SAFE@WORK
Fire and Emergency New Zealand

Level 2 Investigation Report

Event title: Newtown 225 Aerial Failure V1.0

Event ID: 9107

Event date: 02 February 2022

FIRE EMERGENCY NEW ZEALAND

WHAKARATONGA IWI

Document information

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Safe@Work event title:	Newtown 225 Aerial Failure (FEY849)
Event ID:	9107
Event type:	Near miss
Report completed by:	[redacted]

Terms of reference

Sponsor:	Bruce Stubbs
Assessor:	[redacted]
Report due date:	16 March 2022

Investigation team:

Role	Name	Position
Investigator	[redacted]	Group Manager, Kāpiti
Investigator	[redacted]	External Specialist Support (IMPAC)
Fleet SME	[redacted]	National Manager Programmes & Standards
NZPFU Investigator	[redacted]	NZPFU, National Vice President Station Officer, Christchurch Fire Brigade

Terms of reference

1.	Assess initial information gathered about the event and, in collaboration with the investigation team, establish the facts of the event and the relevant facts leading up to the event, and the associated timeline.
2.	Undertake an analysis of the positioning of the appliance at the incident, examining the geographical and topographical considerations for the application of aerial tactics.
3.	Determine what approved training standards, standard operating procedures, guidelines, or policies provide a framework for the decision making around the placement of the appliance and around the subsequent operation of the appliance and, using a gap analysis format, document what was in place at the time of the event.
4.	Determine if there were any current faults with the appliance prior to the event and, if so, how those faults were reported and how they were addressed.

	a. Review the maintenance records and historical faults, over the life of the vehicle with a view of seeing any patterns that could be helpful for future predictive maintenance.
5.	Determining whether a material risk to health and safety arose during the incident.
6.	Identify continuous improvement recommendations for consideration.

Revision status

Rev	Date	Revision Description
0.3	14 April 2022	Initial draft
0.4	29 April 2022	Summary of findings and recommended actions updated, minor grammatical changes
0.5	25 May 2022	Terms of Reference (ToR) updated, to reflect original agreed ToR. Added additional interviews and contributions, addressed comments from Stakeholder Group
0.5.1	01 June 2022	Report reformatted to improve clarity and readability
1.0	28 July 2022	Final report – Approved by Bruce Stubbs, Region Manager Te Ūpoko Rohe

Contents

Investigation summary

Summary of the event

At 08.51hrs on Wednesday 2nd February 2022, NEWT225 (Type 5 Bronto F32 RLX heavy aerial registration FEY849) responded to a well involved residential structure fire at 91 Yule Street, Lyall Bay, Wellington, while enroute to Kilbirnie. NEWT221 and WELL211 pump appliances arrived at the location at 08.55hrs. On arrival at 08.56hrs the NEWT225 crew was immediately tasked by the Incident Controller to set up the aerial appliance to provide exposure protection for the dwelling next door (93 Yule Street). The Operator and Officer set the jack legs before the Operator raised the main boom to approximately 70 degrees. As the Operator attempted to extend the fly boom, he lost all power and was unable to undertake any further movements of any part of the aerial. The Operator and subsequently the aerial Officer undertook immediate fault-finding, attempting to use the diesel and electrical backup systems to regain movement. During this fault finding process an additional aerial appliance (THOR235) was called for, and a change in firefighting tactics was implemented, including the use of a ground monitor.

After a period of approximately 10 minutes the battery backup activated allowing the Operator to slew the main boom towards the fire for the purposes of protecting the scene coupled with damping down activities. At this stage the Operator activated the start button and full functionality returned to the aerial appliance. Once the fire was extinguished to the point the aerial appliance was no longer required it was made up and taken to the service provider in Trentham for further analysis.

Summary of investigation findings

- A load cell intermittent failure caused the aerial appliance to stop working on 02/02/22. The investigation team found that due to the extensive safety features, sensors and computer control systems typical of this type of appliance, the fault proved challenging to diagnose.

- The emergency stop activation had the effect of temporarily disabling the backup Hatz diesel and battery power systems as it is designed to do. It is unclear as to why the backup systems continued to remain deactivated. The emergency stop design includes an audible alarm, and a symbol on the control panel. Although we have no evidence to support this, one hypothesis is the emergency stop was not fully reset.

- The Operator used the emergency stop (button) to ensure the appliance main engine was shut down before attempting to start up the Hatz diesel back-up. Enquires made by the investigation team of Operators in Wellington, Auckland, Christchurch and Dunedin suggest that this has become common practice in some locations, indicating inconsistent approaches to using the emergency stop (button) in different parts of the country. It should be noted that the Type 5 Bronto F32 RLX and F32 RLH Study Guide states that the start/stop button should be used to shut down the main engine before activating the Hatz.

- The Operator and Officer involved have had more than 25 years' experience in operating aerial appliances and have participated in all training and revalidations. The investigation found no reason to doubt their capability, competency or decision making under pressure. At no point was there an increased risk to safety because of Operator decision making, or the appliance fault. They were not concerned for their immediate safety due to the fact that a water supply to the aerial appliance had been established (it is able to deploy a 'water curtain' to protect the cage from heat and smoke if necessary) and the appliance had been appropriately placed to provide maximum operational effectiveness and safety.

- The positioning of the aerial appliance on the incident ground was operationally sound based on the Type 5 Bronto F32 RLX and F32 RLH Study Guide which states; that the appliance should be sited to "Ensure the safety of the appliance and aerial." Exact positioning on the fire ground is determined by Operator and Officer expertise.

- The investigation team found that the current aerial fault logbook provided with the appliances does not allow for faults to be clearly defined, categorised, prioritised and rapidly communicated. It also does not encourage feedback between the Operators and the Service Providers. The investigation found document PMFT02 that details the process for determining the definitions and severity of faults and fault reporting for appliances. It is not written as a national policy or procedure and it was found to be unknown at station level. Regions and Districts (formerly Areas) have developed their own procedures in the absence of national level guidance.

- Procedures developed at a District/station level including weekly inspections and checks for heavy aerial appliances are inconsistent across regions and may not be aligned to manufacturer and/or AFAC guidelines. It is possible that the common practice of using the emergency stop to ensure the main engine is off has developed in part through how weekly inspections and checks are conducted. The design and management of training and continuing professional development for aerial Operators is a complex and challenging task requiring on-going cooperation and collaboration between Service Delivery, Workforce Capability and Fleet, and including end users.

Other observations

- Safe@Work action management features are not being fully or consistently utilised. The system has the capability for actions to be created and managed as part of a Level 1 and 2 investigations.

- At the time of the investigation, it is not known whether the load cell failure and the use of the emergency stop were interlinked in some way via the electronic and programmable systems of the Bronto F32 RLX.

- The investigation team found that there is no consistent document control applied within the organisation as a whole. This can make it difficult to confirm document versions and ensure consistency.

- The investigation team noted that although PMFT02 Repair and Maintenance of Vehicle Process (26/06/2018) exists, there is no process documented for the impounding of a vehicle due to an incident or injury that may be notifiable to WorkSafe.

- A Level 2 investigation was completed in 2017 but, due to a change in software systems, the investigation team were not able to discover if any of the recommendations arising have been progressed or completed.

- National Fleet consists of a team of six (plus seven Region Coordinators). The investigation team is concerned that this represents under-resourcing of a critical function within the organisation.

- The use of heavy aerials to respond to this type of single-storey, residential fire has become standard practice in Wellington. The rationale for this includes tactical siting considerations taking into account Wellington's steep and narrow streets, vehicle congestion and the ability a heavy aerial has to reach horizontally over obstacles. The strategy for procurement, placement and use of aerials across NZ has been under discussion since April 2020, with the aim of understanding how aerials are used and providing strategic guidance and policy moving forward.

Summary of recommendations

The investigation team has made the following recommendations, both immediate and for the longer-term.

Immediate Recommendations:

1. Re integration of FEY849 into full operational service (as detailed in Recommendation #1).

2. Technical expert facilitated session on FEY849 Bronto F32 RLX operation (ideally undertaken concurrently with recommendation #1).

3. Develop and publish a national procedure for identification, assessment, and reporting of aerial faults.

Continuous Improvement/Longer-term recommendations:

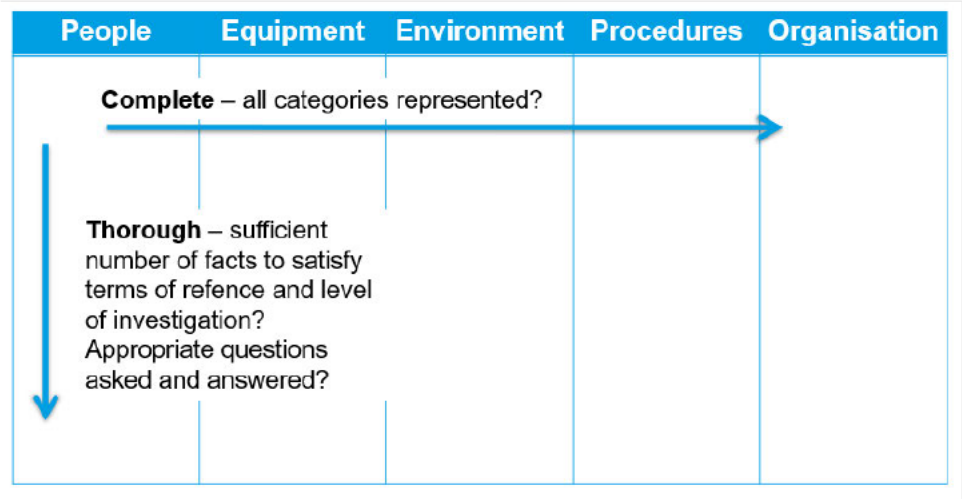
4. Type 5/6 Aerial Training Review and Improve aerial Operator training and refresher training.
5. Foster stronger collaboration between Fleet and Service Delivery.
6. Trial a software-based system for recording and reporting on heavy aerial faults.
7. Improve the recording, tracking and assurance of recommendation responses and any corrective actions associated with investigations.

Methodology

This investigation has followed the Incident Cause Analysis Method (ICAM), as adapted by Workplace Health and Safety Risk Specialists IMPAC.

Phase 1: Gathering and organising information

Phase 1 of the investigation involved gathering and organising information that may be relevant to the incident and may assist in understanding and learning. The 'PEEPO' chart was used to visualise and organise the information and to keep track of (and guard against) potential bias towards preconceived conclusions. The PEEPO chart enabled all members of the investigation team to have up-to-date oversight of the information gathered, to pose questions, and to point out gaps in understanding that warranted further information gathering activity.



People

During phase 1, the investigation team interviewed a range of people who were directly involved in the event under investigation, people with practical operational experience and expertise in aerial appliance firefighting. People with knowledge of organisational management factors and historical factors, as well as engineering and maintenance subject matter experts were also interviewed. Union representation was present at all times during all interviews. Interviews were conducted as small group discussions as well as singularly. Interview audio was recorded with the consent of those involved. The NZPFU met with the crew involved in the incident prior to the Level 2 investigation Team interviewing the crew as per standard practice to provide employment advice and support.

The aerial Operator and Officer involved in the incident under investigation have each had more than 25 years' experience in operating aerial appliances and have participated in all training and revalidations. They were able to adapt quickly and effectively under pressure when the aerial failed; changing their tactics and commencing fault-finding on the aerial and continuing to account for the fire, the exposures, and the many dynamics of the situation. The other Firefighters in attendance also worked professionally and effectively to deal with the situation.

The list of people approached for information, insight and expertise is included in the appendices. Many others could have contributed, however the investigation team had to limit the scope of the investigation in order to stay within reasonable resource and time limits.

Equipment

On Wednesday 2 March 2022 the investigation team visited aerial appliance FEY849 Bronto F32 RLX at Trentham NZDF Base and were able to operate the aerial through a wide range of motion and test multiple functions.

Figure 1 FEY849 Bronto F32RLX.

Figure 2 FEY849 undergoing examination by the investigation team.

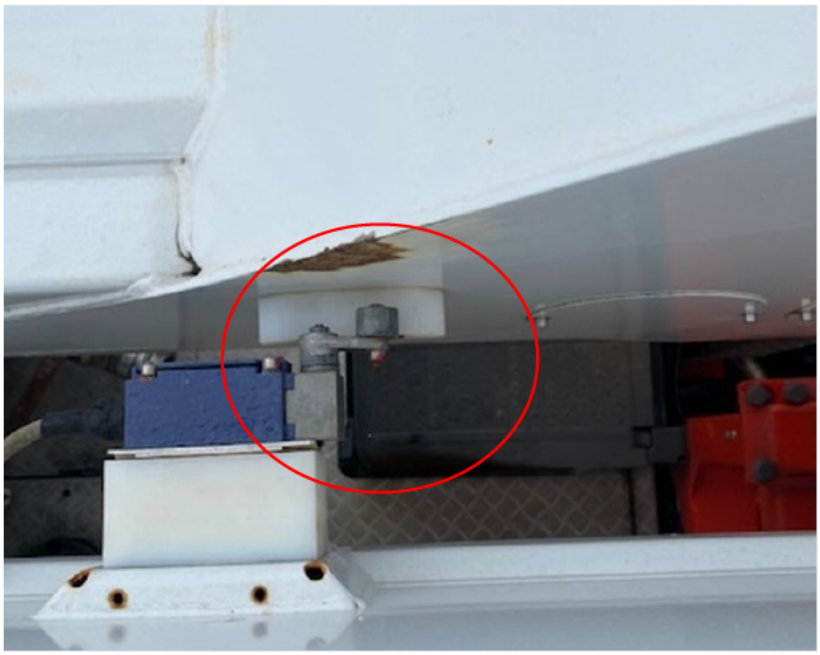


Figure 3 While examining the aerial unit, the cage auto-housing feature 'failed' and the fault was traced to a small sensor on the boom, designed to give the computer system position status information. The photograph shows the sensor, which had likely gone outside of its tolerance range because of 1-2mm wear on the nylon sensor pick-up plate.

The investigation team noted that the Bronto F32 RLX is an impressive asset, with many interconnected sensor, functions and safety features. It was notable that the effective functioning of such a large machine could be reliant on 1mm of wear on a tiny plate. It underlined the complexity of the tasks of operation and maintenance of such equipment.

Environment

The investigation team visited the site of the event; 91 Yule Street, Lyall Bay, Wellington. The street is wide and flat, with timber construction houses set close together. Wind speed and direction on the day of the incident was estimated to be northerly 30kmph.

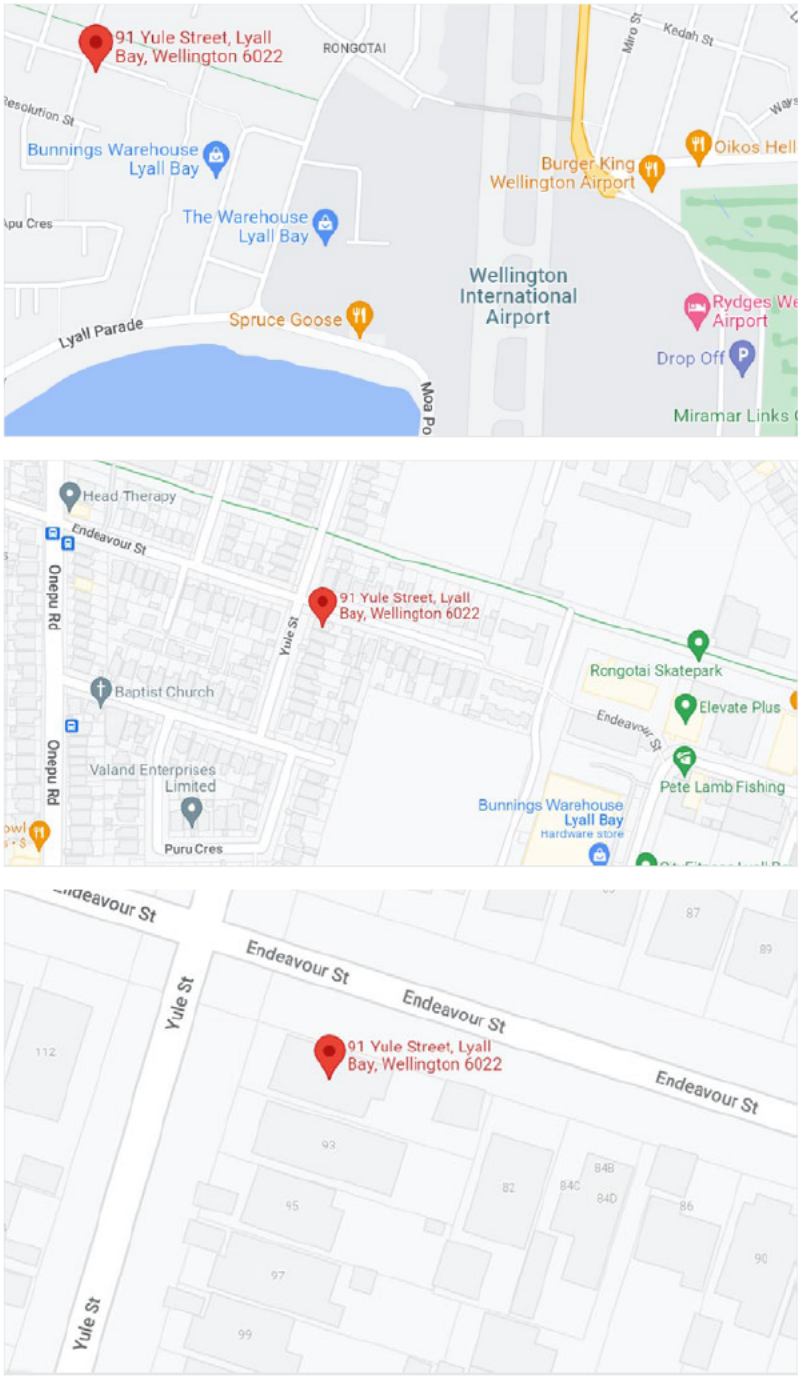


Figure 4 Series of Google Maps images showing the location of the incident.

The event was reported extensively in the local media and photographs as well as video footage is available online. Members of the public and the media were present at the time of the event.

Figure 5 Images published by Newshub showing the extent of the fire and FEY849 while it was in a fault condition.

Figure 6 Image published online by Stuff showing the fire and location of the 1st arriving appliance (Newtown 221).

Figure 7 Image published online by NZPFU showing FEY849 in fault condition.

Figure 8 91 Yule Street on 02/03/2022 as seen by the investigation team, one-month post-incident.

Procedures

The investigation team considered a wide range of internal and external documents, records, procedures, guidelines, standards, codes of practice, strategies and policies. A complete list of documents considered and referred to by the investigation team can be found in the appendices.

Figure 9 The appliance fault book for FEY849.

The following three documents provide limited high-level information on the siting and set up of aerials:

- Type 5 Bronto F32 RLX & F32 RLH Study Guide (P30: Siting the appliance & Siting responsibilities).
- OSM Specialist Skill Type 5 appliance.
- Dynamic Risk Assessment including the safe person concept.

There are no other Policy or Procedures that provide a framework for the decision making around placement of the appliance.

The following document provides limited high-level information on the operation of the appliance:

- Type 5 Bronto F32 RLX & F32 RLH Study Guide

District Trainers provide guidance on both siting and setup, but this is based on a combination of the study guide and their own learnings. Other than what is contained within the current study guide, there is no information.

Organisations

The investigation team found that many organisations were involved in events and conditions leading up to the day of the event under review, as well as subsequent action.

The organisations involved both directly and indirectly include:

- Fire and Emergency New Zealand (FENZ).
- Bronto Finland – Bronto is the manufacturer of the aerial component.
- Access Specialties – Access is the New Zealand service agent for Bronto (Auckland based).
- Lockheed Martin – Lockheed is the local FENZ contracted service provider.
- New Zealand Professional Firefighters Union (NZPFU) - A registered Trade Union and a representative organisation for personnel employed by Fire and Emergency New Zealand.

Phase 2: Developing the sequence of events and conditions

The investigation team used the information gathered to build a sequence of events including a pre-incident, incident and post-incident phase. Events are 'happenings'; occurrences, decisions and actions that tell the story leading up to the event under investigation, the event itself, and what happened after the event.

Including conditions with a sequence of events can help those seeking to learn from an investigation to understand what it was like for those involved at the time that events took place. Decisions and actions taken by those involved in an incident are bounded by contextual factors. A retrospective understanding of work activities is not possible without careful consideration of the conditions at the time of events. This approach is based on 'Event and Causal Factors Analysis', a tool developed within the nuclear power industry.

The pre-incident phase was taken from the time (13/01/2010) the Type 5 Bronto F32 RLX FEY849 went into service. The incident phase was taken to include the events of the response on the day (02/02/2022) to the fire at 91 Yule Street. The post-incident phase was taken from after the day of the incident up to the time of the investigation commencing.

Conditions (also taken from the information gathered and organised in the PEEPO chart) at the time of the events were added in an effort to understand the frames of reference, challenges, constraints, assumptions, task conditions, environmental factors and so on. Any further gaps in understanding or in the logical progression of events were identified and additional questions raised. This approach can help guard against hindsight bias, as events are seen, and decisions understood in the context of the conditions at the time.

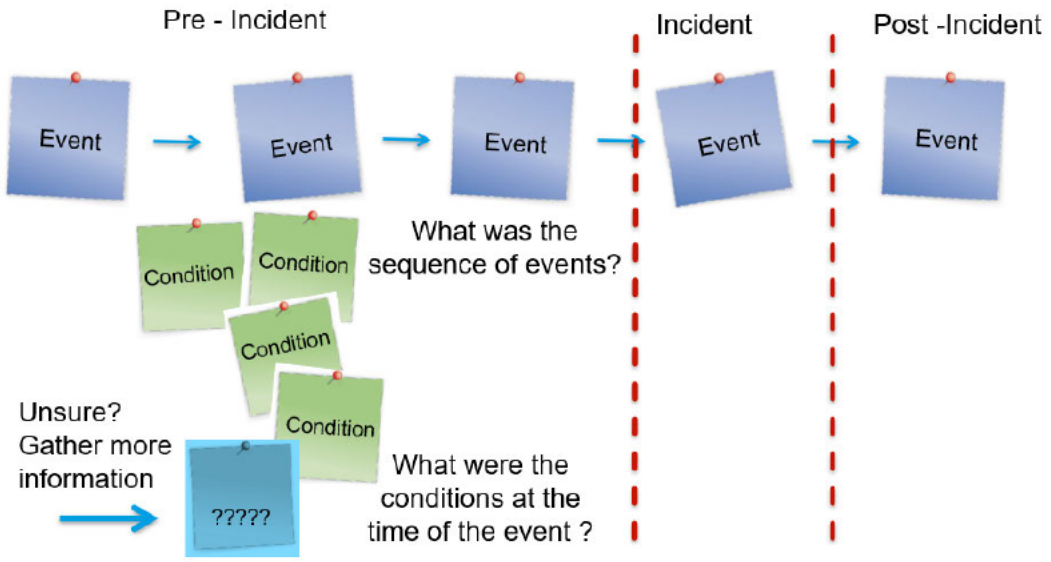


Figure 10 A diagram showing how an event and conditions chart can be built.

Phase 3: Framing the contributing factors to allow for organisational learning

The IMPAC Incident Cause Analysis Method uses an adapted version of the 'Barrier Model', developed by James Reason, Jens Rasmussen and others as a way of using systems theory to model accidents and enable learning and improvement at multiple levels within the organisation.

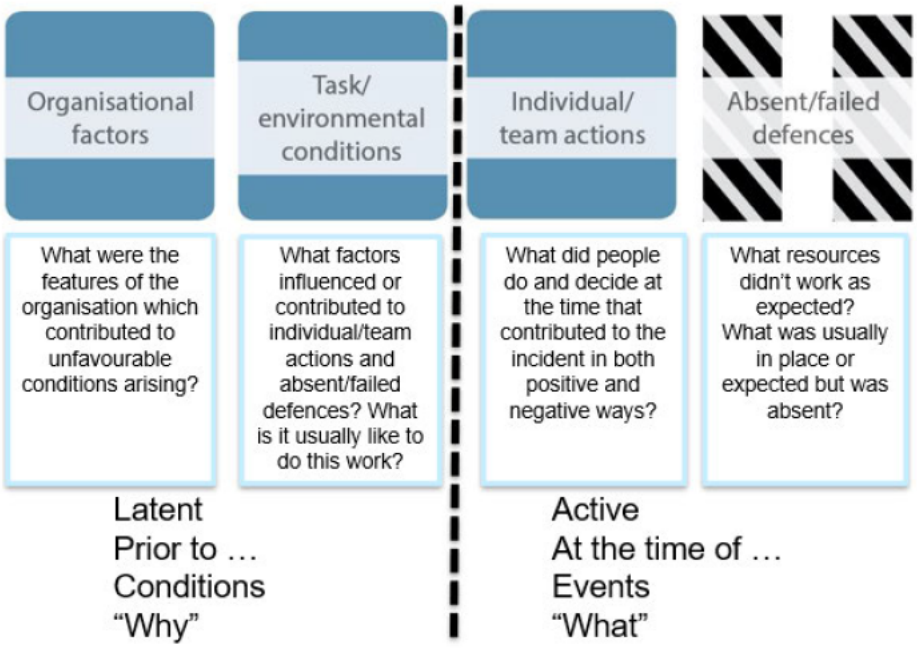


Figure 11 A diagram showing how an ICAM Analysis chart can be built.

Phase 4: Drafting the investigation report and developing recommendations and action plans

The investigation report has been written with the multiple aims of providing a clear picture of how the investigation was conducted, building a comprehensive narrative of what happened and why, and creating a platform for learning and improvement.

Recommendations are both shorter and longer-term, and flow from the contributing organisational factors and absent and failed defences.

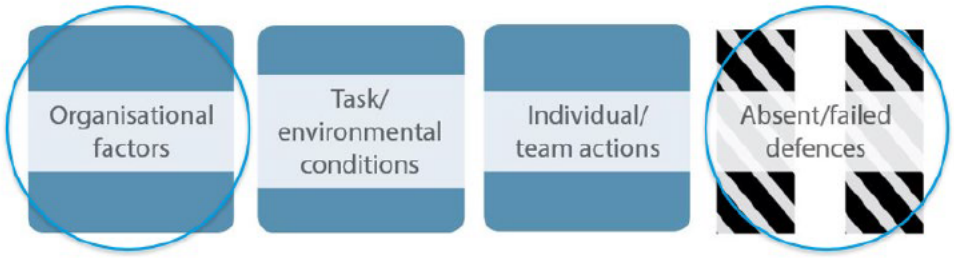


Figure 12 A diagram showing how the ICAM Chart can be used to develop both immediate and longer-term recommendations for both operational and organisational learning and improvement.

Investigation findings

Sequence of events (summary)

Refer to appendix for the full sequence of events.

Pre-Incident	
13/01/2010	**Bronto F32 RLX FEY849 goes into service**
20/06/2017	**L2 Investigation due to auto-levelling fault on cage**
20/11/2019	**L1 Investigation due to load cell and cage impact damage, load cell replaced**
20/09/2020	**10-year major service**
21/12/2020	**Appliance acceptance test in Auckland completed**
17/02/2021	**Suspension issue noted**
15/03/2021	**L1 investigation (#6709) engine labouring while deploying hydraulic jacks**
21/03/2021	**Hydraulic leak and cracks noted in sub-frame, sent to Auckland & Hamilton for repair, delays due to Covid**
16/12/2021	**Appliance back in service**
21/01/2022	**L1 investigation resulting from cage loading sensor fault (#9185)**
25-27/01/2022	**Cage load sensor recalibrated**
01/02/2022	**Report of engine labouring while deploying all jacks simultaneously**

Incident: Events of 02/02/2022	
08.00 approx.	**Shift handover at Newtown, decision made to take FEY849 to Kilbirnie to explore engine labouring issue**
08.40 approx.	**FEY849 departs Newtown for Kilbirnie**
08:48.34	**FEY849 responded to fire at 91 Yule Street**
08.55	**NEWT221 and WELL211 pump appliances arrived at 91 Yule Street**
08.56.39	**FEY849 arrived at 91 Yule Street, NEWT225 crew was immediately tasked by the Incident Controller to set up the aerial appliance to provide exposure protection for the dwelling next door (93 Yule Street)**
08.59.26	**FEY849 requested a base pump to supply water to aerial monitor (at time of call)**
09.00 approx.	**The Operator and Officer position the aerial and deploy the jack legs**
09.05.53	**Message to FireCom: "Setting up aerial monitor for fire attack"**
09.06 approx.	**Operator raised the main boom to approximately 70 degrees**
09.06 approx.	**As the Operator attempted to extend the fly boom, they lost all power and was unable to undertake any further movements of any part of the aerial. The Operator and subsequently the aerial Officer undertook immediate fault-finding, attempting to use the diesel and electrical backup systems to regain movement. During this fault finding process an additional aerial appliance (THOR235) was called for, and a change in firefighting tactics was implemented, including the use of a ground monitor. During an emergency fault process the OIC and Operator will work concurrently on fault resolution coordinating their activities. They will communicate as they work as each alternate between fault resolution and providing feedback. The aerial has three control panels at the rear, the pulpit and in the cage; all equipped with an intercom system to enable communication**
09.13	**Message to FireCom advising aerial not functioning and request for second aerial (THOR235)**
09: 31	**THOR235 received a K28 (appliance no longer required, can return to station)**

Post-incident	
08/02/2022	**PIN and Cease Work Notice issued by a Health and Safety Representative on FEY849**
08/02/2022	**Access Specialties and Fleet Representative complete further diagnostic work on FEY849, noting the load cell needs replacing**
14/02/2022	**Fleet notified that a L2 investigation was proposed for the incident at 91 Yule Street**
25/02/2022	**WorkSafe issue a letter to DCE requesting the PIN lodger to conduct further work with the PCBU with regard to the specific issue.**
02/03/2022	**L2 investigation team undertook testing on FEY849, identifying a worn sensor block and replicating the engine labouring issue**

Causation analysis

Absent/failed defences

This section analyses the risk controls and defences at the time of the event that contributed to the incident and discusses learning opportunities.

Factor	Type	Description
Control and recovery	Failed	An intermittent failure of the load cell caused the aerial appliance to stop working on 02/02/22.

Factor	Type	Description
Control and recovery	Failed	The emergency stop activation had the effect of temporarily disabling the backup Hatz and battery power systems, as it is designed to do. It is not known whether there was an intermittent fault with the emergency stop or whether the emergency stop buttons were not fully reset.

Factor	Type	Description
Detection	Failed	The control panel display on the Bronto RLX does not clearly indicate status of power supply to the aerial unit (i.e., main engine, diesel Hatz or battery). This is not helpful for Operators when trying to diagnose a fault under time pressure.

Individual/team actions

This section provides analysis of the contribution of individuals and teams at the time of the event. The analysis of individual/team actions at the time of the incident is done from the starting point of appreciating and understanding, not blaming and defending.

Factor	Description
Knowledge	The Operator used the emergency stop (button) to ensure the appliance main engine was shut down before attempting to start up the Hatz diesel back-up. Enquires by the investigation team to Operators in Wellington, Dunedin and Christchurch suggests that this has become common practice. Auckland Operators said they use the engine start stop button to stop the engine before using the Hatz. It should be noted that the Type 5 Bronto F32 RLX and F32 RLH Study Guide states that the start/stop button should be employed before activating the Hatz. The Bronto design intent for emergency stops is to stop all movement of the aerial and shut the truck engine off in an emergency. This indicates a potential gap between the designer's intent and how the appliance is operated.

Factor	Description
Knowledge and skill	Both Operators each have had more than 20 years' experience in operating aerial appliances and have participated in all training and revalidations. The investigation found no reason to doubt their capability, competency or decision making under pressure. At no point was there an increased risk to safety as a result of the Operator decision making, or the appliance fault. The Operators were not concerned for their immediate safety due to the fact that a water supply to the aerial appliance had been established.

Factor	Description
Knowledge and skill	The decision for positioning of the aerial appliance on the incident ground was operationally sound based on dynamic risk assessment and the Type 5 Bronto F32 RLX and F32 RLH Study Guide which states; that the appliance should be sited to "Ensure the safety of the appliance and aerial." Ultimately, the positioning had no adverse impact on the strategy and tactics deployed.

Factor	Description
Knowledge and skill	The decision to divert NEWT255 from its journey to Kilbirnie to the Yule Street fire was made on the understanding that the engine labouring fault reported the night before in no way compromised the operational capability of the aerial. The OIC made the decision for the aerial to remain operational on 02/02/2022 based on a dynamic risk assessment.

Task/environmental conditions

Factor	Description
Task complexity	There were many other layers of defence which meant there was no uncontrolled risk to Operator safety as a direct consequence of the aerial failure. The use of heavy aerials to respond to this type of single-storey, residential fire has become standard practice in Wellington. The rationale for this includes tactical siting considerations taking into account Wellington's steep and narrow streets, vehicle congestion and the ability a heavy aerial has to reach horizontally over obstacles. The strategy for use of aerials across NZ has been under discussion since April 2020, with the aim of understanding how aerials are used and providing strategic guidance and policy moving forward. Heavy aerials are complex with many safety features, sensitive electronic sensors, and computer control systems. Both Operators have had more than 25 years' experience in operating aerial appliances and have participated in all training and revalidations. This expertise likely enhanced effective dynamic risk assessment, and contributed to the successful outcomes of the incident, despite challenging conditions and equipment failure. Conditions at the time were very noisy. [redacted] The computer screens at the cage, pulpit and rear control positions are small and difficult to read outdoors because of light reflections, even under overcast conditions. This can make it difficult to quickly see system status.

Organisational factors

Factor	Description
Maintenance management	Maintenance management challenges exist with fault reporting and communication between Fleet and Service Delivery (operational Firefighters). The current fault logbook does not allow for faults to be clearly defined, categorised, prioritised and rapidly communicated. It also does not encourage feedback between the Operators and the Service Providers. National and organisational guidance on how vehicle maintenance, fault reporting and recording (e.g., PMFT02 Repair and Maintenance of Vehicle Process) is not consistently known, understood, or applied. The Yule Street incident has revealed an important improvement opportunity for FENZ at an organisational level – namely to improve how aerial faults are understood and reported by Service Delivery, and how Fleet define faults, communicate maintenance activity and operational readiness of aerials.

Factor	Description
Procedures	Procedures developed at a District/station level including weekly inspections and checks for aerials are inconsistent across regions and may not be aligned to manufacturer and/or AFAC guidelines. The FL7 forms (daily/weekly checklists) currently located under 'Bookshelf', are titled 'service checklist', contain terminology that creates confusion between Fleet and Service Delivery (Operators). While much of the content of the FL7 documents is correct, the design and layout of the documents is not optimised for the end user/Operator.

Factor	Description
Organisation culture	Challenges with trust and transparency exist between parts of the organisation may lead to barriers to collaboration and effective communication.

Factor	Description
Incompatible goals	The organisation and its constituent parts has multiple goals which include reducing the incidence and consequence of fire and other emergencies in the community, to protect what communities' value and to use and maintain resources and assets most effectively. These goals can become misaligned and ultimately a source of frustration and conflict. The investigation team found that different parts of FENZ have perceptions of each other that they are pursuing goals in ways that are incompatible. Specifically, how, when and where heavy aerials are used, the maintenance and repair demands' that usage create, and the resourcing and management of this maintenance and repair. The investigation team also found that some good work is underway to address these issues and realign goals – namely the national aerial strategy review and recent collaborative work for aerial replacement.

Factor	Description
Training	The design and management of training and continuing professional development for aerial Operators is a complex and challenging task. There are gaps in the technical training of aerial Operators. Furthermore, the aerials incrementally change and improve over time, resulting in subtle but significant differences even within model numbers. The subject matter experts (in this case Bronto) are not NZ-based, and more recently Covid has limited the ability of the SME to travel to NZ. A procurement process for complex equipment such as aerials must consider effective on-going technical training/upskilling and support for Operators.

Recommendations

Immediate/short-term recommendations

Recommendation 1

Title:	Re integration of FEY849 into full operational service
Person responsible:	Mike Moran, National Manager Fleet
Date due:	Six weeks (30 September 2022) subject to Station Representatives' availability.
Description:	a. The fault that caused the incident is found and rectified (cage load cell). b. A facilitated meeting between on Station Representatives and the Region Fleet Coordinator to share and outline potential ongoing faults (that have been recorded by Station Representatives) and a fault resolution strategy. c. The completed appliance is carefully checked over, paying particular attention to aerial sensors to ensure they are working within manufacturers tolerances, resolving the reported engine labouring issue and checking the functions of the emergency stop system are working to manufactures specifications. d. A new CoF to provide a 3rd party road worthiness safety inspection, operational acceptance and refresher training as required.

Recommendation 2

Title:	Technical expert facilitated session on Bronto F32 RLX FEY849 operation
Person responsible:	Mike Moran, National Manager Fleet
Date due:	One month subject to availability of the Bronto Technical Expert, Wellington-based Aerial Trainers and Station Representatives.
Description:	Ideally undertaken concurrently with Action 1, subject to COVID-19 restrictions, support the Wellington-based type 5 aerial Trainers and Representatives by running a practical training session, with Bronto F32 RLX FEY849, provided by a Bronto technical expert. This will serve multiple purposes: it will improve technical knowledge of the complex automation features of the Bronto F32 RLX FEY849, it will help to rebuild trust in the appliance, and allow for specialist advice for operation and Operator checks.

Recommendation 3

Title:	Develop and publish a policy and procedure for identification, assessment, and reporting of faults
Person responsible:	Mike Moran, National Manager Fleet
Date due:	Six months

Description:	PMFT02 Repair and Maintenance of Vehicle Process (26/06/2018) exists and can form the basis of a policy and procedure for identification, assessment, and reporting of faults. There must be clear description of how the fault logbook is used, how faults are risk assessed and classified, and even the language used to talk about 'faults', 'damage', 'breakdowns. This should also be aligned with other parts of the organisation where reporting is required, as far as possible. *In April 2014 the then Region Fleet Coordinator issued a diagrammatical memo detailing an instruction for how to capture Type 5 faults utilising the display screen on the aerial unit. This can be used as a basis for reporting moving forward.*

Continuous Improvement/Longer-term recommendations

Recommendation 4

Title:	Type 5/6 Aerial Training Review and Improve aerial Operator training and refresher training
Person responsible:	Bruce Stubbs, Region Manager
Date due:	12-24 months
Description:	Review and improve the Type 5/6 aerial training programme to include an advanced practical training course provided by a Bronto technical expert. This will help aerial Trainers to have a more in-depth understanding of the underlying design features and the differences between FENZ appliances. *National Training (with the assistance of Fleet as required) and aerial appliance Trainers should collaborate to improve the content and frequency of the training provided to aerial Operators.*

Recommendation 5

Title:	Foster stronger collaboration between Fleet and Service Delivery
Person responsible:	Bruce Stubbs, Region Manager and Mike Moran, National Manager Fleet
Date due:	Six months
Description:	There needs to be a concerted effort by both National Fleet and Service Delivery to work more collaboratively on national aerial appliance issues when they arise. The current Aerial Appliance Strategy has begun to mend this relationship by bringing key Stakeholders together in a more cohesive and collaborative approach. That being said, there needs to be more transparency and good faith engagement from both Fleet and Service Delivery (end users) with an intent to successfully resolve issues as they arise.

Recommendation 6

Title:	Trial a software-based system for recording and reporting on heavy aerial faults
Person responsible:	Mike Moran, National Manager Fleet
Date due:	24 months
Description:	The current paper-based system has limitations for both Operators and the service provider. Maintenance management systems such as Zendesk present many opportunities for improving the quality and speed of communication between the end user and the service provider. This system is in use in other sectors of FENZ, having a common system makes it easier for the end user to navigate and use.

Recommendation 7

Title:	Action management and resourcing of Level 2 investigation recommendations
Person responsible:	Bruce Stubbs, Region Manager and [redacted], Manager Safety Health And Wellbeing
Date due:	12 months
Description:	Fire and Emergency New Zealand should review how it manages and resources the completion of recommendations from past Level 2 Investigations. This investigation has raised questions over the ownership and implementation of recommendations between directorates, and the level of inter-organisational co-operation.

Notable findings which did not directly contribute to the incident

Safe@Work action management features are not being fully or consistently utilised. The system has the capability for actions to be created and managed as part of a Level 1 investigation.

At the time of the investigation, it is not known whether the load cell failure and the emergency stop use were interlinked in some way via the electronic and programmable systems of the Bronto F32 RLX.

The investigation team found that most of the documents referred to by the investigation team did not have consistent document control applied. This can make it difficult to confirm versions and ensure consistency.

The investigation team noted that although PMFT02 Repair and Maintenance of Vehicle Process (26/06/2018) exists there is no process documented for the impounding of a vehicle due to an incident or injury that may be notifiable to WorkSafe.

Appendices

Witness interviews

The names of the people who witnessed the event and were interviewed as part of the investigation:

Detailed Sequence of Events and Conditions

Pre-incident:

1. **13/01/2010:** FEY849 goes into service. The newly procured Bronto 32m RLX aerial fitted to a Mercedes chassis goes into service in Wellington Area with the callsign Wellington 215 (WELL215).

   The Bronto F32 RLX unit fitted to FEY849 is the 32nd of this model ever built by Bronto globally. The RLX currently in use in Auckland is the 83rd RLX built. We have confirmed that Bronto make incremental design improvements to the RLX over time. An example of this is that the Auckland-based RLX Boom to cage transition ladder controls are integrated into the both the cage and pulpit operating stations. The Newtown Bronto F32 RLX has separate controls for the same component in the cage (controls were retro fitted at the pulpit station at a later date). It is a complicated machine with many back-up and safety systems and features. The investigation team had first-hand experience of how very small issues can result in designed safety features preventing normal operation. Ref. Auto-housing system disabled by the computer control system due to sensor pad wear of only a few millimetres, noted during site visit to Trentham, 02/03/2022.

   From 2011, the Senior Station Officer at Newtown developed an innovative approach to aerial tactics, in part influenced by overseas learning opportunities, and in part by the geography (steep hills), building types (older timber buildings, single storey, close together) and access constraints (narrow winding streets with many parked vehicles). Aerials were, and still are, sent to single storey building fires, for their ability to reach horizontally, over obstructions, and deliver greater volumes of water to protect exposures and attack fires to extinguish them rapidly. This may explain in part the varying perceptions and opinions on what aerials are used for, and should be used for, in different regions, and by different groups within the organisation as a whole.

2. **2013:** FEY849 (WELL215) moved to Newtown station with the callsign Newtown 225 (NEWT225) during the refurbishment of Wellington station. This aerial appliance was temporarily moved to Newtown fire station while earthquake strengthening, and the refurbishment of Wellington fire station was undertaken.

3. **01/04/2014:** A diagrammatical Type 5 fault reporting instruction issued to Area 16 by Region Fleet Coordinator.

   There is a gap between how Fleet see and define 'faults' and how 'faults' are seen and therefore reported by Operations. For example, aerials are designed with numerous sensors which are connected to their computer control systems, Bronto systems are monitoring all the sensors/signals constantly and will prevent the aerial getting into an unsafe situation. When the system prevents the Operator going into unsafe territory and stops the boom movements then Fleet do not consider that a fault. However, if a sensor is out of adjustment i.e., 'not sending the correct information' Fleet would consider this a fault. The investigation did not find a National Policy and Procedure that defines fault types or details the process for determining the severity of faults and fault reporting for aerial appliances.

4. **2015:** Due to space constraints during the Newtown Fire Station rebuild, FEY849 (NEWT225) is relocated to Wellington fire station.

5. **2016:** FEY849 permanently located at Newtown fire station and put on PDA/ beat list for the South coast areas. This appliance is strategically moved from Wellington fire station, and the PDA and beat lists are modified to reflect this. It is also added to structure fires along the South coast area.

6. **20/06/2017:** Following an incident where the auto levelling on the cage of FEY849 failed, a Level 2 Investigation was conducted, and seven corrective actions recommended. The corrective actions were recorded in a now defunct system (AERIK). As a result, the CAPs could not be recorded or assigned, so ultimately, we have no way of tracking whether these were completed or not.

7. **20/11/2019:** A Level 1 investigation (#2409) was conducted after the cage and subsequently the load cell was damaged on FEY849. The report concluded; "*the damage was caused by the cage striking the jack block housing. There was not a satisfactory agreement between the Driver and the Operator as to where the appliance was sighted to be deployed. The Operator was either not trained adequately in the hazards associated with unhousing the cage and boom of the apparatus or was not instructed and therefore not aware of the obstruction that could be encountered when manoeuvring the cage and boom in such a configuration, or, had no adequate observation by themselves or a designated Observer to avoid the encounter, or, did not have the competency to conduct such a manoeuvre*." A subsequent insurance claim was lodged on 12/12/2019. The cage was repaired, and the load cell replaced under insurance. There were no further details in the investigation report with regards to corrective actions.

8. **20/09/2020:** FEY849 was sent to Access Specialties, Auckland for the scheduled 10-year major service.

   A 10-year major service is recommended by WorkSafe (Best Practice Guidelines, Mobile Elevating Work Platforms, 2014) however fire appliances are excluded from the scope of these Guidelines. The AS/NZS 2550-10 standard includes an exemption for Fire services from the 10-year major service requirement. FENZ Fleet however choose to complete these services on aerials as a commitment to best practice.

9. **03/12/2020:** Post major service QA completed at Access Specialties, Auckland by Access Specialties staff and Representative from National Fleet Team.

10. **21/12/20:** the appliance was acceptance tested by career Type 5 Operators in Auckland to ensure it was at an acceptable standard before returning to Wellington. The following is an email from one of the Auckland type 5 testers following the acceptance test:

[email from [redacted]) to [redacted]) 21/12/2020]

Re checked 21-12-20
** leveling system for aerial worked ok.*
**cage staying on 3MAN setting after power off., Suspect this may be normal.*
**fly boom ladder fixed*
**basket level fixed*
**wheel nuts fixed*
**Hatz motor painted*
**Water curtain fixed*
**Foot plates have been adjusted.*

To be rectified

- *didn't find evidence of testing of the breathing air system. Assuming this will get sorted in Wellington?*
- *The appliance is still not reliably returning to the correct ride height after the aerial has been used. It appears if you engage the PTO and then disengage without using the aerial the ride height drops and re levels as expected. However, when using for longer periods the truck will not re level after pack up.*
- *The test conditions where it did not re level were.*
- *PTO engaged, appliance auto levelled, boom operated from ground control, appliance stopped using emergency stop at GC., restarted at GC, power changed to basket, all controls operated, booms auto housed, jacks packed up PTO disengaged.*
- *Ride height warning showing on dash, truck driven forwards and reverse around car park and wouldn't return to correct ride height. Fixed problem by turning truck on and off.*

11. **17/02/2021:** Suspension issue noted via email to Region Fleet Coordinator. This was determined to be an airbag fault and picked up during an acceptance test conducted in Auckland by career Type 5 Operators, see above.

12. **15/03/2021:** Email from [redacted] to Area 16 indicates that FEY849 is back on the run as of today.

13. **15/03/2021:** Level 1 investigation undertaken (#6709). The description of the incident was similar to what occurred in 02/02/2022. The findings of this investigation included issues related to both the maintenance and operation of the aerial appliance.

14. **21/03/2021:** Hydraulic leak and subframe cracks: A hydraulic leak was found, and the vehicle was sent to Dynaflow, Wellington (hydraulic experts). While Dynaflow were conducting checks, they noted and photographed some cracks in the subframe of the vehicle. The Region Fleet Coordinator was notified of the cracks.

15. **30/03/2021:** Bronto Australia were contacted regarding the cracks and provided drawings for a pre-determined modification (for gussets to strengthen the frame and alleviate the cracking). When the drawings arrived the local service agent Lockheed Martin determined they were not sufficiently qualified with the required welding procedure to undertake repairs, so it was determined that the vehicle would be sent to Access Specialities (Auckland) who were better equipped to carry out the modification. There was a time delay due to awaiting the sourcing of the correct grade of steel, laser cutting and then sending the vehicle to Auckland for repair.

16. **18/05/2021:** FEY849 sent to Access Specialities, (Auckland) to fit/weld in the gussets as per Bronto's instructions.

17. **June to Sept 2021:** Unsure of the exact date but FEY849 went to Keith Andrews in Hamilton to get the suspension issue sorted. The Auckland Covid lockdown made it difficult to move people and equipment across the Auckland/Waikato border. As best we can see, appliance FEY849 left Hamilton around the 9/10th September.

18. **16/09/21:** FEY849 sent to Access Specialties for internal testing, due to suspension levelling issues.

19. **23/10/2021:** Acceptance test of FEY849 conducted by Access Specialty staff and Auckland career Type 5 operators. This acceptance test was put in place to prevent the appliance being returned to Wellington, failing a test, and then having to be sent back to Auckland. An email (see below) indicates that the Auckland career Type 5 operators were not happy with the results of the testing undertaken.

20. **26/10/2021:** Email from [redacted]) to [redacted]

On the advice from crews in Auckland and subsequently the users in Wellington we asked for the repairs to be undertaken in Auckland with their service agents before sending it back. We had similar experiences of ongoing reliability issues after 235 had undergone its mid-life refurbishment so were keen to avoid that.

AIR BAG SYSTEM.

My understanding of the air bag problem was the truck would not reinflate its airbags after the aerial had been housed and the PTO disengaged. The fix Appears to be that the Air bags no longer deflate when the aerial is engaged. The air bags stay inflated at all times in road and aerial modes. If this is how the fix is supposed to work, then it worked as expected and there were no occasions where the appliance was not ready to drive after aerial use.

EXTENDING FLYBOOM LADDER CONTROLS

I noticed the fly boom extension ladder controls appear to be an afterthought and do not operate off the standard Bronto control panel like the Auckland type 6. If this is an afterthought the controls stay live at all boom angles and allow the ladder to be deployed in situations that cause the ladder to crash into the main fly boom ladder. Just need clarification this is how it should work.

ENGINE POWER WHEN JACKING.

While testing the jacking functions I found operation of all 4 jacks at once caused the motor to really struggle and when the jacks reached the end of their travel the engine almost stalled. This seems very unusual; I spoke to a Wellington Operator about it, and they don't believe that is how it operated when new but has been an issue for the last few years. He also mentioned the truck would really struggle with hill climbs in Wellington, It would almost stall in first gear. Not sure if this is a fault or if high idle has been set to low or we don't have enough horses under the bonnet

21. **16/12/2021:** Email from [redacted] to DM [redacted]:

> *Hi* [redacted]
>
> *You're probably aware that the Newtown Type 5 is back in Wellington and the crew are training on it. Apart from one rubber block that could do with replacement (not a safety issue nor does it affect the operation of the appliance, and we have action underway to replace), I'm not aware of any other issues with the appliance. Our aim is to get the Type 5 back into operational service in Newtown before Xmas, which will release the Type 4 currently at Newtown so that it can be available as a relief Type 4 should one be needed over the Xmas break. We would locate the Type 4 at Lockheed until and if it's needed to be used as a relief at a station either in Wellington or elsewhere.*

This email is an example of the challenges of managing the inspection and maintenance of a highly complicated item of plant, with extensive safety features and low tolerances, for both Service Delivery and Fleet. The Fleet SME suggested that either damage or misalignment of these rubber blocks, or replacement with a block of a slightly different size, could cause 'negative loading' of the load cell over time resulting in an intermittent fault.

22. **20 -21/12/2021:** Fault book records faults not affecting the aerial component.

23. **21/01/2022:** Incident happened which resulted in Level 1 investigation (#9185), reported 07/02/2022) due to boom failure, (the Bronto unit constantly monitors all boom systems, if it detects any variation outside of the manufactures operating parameters the boom will stop, and a fault will be logged in its system) movements of the boom were halted during a movement. *Appliance froze. Cage loading sensor was showing an overload, with four Firefighters and gear in the cage. Set for five persons. The problem occurred again with only two personnel in the cage. Multi button was used to deliver crew back to solid ground.* The outcome of this investigation noted "the *appliance recalibrated at workshops by technician. Appears to be working properly, with a few idiosyncrasies. These have been pointed out verbally, they result in a cage loading variation of up to 50kg. We have requested written notice of these faults from the Technician".* On 28/02 [redacted] noted: Investigation outcome inconclusive. Fault still occurring. Recommendation that this fault is further investigated.

24. **25-27/01/2022:** Access Specialities had been with this truck on the 25-27 January 2022 to recalibrate the cage load sensor as they believed at the time it was out of calibration and causing an issue. #9185 states that a verbal report was provided by Access Specialties *that the aerial 'appeared to be working properly, with a few idiosyncrasies, they result in a cage loading variation of up to 50kg*. The GM requested written notice of these faults from Fleet to be provided by the Access Specialties Technician. (Subsequent work done on 08/02/2022 following the Yule Street incident revealed that the load cell was malfunctioning and needed replacing. This is a part that usually does not need replacing).

25. **01/02/2022:** Fault book noted: Rubber mount under cage deteriorated, needs replacing.

26. **01/02/2022:** Fault book log of engine labouring: While raising the jack legs of FEY849 the engine was labouring. This was captured on video and subsequently given to the Fleet team and the Level 2

investigation team. It has been noted by the Fleet SME (Subject Matter Expert) on the investigation team that *this engine labouring is not normal according to Bronto. (Note:* The Level 2 investigation team were able to replicate this issue at Lockheed Martin).

Incident:

1. **08:30 approx.:** NEWT225 Aerial (FEY849) Departed Newtown Station bound for Kilbirnie Fire Station in order to conduct checks related to the engine labouring incident noted the previous night while "jacking" the vehicle.
2. **08:45.45:** 02/02/2022, Structure Fire at 91 Yule Street, Lyall Bay, called in by GM [redacted] who happened to be driving in the area and noticed smoke.
3. **08:48.34:** NEWT225 (FEY849) alerted to a structure fire, 91 Yule Street. Re-routed to 91 Yule Street.
4. **08:48.45:** House reported to be fully engulfed.
5. **08:50.51:** 'Persons Reported' (means there could be people inside).
6. **08:51.42:** Newtown 225 Proceeding to 91 Yule Street.
7. **08:52:** GM [redacted] arrived [redacted]
8. **08:56.39:** Newtown 225 logged in attendance at 91 Yule Street.
9. **08:56 – 09:06:** Seven appliances arrive between this time.
10. **08:59.26:** NEWT225 request base pump to supply water for aerial monitor.
11. **09:05.53:** Sitrep: Exposures protected by LPDs (low pressure deliveries) on 2 sides, defensive tactical mode, setting up aerial monitor (NEWT 225) for fire attack.

[redacted]

[redacted]

Post incident:

1. **08/02/22:** Provisional Improvement Notice (PIN) and cease to work notice issued by the District Safety, Health and Wellbeing Representative against FEY849. Following the incident at 91 Yule Street, the Health and Safety Representative advised District Manager Pyatt in writing that they were issuing a PIN and Cease to Work notices against NEWT225 (FEY849). On 25 February Worksafe issued a letter to DCE Wood cancelling the PINs on the grounds that the Health and Safety Representative that lodged the PINs failed to consult with FENZ on this specific matter first.

2. **08/02/22:** Access Specialties and Fleet Representative completed further diagnostic work on FEY849. There was contact throughout the day with a Bronto Tech based in Australia. It was found that when the boom was housed in the transport position the cage was tilting slightly forward and the cage was hard down on the rubber buffers. (With the vehicle stationary this gave a minus 130Kg and minus 136Kg reading from the load cell). Bronto Australia said this was too much of a negative load on the load cell. There was also an intermittent fault with the load cell, with different readings in 'hot' and 'cold' states. The 'amplifier card' was ruled out. The conclusion of the investigative work on the aerial was that it was the load cell itself that has a changeable variance between cold and warm. Therefore, the load cell needs replacing.

3. **09/02/22:** Russell Wood, FENZ Deputy Chief Executive Organisational Capability and Strategic Development issued a statement regarding the reliability of the FENZ aerial Fleet.

4. The National Fleet Team proceeded to investigate the fault on FEY849 following the Yule Street incident, decided on a remedial course of action and as a result replaced the load cell on the vehicle prior to the Level 2 Investigation Team having sighted the vehicle. The investigation team noted that although PMFT02 Repair and Maintenance of Vehicle Process (26/06/2018) exists there is no process documented for the impounding of a vehicle due to an incident or injury that may be notifiable to WorkSafe.

5. **14/02/22:** Fleet notified that a Level 2 investigation was proposed for the 02/02/2022 Yule Street incident.

6. **02/03/22:** The Level 2 Investigation Team gathered at Lockheed Martin and undertook some tests with FEY849. During these tests a worn nylon sensor block was identified which caused a boom sensor not to activate. The Fleet SME was also able to replicate the engine labouring fault that was mentioned on 20/01/21 (see pre-Incident point 15) and again on 01/02/22 (see pre-incident point 28).

Documents reviewed

Documents reviewed as part of the investigation process:

- Report written by the NEWT225 OIC giving an account of events on the day of the incident.
- AER2017 15977-N Fire and Emergency Level 2 Investigation Report 20th June 2017.
- Fire and Emergency Safe at Work Incident Case Report #2409, 19th November 2019.
- Fire and Emergency Safe at Work Incident Case Report #6709, 15th March 2021.
- Fire and Emergency Safe at Work Incident Case Report #9185, 21st January 2022.
- NZFS 2010 Scholarship Report "The Response & Tactical Deployment of Aerial Appliances".
- FENZ Procedure, FL7-Mu, Aerial appliance Service Checklist V4.0, 23rd February 2021.
- AFAC Aerial Appliance Maintenance Guideline, V3 13th May 2021.
- Fire and Emergency aerial strategy discussion document (July 2020).
- FENZ Aerial strategy Review Discussion Document "*Collated Feedback*", 9th August 2021.
- FENZ Incident Report F3413110 (including the ICAD log).
- Bronto Skylift F32 RLX User Manual.
- FENZ Type 5 Bronto F32 RLX and F32 RLH Study Guide.
- FENZ Policy FL4 Aerial Appliances 27th January 2022.
- PMFT02 Repair and Maintenance of Vehicle Process, 26 June 2018.
- AS 2550.10: Cranes, Hoists and Winches – Safe Use – Mobile Elevating Work Platforms.
- AS/NZS 1418.10 Cranes, hoists and winches - Part 10: Mobile elevating work platforms: Amendment 1:2017.
- FEY849 Appliance Fault Book.
- Area 16 Aerial appliance fault reporting Instruction 1st April 2014
- WorkSafe (2014) Mobile Elevating Work Platforms Best Practice Guidelines