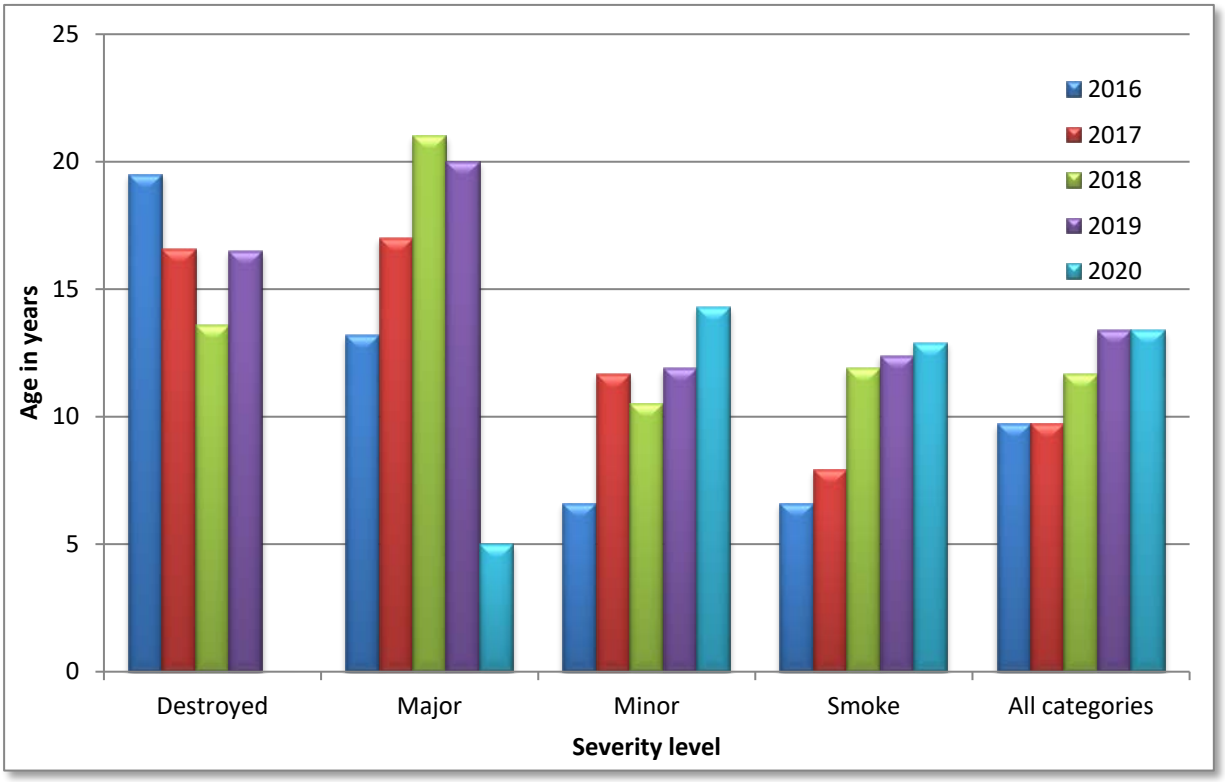

Figure 6: The severity level and the average age of the bus in 2020

Origins and causes

Overall origin

In 2020, the majority of fire and thermal incidents (57%) originated in the wheel well area. The engine bay had 26% and the body had 17%. Figure 7 shows the originating area of all incidents in 2020.

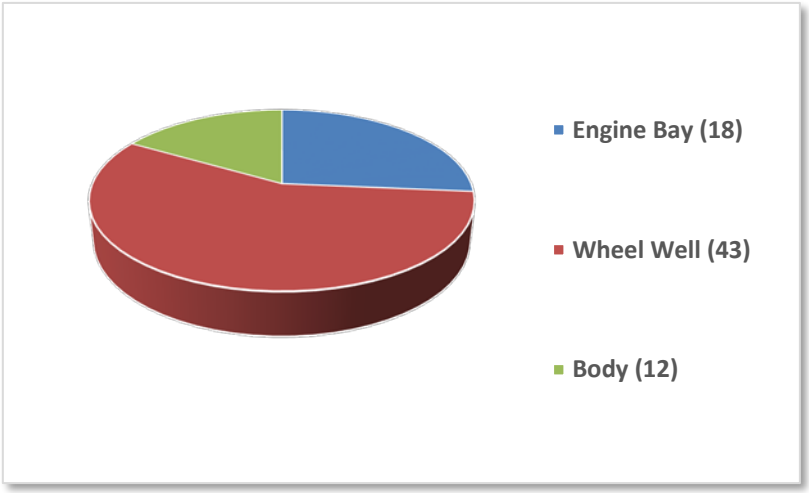

Figure 7: Location by origin 2020

Overall causes

The data for the causes of fire and thermal incidents in 2020 are shown in Figure 8.

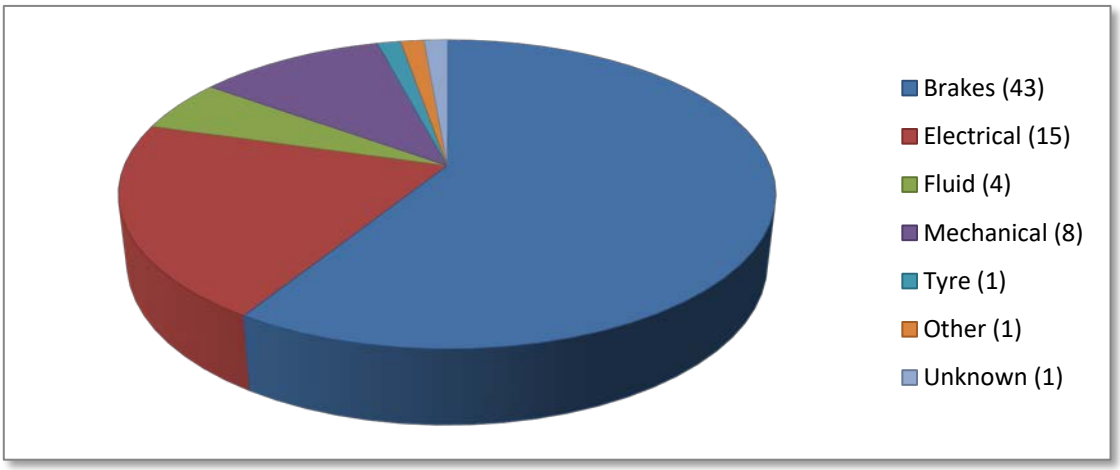

Figure 8: Causes of incidents 2020

Breakdown by origin of incident

The origin of fire and thermal incidents was divided into 3 categories:

- Engine bay
- Wheel well
- Body

Number of engine bay incidents

In 2020, 18 incidents (25% of all incidents) originated in the engine bay. This is a significant decrease from 2019 (Figure 9).

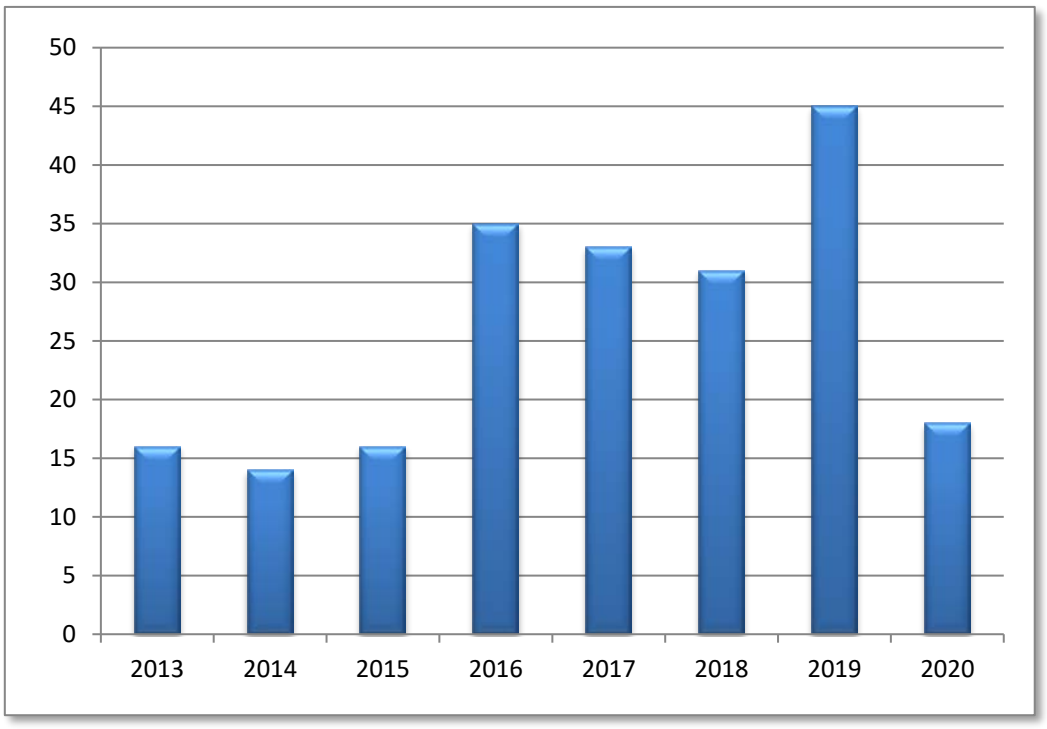

Figure 9: Number of engine bay incidents 2013-20

Cause of engine bay incidents

The cause of the engine bay incidents in 2020 was mechanical malfunction (8), fluid leakage (4), electrical malfunction (3), other (2) and unknown (1) (Figure 10).

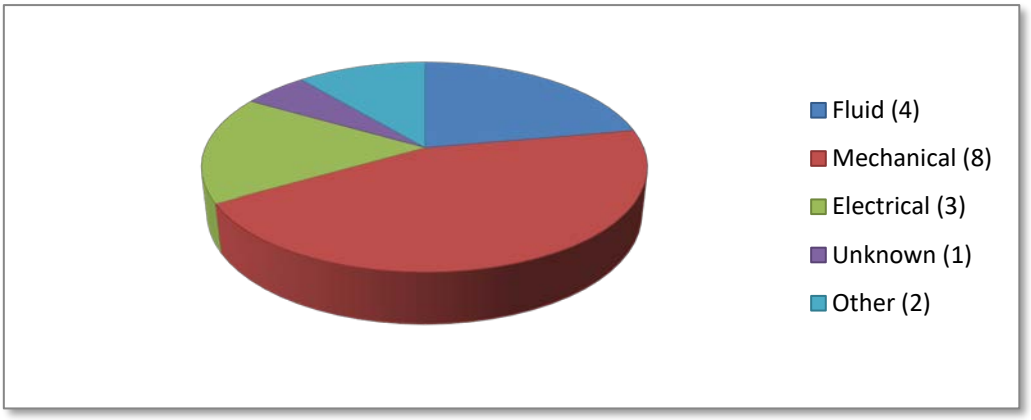

Figure 10: Cause of engine bay incidents 2020

Number of wheel well incidents

In 2020, 43 incidents (57%) were located around the wheel well. It was noted that the majority of these incidents (98%) resulted in smoke damage. These precursor incidents should not be ignored as wheel well fires have destroyed buses at Texas, USA in September 2005 (23 people fatally injured), Thornton, NSW in October 2016, and on the Sydney Harbour Bridge in November 2018. The numbers show a steady increase in wheel well incidents from five in 2013 to 59 in 2019 with a decrease to 43 in 2020 (Figure 11).

For the thermal incidents involving brakes, eight were front, 30 were rear, two were centre axle on articulated buses, one involved a transmission brake and four were unknown.

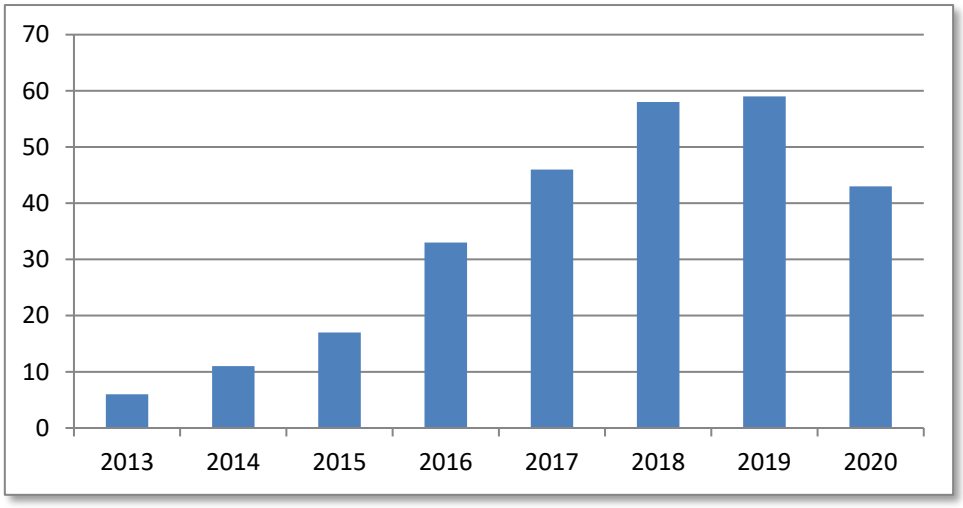

Figure 11: Number of wheel well incidents 2013-20

Cause of wheel well incidents

The majority of incidents (93%) were a result of brake issues, which had a variety of causes: faulty brake calliper, faulty brake booster, faulty park brake relay valve, worn park brake valve, brake blending issues, faulty slack adjuster, over-cammed linings, faulty EBS modulator valve and incorrectly adjusted brakes. Tyre problems occurred on one occasion, an electrical fault on one occasion and a mechanical failure on two occasions (Figure 12).

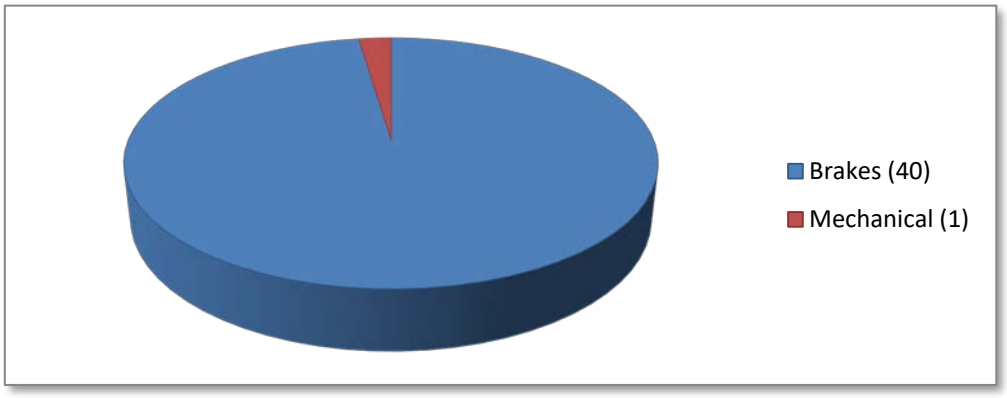

Figure 12: Causes of wheel well incidents 2020

Number of incidents originating in the body

A smaller number of incidents originated within the saloon area of the bus. There has been a steady increase in body incidents from 2014 (Figure 13). The majority of these incidents are caused by electrical faults. This is coincidental with an increase of electrical equipment fitted as the bus fleet modernises.

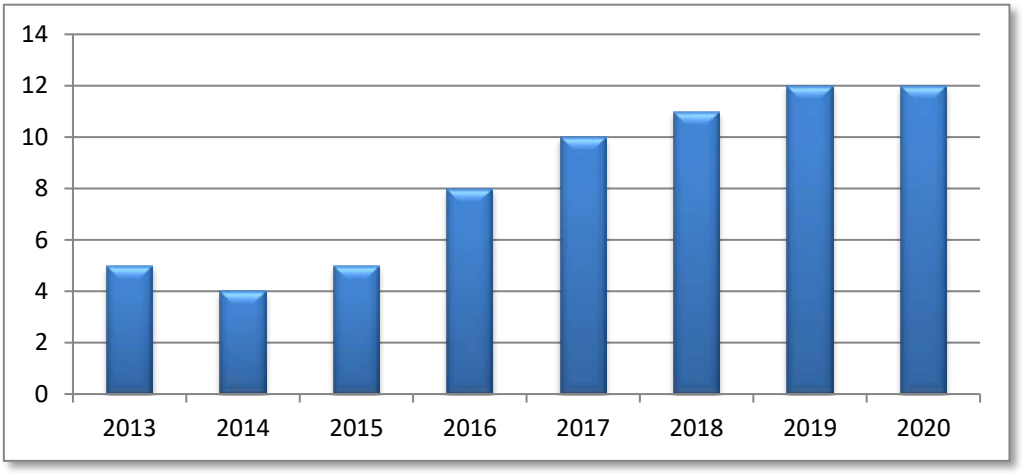

Figure 13: Number of body incidents 2013-20

Cause of body incidents

All the body incidents were attributed to electrical malfunction or failure. The 12 electrical incidents had a wide variety of origins: wiring insulation abrading, A/C control gear, high resistance connections, water ingress to electrical components and faulty wiring.

Compressed Natural Gas (CNG) incidents

In 2020, there were six incidents involving CNG-fuelled buses. The number and causes of fire and thermal incidents involving CNG-fuelled buses is shown in Figures 14 and 15. There was a significant decrease in incidents involving CNG buses from 2019. Contributing to this is the retirement of approximately 300 CNG buses from the original fleet total of 657 over the past three years. It should be noted that the cause of most of these incidents was unrelated to the fuel type.

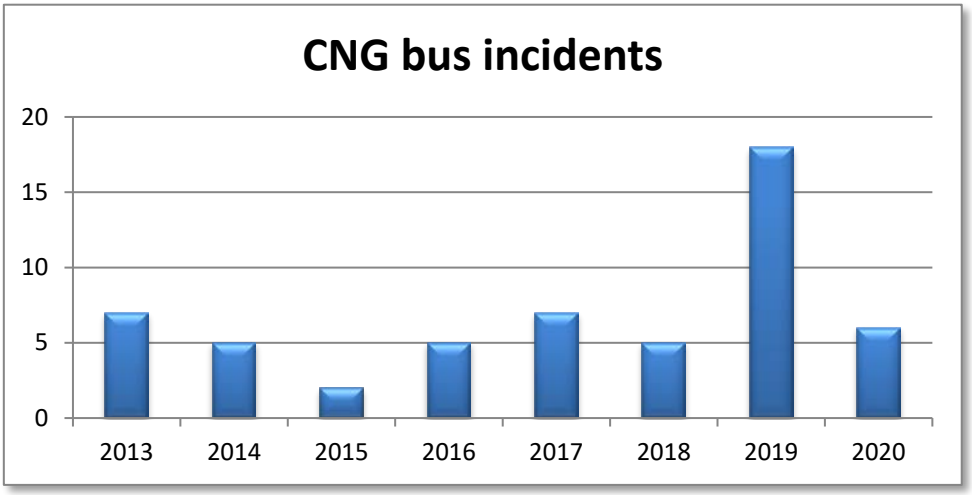

Figure 14: Number of CNG bus incidents 2013-20

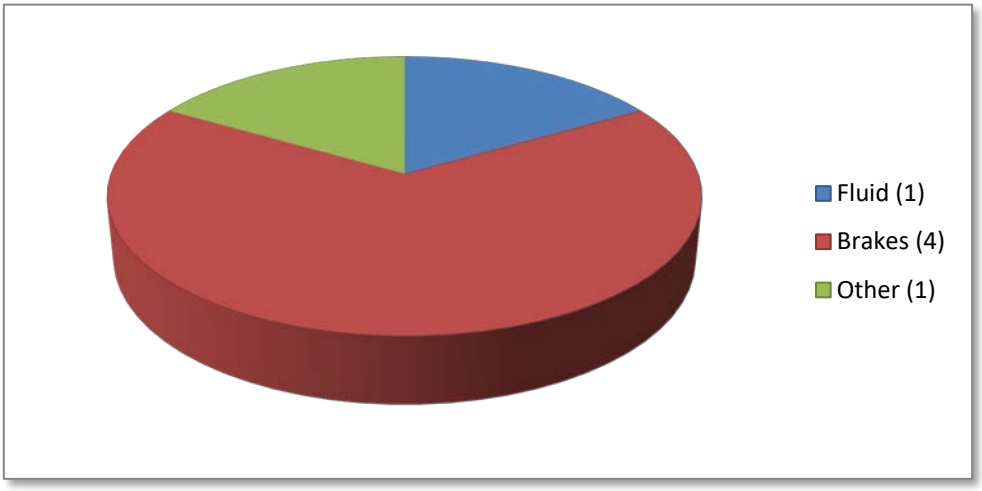

Figure 15: Causes of CNG bus incidents 2020

Description of CNG bus incidents	Damage level[4]
Near-side rear brake calliper problem.[5]	Smoke
Near-side rear brake calliper problem.	Nil
Combustible material lodged onto hot exhaust.	Minor
Off side rear brakes dragging.	Minor
Off side rear brakes dragging.	Minor
Oil leak from engine onto hot exhaust.	Smoke

Figure 16: Description of CNG bus incidents 2020

Electric vehicle (EV) incidents

There were no EV incidents reported to OTSI in 2020. The NSW government has recently announced that 50 new EVs will be added to the TfNSW bus fleet. With the emergence of new technologies, new risks can often be present. It is essential that these risks are addressed and adequate training is provided to all personnel maintaining, operating and responding to incidents.

According to research most EV fires are the result of thermal runaway of lithium-ion batteries.[6] The common causes include fire during the charging process, self-ignition while driving, or fire after a collision. The propensity of self-ignition during normal activities due to the thermal runaway of the lithium-ion batteries make EV fires different from internal combustion engine vehicles.

[4] For description of damage level classifications see Appendix B.

[5] Near-side refers to the left hand side of a vehicle viewed from the driver's seat; the off-side refers to the right hand side.

[6] *A review of battery fires in electric vehicles.* Sun. P, Bisschop. R, Niu. H, Huang. X. Fire Technology, 56. (2020)

Detection of fire

The data for the detection of incidents in 2020 are shown in Figure 17.

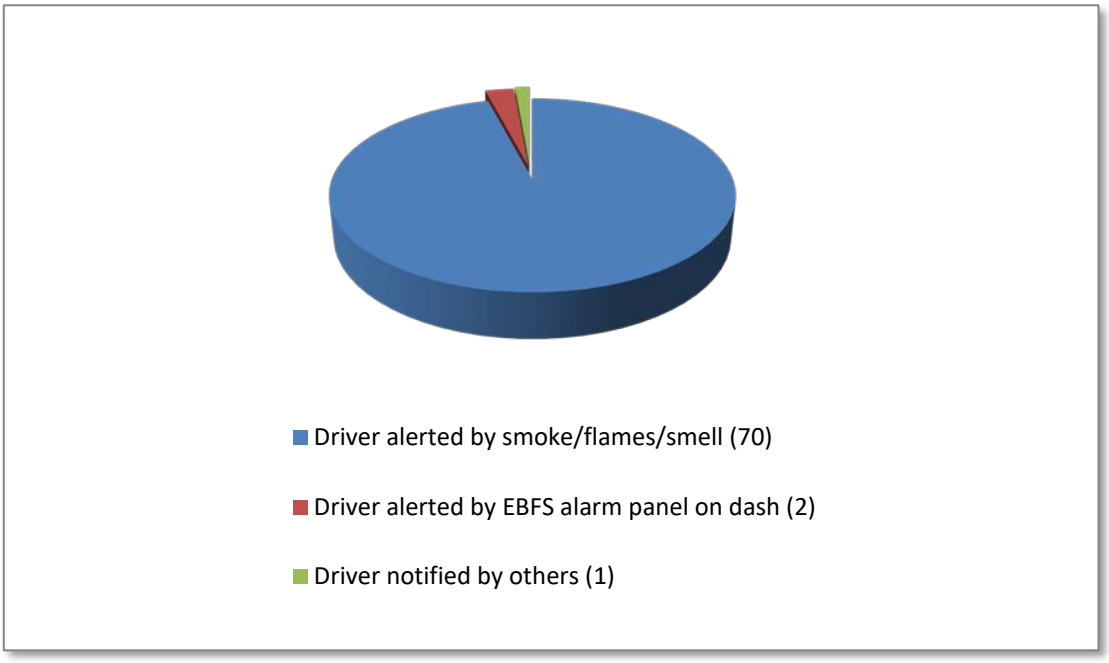

Figure 17: Detection of incidents 2020

In 2020, bus drivers were the first to either see or smell smoke or see flames on 96% of occasions. This highlights the importance of the driver's role in detecting the fire and acting accordingly. In the remaining occasions, the driver was alerted by the activation of the EBFS alarm on two occasions and once by a passing motorist.

Fire fighting

Portable fire extinguishers were used on seven occasions (10%). The use of portable extinguishers was successful on six of those occasions. In relation to the overall occurrences, the importance of the role of fire extinguishers, their location and the ongoing training for bus operators in limiting fire damage is important.

An extinguisher was unsuccessful in defeating a fire on one occasion.

In 2020, NSW Fire and Rescue was called upon to attend on 10 occasions. The percentage of occasions that NSW Fire and Rescue attended for the past six years is shown in Figure 18.

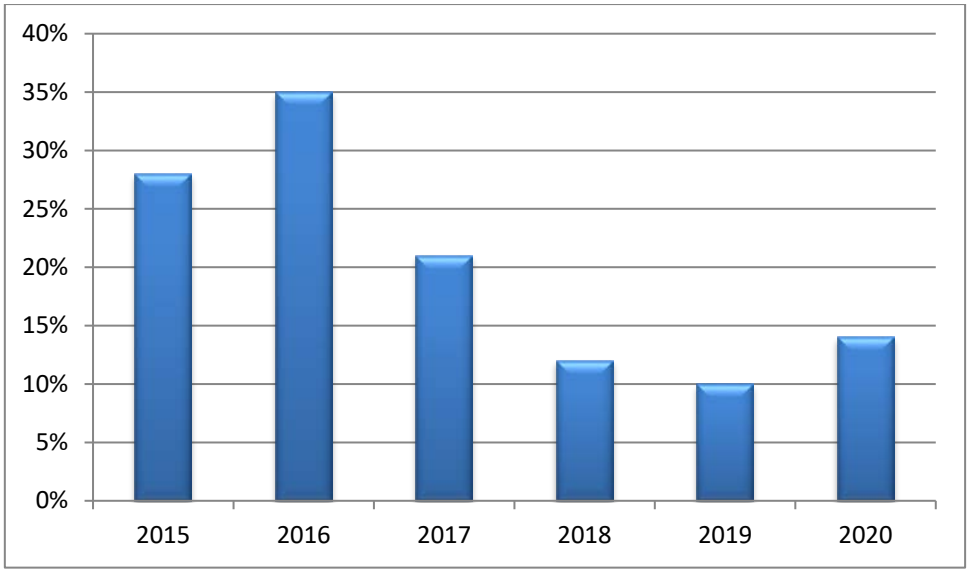

Figure 18: NSW Fire and Rescue: percentage attended 2015-2020

Effectiveness of Engine Bay Fire Suppression systems

In 2020, of the 73 incidents reported to OTSI, a total of 70 buses had an EBFS system fitted. An activation of the EBFS system was recorded for two incidents. A description of these EBFS system activation events is provided in Figure 19 below. These activation records show that EBFS systems successfully extinguished a fire on one occasion.

There were also five incidences of EBFS activations which were not defined as a thermal incident. In three incidents the system was activated by hot exhaust gases causing the detection system to activate and two incidents where the EBFS was accidently activated by the driver.

EBFS activation description	Damage level
Combustible fluid fire within the confines of the engine bay area. On-board dry powder FSS activated - Fire was not contained and was eventually extinguished by emergency services.	Major
Bus operator advised fire suppression system activated following ignition of a rag left on top of the engine by maintenance staff. Emergency services attended, however the small fire was extinguished by the EBFS.	Minor
Fire suppression system was activated by a faulty exhaust flex pipe which directed hot exhaust gases towards the fire suppression system detection line.	Nil
Fire suppression system was activated by a faulty exhaust flex pipe which directed hot exhaust gases towards the fire suppression system detection line.	Nil
Fire suppression system was activated by a faulty exhaust flex pipe which directed hot exhaust gases towards the fire suppression system detection line.	Nil
Driver accidently discharged EBFS.	Smoke
Driver accidently discharged EBFS.	Nil

Figure 19: EBFS Activations

Reporting of fire incidents

In NSW, OTSI receives reports from accredited bus operators conducting public passenger services, as required by the NSW *Passenger Transport Act (2014)*.

It is a legislative requirement that: 'An operator of a bus service who becomes aware that a bus being used to provide the service has been involved in an accident or incident must notify the Chief Investigator of the accident or incident … if the accident or incident involves a mechanical or electrical fire or an explosion on the bus.'[7]

Since 2010, all accredited bus operators have also been required to create an electronic record in the Bus Incident Management Database (BIMD), which is operated and administered by Transport for New South Wales (TfNSW).

It was found that on thirteen occasions OTSI were not notified of a thermal incident. The incidents were instead reported in the BIMD. Recently TfNSW have made additional descriptors to their database to improve the data collection process. These include two new incident descriptions, *False Activation Fire Suppression System* and *Thermal Event (No fire, smoke only).* In compiling data for this report, OTSI regularly cross references with the BIMD to ensure accuracy of reporting and to obtain a holistic overview of the industry. It is important that the legislative requirement is met by all operators in order to gather a complete record of incidents for analysis.

Progress on improving bus fire safety

EBFS systems

All NSW buses under TfNSW contract in the Sydney metropolitan area are now fitted with EBFS systems. According to the major supplier of EBFS systems, over 5500 buses in NSW are fitted with their systems. All future buses supplied under these contracts will be delivered with EBFS systems.

[7] NSW Passenger Transport Regulation 2007 clause 88.

APPENDIX A – SUMMARY OF BUS INCIDENTS 2020

MONTH	VEHICLE TYPE	YEAR	LIKELY FIRE SOURCE	SEVERITY	ONBOARD FIRE EQUIPMENT USED
Jan	Special	2015	Fluid leak in engine bay.	Major	Yes and EBFS activated*
Jan	Bus	2009	Fluid leak in engine bay.	Smoke	No
Jan	Bus	2010	A/C fan motor seized.	Smoke	No
Jan	Bus	2010	Centre axle brakes locked on.	Smoke	No
Feb	Bus	2011	Excessive brake heat due to malfunctioning transmission retarder.	Nil	No
Feb	Bus	1997	High resistance electrical connection causing insulation to burn.	Minor	Yes*
Feb	Bus	2000	Faulty NSF brake calliper.	Minor	No
Feb	Bus	1997	Faulty NSR brake calliper.	Minor	No*
Feb	Bus	2010	Faulty starter motor.	Minor	No
Feb	Bus	2010	Ruptured parking brake airline causing brakes to drag.	Smoke	No
Mar	Bus	2010	Oil leak from turbocharger.	Smoke	No
Mar	Bus	2001	Electrical short circuit in dash area.	Minor	No
Mar	Bus	2005	Combustible material left in engine bay.	Smoke	Yes and EBFS activated*
Mar	Bus	2004	Faulty A/C electronic control unit.	Minor	No*
Mar	Bus	2010	Dragging rear brakes due to sticking callipers.	Nil	No
Mar	Bus	2015	Faulty starter motor.	Minor	No
Mar	Bus	2016	Faulty NSF brake calliper.	Smoke	No
Apr	Bus	2019	Faulty OSR brake calliper.	Minor	Yes
Apr	Bus	2013	Faulty EBS module causing OSR brakes to drag.	Minor	No
Apr	Bus	2011	Faulty rear brake QR valve causing brakes to drag.	Smoke	No
May	Bus	2007	Faulty brake calliper adjustment mechanism.	Smoke	Yes

May	Bus	2009	Rear brakes dragging.	Smoke	No
May	Bus	2007	High resistance connection in electrical switch in dash panel.	Smoke	No
May	Bus	2011	Incorrectly adjusted NSR brakes.	Smoke	No
May	Bus	2004	Electrical short circuit.	Minor	No*
Jun	Bus	2010	Faulty park brake valve causing rear brakes to drag.	Smoke	No
Jun	Bus	2013	Incorrectly adjusted NSR brakes.	Minor	No
Jun	Bus	1995	Electrical short circuit in dash area.	Minor	No
Jul	Bus	2009	Faulty starter motor.	Minor	No
Jul	Bus	2001	Unknown thermal in engine bay.	Smoke	No
Jul	Bus	2012	Unknown thermal in engine bay.	Minor	No
Jul	Bus	2001	Near-side rear brake calliper problem.	Nil	No
Jul	Bus	2013	Short circuit of electrical component.	Minor	No
Jul	Bus	1999	Faulty electrical switch.	Minor	No
Jul	Bus	1999	Dragging rear brakes.	Smoke	No*
Aug	Bus	2016	Faulty park brake valve causing brakes to drag.	Smoke	No
Aug	Bus	2011	Faulty park brake valve causing brakes to drag.	Nil	No
Aug	Bus	1999	Faulty OSR brake booster.	Smoke	No
Aug	Bus	2016	Near-side rear brake calliper problem.	Minor	No
Aug	Bus	2012	Faulty rear brake boosters.	Smoke	No
Aug	Bus	1996	Faulty rear brake boosters.	Smoke	No
Aug	Bus	1996	Dragging OSF brakes.	Smoke	No

Aug	Bus	2015	Dragging NSR brakes.	Smoke	No
Aug	Bus	1998	Seized A/C compressor.	Minor	No
Aug	Bus	2012	Faulty park brake valve causing brakes to drag.	Minor	No
Sep	Bus	2014	Faulty OSR brake booster.	Smoke	No
Sep	Bus	1998	Seized A/C compressor.	Nil	No
Sep	Bus	2017	Faulty brake calliper.	Nil	No
Sep	Bus	1999	Brake “S” cam over centre.	Smoke	No
Sep	Bus	1999	Seized A/C compressor.	Minor	No
Sep	Bus	1999	Combustible material lodged onto exhaust.	Minor	No
Sep	Bus	2011	Dragging OS centre brakes.	Smoke	No
Sep	Bus	1999	Fluid leaking in engine bay.	Smoke	No
Oct	Bus	2006	Wiring rubbing together causing short circuit.	Minor	No*
Oct	Bus	2020	Rear brakes dragging.	Smoke	No
Oct	Bus	2008	Rear brakes dragging.	Smoke	No
Oct	Bus	1997	Faulty wiper switch.	Minor	No
Oct	Bus	2010	Rear brakes dragging.	Minor	Yes
Oct	Bus	20018	Near-side rear brake booster problem.	Minor	No
Nov	Bus	2001	Brakes dragging.	Smoke	No
Nov	Bus	2007	Punctured NSF tyre.	Smoke	No
Nov	Bus	2008	Brakes dragging.	Smoke	No
Nov	Bus	2006	Engine oil leak.	Smoke	No*
Nov	Bus	2010	Brakes dragging.	Smoke	No
Nov	Bus	2006	Brakes dragging.	Smoke	No

Dec	Bus	2000	Seized A/C compressor.	Minor	No
Dec	Bus	2004	Brakes dragging.	Smoke	No
Dec	Bus	2002	OSR brakes dragging.	Smoke	Yes
Dec	Bus	2007	Faulty NSF brake calliper.	Smoke	No
Dec	Bus	2015	Brakes dragging.	Smoke	No
Dec	Bus	1998	Seized A/C compressor.	Minor	No
Dec	Bus	2016	Electrical short circuit.	Minor	No
Dec	Bus	2015	Faulty NSF brake calliper.	Minor	Yes

***** Denotes attendance by NSW Fire and Rescue.

APPENDIX B – SEVERITY LEVEL DESCRIPTIONS

DESTROYED
Due to damage sustained in the fire, the bus cannot be repaired. There was significant destruction to one or more sections. Examples of this category are:

- The bus is completely burnt out.
- The engine bay is burnt out and the rear passenger area of the bus is partially damaged.
- It is no longer economically viable to repair the bus.

MAJOR
Damage to one large section of the bus or multiple parts where the bus can be repaired by replacing the panel or part. Examples of this category are:

- The engine bay sustains a fire, but the fire is contained to that area and the rest of the bus is undamaged.

MINOR
One part of the bus is damaged but that part can be repaired or replaced. Examples of this category are:

- An oil leak from a cracked pipe onto a hot engine part creating a small fire.
- Brake callipers sticking generating intense heat and the need for complete replacement or components thereof.
- An electrical fuse which generates heat to that local area.

SMOKE DAMAGE
No physical damage to any part except smoke stains/residue. No parts need replacing. Examples of this category are:

- Brake callipers sticking generating intense heat and do not need replacing but require some components replaced.
- Smoke from another bus on fire.

NIL DAMAGE
No physical damage to any part, no smoke staining and/or no parts which need replacing. Examples of this category are:

- Tyre lockup and smoke generated.
- Water leak generating steam.
- Brake callipers sticking generating intense heat which do not require repair.