Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT

Aviation Occurrence Investigation AO-2009-075

Final

Midair collision
20 km south-east of Orange
New South Wales, 8 December 2009
VH-NFO, Aerospatiale AS.350B
VH-LXC, Kawasaki BK117

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Midair collision - 20 km south-east of Orange, New South Wales - 8 December 2009 - VH-NFO, Aerospatiale AS.350B and VH-LXC, Kawasaki BK117

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Abstract

On 8 December 2009, at about 1840 Eastern Daylight-saving Time an Aerospatiale AS.350B helicopter, registered VH-NFO (NFO), and a Kawasaki BK117 helicopter, registered VH-LXC (LXC), were engaged in aerial firebombing operations about 20 km south-east of Orange Aerodrome, New South Wales (NSW). During one of the water drop sequences, while in the vicinity of the drop point, LXC's main rotor blade tip(s) contacted the trailing edge of NFO's vertical fin. There was light damage to NFO and there were no injuries, although the outcome could have been more serious.

There were no published procedures for pilots to follow to ensure separation from other aircraft when there was no air attack supervisor present. Instead, the system relied on the airmanship and experience of pilots to mutually arrange separation. In this case, the water source was about 600 m from the fire front and NFO had departed the water source shortly before LXC. The investigation established that neither pilot was aware of the position of the other helicopter as they approached the drop point.

In response to the occurrence, the NSW Rural Fire Service developed a series of mission management standard operating procedures, including the use of standard terminology for aerial firefighting activities. These were to be introduced to contracted and other operators via a series of workshops commencing in November 2010.

After being approached by a number of firefighting authorities, in July 2009 the Civil Aviation Safety Authority (CASA) commenced a Firefighting Review. In November 2009, a Firefighting Operations Manual project team was established including five CASA staff, one fire authority staff member, 11 industry representatives and one consultant to draft a proposed manual. The aim was for the manual to standardise aerial firefighting procedures across the authorities. At the time of release of this report, the draft manual had been distributed to the various fire authorities for their review.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB’s investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flight

On 8 December 2009 at about 1840 Eastern Daylight-saving Time[1], an Aerospatiale AS.350B helicopter, registered VH-NFO (NFO), and a Kawasaki BK117 helicopter, registered VH LXC (LXC), were engaged in aerial firebombing operations about 20 km south-east of Orange Aerodrome, New South Wales (NSW) (Figure 1). One pilot was on board each helicopter. After the pilot of NFO had landed to refuel, he noticed damage to the trailing edge of the helicopter's vertical fin. In addition, the plastic anti-collision light cover on top of the vertical fin was broken. The pilot reported the damage to the pilot of LXC. Examination of LXC did not reveal any apparent damage. There were no injuries.

Figure 1: NFO (left) and LXC (right)

There was significant bushfire activity in NSW on the day of the occurrence and the weather conditions in terms of fire risk were categorised as 'catastrophic'. NFO and LXC had been hired by the NSW Rural Fire Service to conduct fire related operations. In the period leading up to the occurrence, the helicopters were employed by an Air Attack Supervisor (AAS)[2] to conduct firefighting activities (water bombing) along with another helicopter and two aeroplanes. However, a higher priority task required the AAS and the other helicopter and two aeroplanes to depart, leaving only NFO and LXC on task. That development was communicated to the pilots of NFO and LXC by radio. Situations where pilots conducted firefighting operations without an AAS were not unusual and both pilots had operated in such an environment many times. The practice was for pilots to maintain separation from other traffic using 'see-and-avoid' procedures.

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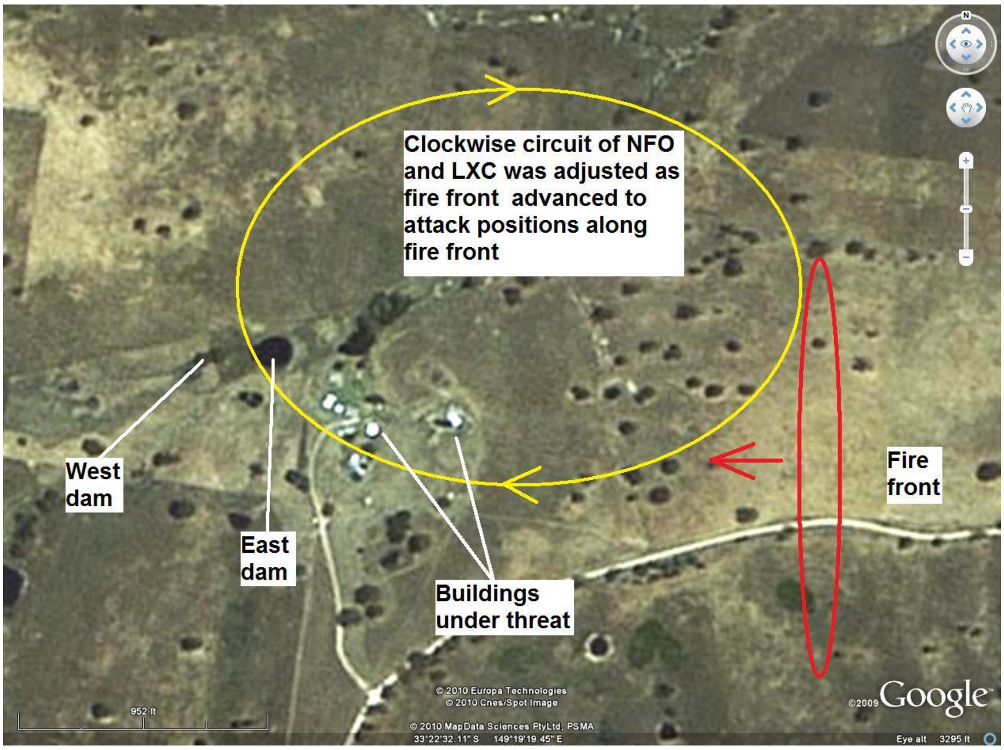
1 The 24-hour clock is used in this report to describe the local time of day, Eastern Daylight-saving Time, as particular events occurred. Eastern Daylight-saving Time was Coordinated Universal Time (UTC) + 11 hours.

2 The NSW Fire Agencies Aviation Standard Operating Procedures described an Air Attack Supervisor (AAS) as being skilled and experienced in fire behaviour and aerial suppression and the planning of air attack operations. The AAS's responsibilities included directing firebombing aircraft over a fire. In all cases, the AAS operated from an airborne platform, usually a helicopter positioned above the fire and clear of firefighting aircraft. AAS were usually experienced volunteers who had completed specific training.

Both pilots were flying their respective helicopters from the right seat.[3] NFO was being operated with the cabin doors closed, while LXC was being operated with the pilot's door removed. The task involved the helicopters 'bombing' the fire with water carried in specifically-designed underslung buckets. The pilots were flying a clockwise circuit pattern[4] from two adjacent water sources where the buckets were 'dipped' and refilled, flown to the fire front and returned to the water sources.

The pilots stated that the fire front was aligned approximately north-to-south and was moving west. The wind was generally from the south. The fire was advancing rapidly and had progressed to within 150 to 200 m of a house and other buildings (Figure 2). There were two small dams 80 m apart about 100 m north-west of the buildings. Both pilots were initially refilling the buckets from the larger, eastern-most dam, but subsequently took water from both dams. They were conducting firebombing runs from north-to-south.

Figure 2: Aerial view of the area showing the east and west dams and the buildings that were under threat relative to the fire and its direction of advance. As an indication of scale, the distance from fire front as marked to the east dam was approximately 600 m



An 800 L orange Bambi® bucket[5] was attached to the cargo hook of NFO by the bucket's 7.5 m long suspension cables and line. A 1,000 L bright yellow Water hog® bucket[5] (Figure 3), was attached to LXC via a 15.2 m line. That positioned the bucket, including its suspension cables, about 75 ft (23 m) below LXC. The

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3 Helicopters are generally flown with the pilot flying in the right seat.

4 The direction, size, and shape of the circuit pattern was adapted to suit the many factors that applied at the fire. The circuit direction could be clockwise or anticlockwise.

5 Collapsible firefighting buckets that allowed the carriage and delivery of water or foam to a target fire or hotspot.

pilot of LXC advised that his usual practice was to use a 150 ft (45.7 m) line but that he had opted for the shorter line on this occasion because of the extreme conditions.

Figure 3: The 1,000 L Water hog bucket that was carried by LXC

Immediately before the occurrence, the pilot of LXC was refilling his bucket from the west dam while the pilot of NFO was refilling his bucket from the east dam. The pilot of NFO recalled that he had visual contact with LXC while both pilots filled their buckets. The pilot of NFO completed his refill first and broadcast to the pilot of LXC that he was departing the dam.[6] A short time later, the pilot of LXC completed his refill and broadcast that he was departing his dam. The pilot of NFO observed LXC take up a position behind NFO as had been the case on all the previous circuits.

As the pilot of NFO banked and turned towards the north, he lost sight of LXC and did not regain sight of LXC at any stage during the circuit. He reported that there had been 'fairly constant radio chatter' between himself and the pilot of LXC. However, he did not recall hearing any transmission from the pilot of LXC during that period regarding separation from NFO, his having visual contact with NFO, or that he was overtaking NFO. He thought LXC was at least 'a couple of hundred metres' behind him as he lined up for the water drop.

Just as the pilot of NFO completed the drop from an altitude that he estimated to have been about 100 ft above ground level, he felt 'a slight jolt' through the helicopter. He was flying straight and level at the time. He initially thought it was a water bombing aeroplane that had not reported its bombing run and that the 'slight jolt' had been from the aeroplane's slipstream. He immediately rolled right and turned away from the fire line. He performed a 'normal turn' which involved the application of right cyclic control, followed by slight rear cyclic control input. He did not did recall applying any right rudder input as he entered the turn, noting that such a control input was counter-intuitive for a helicopter in normal forward flight.

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6 The term normally used was 'out of the dip'.

In his peripheral vision through the lower left cabin window, he saw a yellow coloured object flash past in a direction approximately parallel to NFO's flight path. He then received a radio call from the pilot of LXC asking if he was 'okay'. He replied that he was. The pilot of LXC then responded with the words 'that was close – way too close'.

The pilot of LXC recalled that after he departed the western dam and turned right, he had to conduct a wide turn because the helicopter was carrying a heavy load and was under the influence of a tailwind. As he looked towards the fire, he noticed an area towards the southern end of the fire front where the fire had 'spotted'[7] across a road and as a result, considered the threat to the house and other buildings had significantly increased. He considered it a priority in terms of the fire's advance and decided to conduct his drop at that location and adjusted the helicopter's track accordingly. The pilot of NFO did not recall observing any spot fire, or being advised of such by any other source.

The pilot of LXC stated that his flying speed around the circuit varied depending on the conditions but was usually not greater than 60 kts. He indicated that his focus was directed more towards how the bucket was 'flying', rather than the speed of the helicopter.

The pilot of LXC recalled that he turned the helicopter to line up to drop on the spot fire and was tracking parallel to a set of powerlines. At the time, he believed that his turn had taken him inside NFO's circuit and placed him ahead of NFO by about 300 m. However, he did not make any radio broadcast to advise the pilot of NFO of his intentions. He estimated that his bucket was at about the same level as the powerlines as he lined up for the drop and reduced speed. He was leaning out of the right cockpit door opening to observe the bucket's behaviour and to maintain clearance between the bucket and the powerline.

The pilot of LXC reported that he had slowed the helicopter to about 20 kts in preparation for the drop when he heard a loud noise to the right of LXC. He saw NFO immediately to his right, at about his 2 o'clock position in a right bank, turning and accelerating away. He considered that the pilot of NFO had taken action to avoid a collision with LXC as he approached it from behind. He suggested that the pilot of NFO had 'kicked in right rudder' as he turned away from LXC, 'possibly flicking the tail fin of NFO into LXC's rotor disc'.

The pilot of LXC stated that after observing NFO turning away, he made a radio transmission to the pilot of NFO asking if he was 'okay'. Initially, there was no reply, so he repeated the call and the pilot of NFO responded 'that was close' and asked the pilot of LXC 'did you see that plane?' The pilot of LXC transmitted to the pilot of NFO that there was no plane.

The pilot of LXC reported that he did not feel anything through the flight controls to indicate a collision. His normal practice was to broadcast when he was 'into the drop' but he had not made that call on this occasion because he was still lining up for the drop when the collision occurred. He could not recall hearing any broadcast from the pilot of NFO apart from advising that he had departed the dam.

Immediately after the event, both pilots considered that their helicopters were performing normally and continued with the firefighting task. The pilot of NFO

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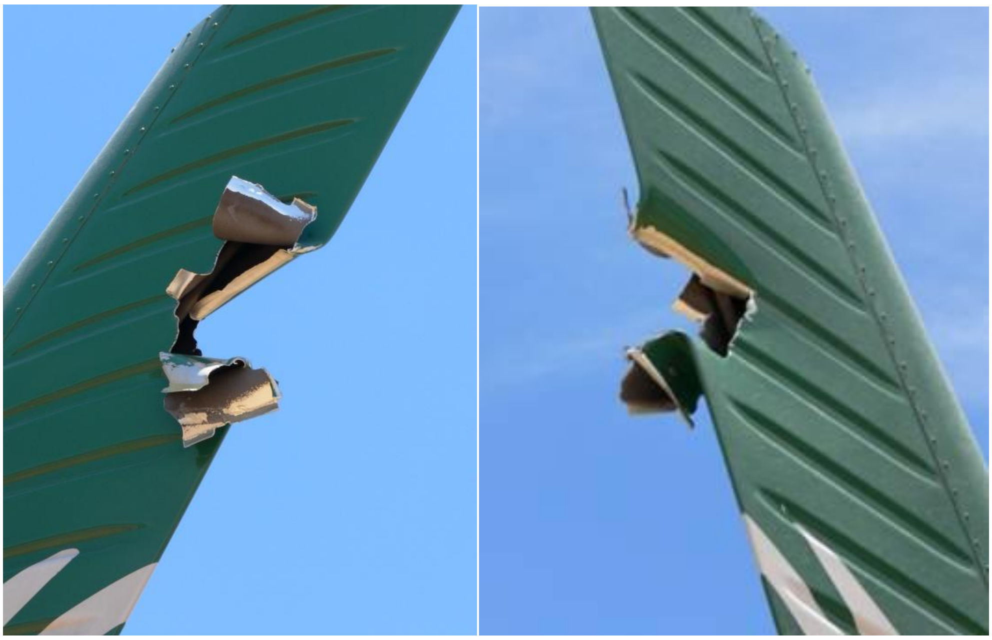
7 The commencement of small sections of fire ahead of the main fire as a result of flying debris or sparks.

stated that he completed two or three more circuits before he departed to refuel at a location about 4 km south of the fire. The damage to NFO was discovered during that refuelling stop. A message was broadcast for the pilot of LXC to land at the refuelling point.

Damage to the helicopters

Examination of a series of photographs of the damaged vertical fin of NFO revealed that the impact was about 50 cm from the arc of rotation of the tips of the tail rotor blades (Figure 4).

Figure 4: Damage to the vertical fin of NFO as viewed from the left and right sides



Examination of the damaged skin sections following their removal for repair confirmed that the damage displayed the characteristics of a high energy impact. It was evident that the direction of impact was horizontal and from right to left (looking forward).

Photographs of the main rotor blade tips of LXC did not show any evidence of contact with foreign material. The blade tips were constructed from high strength material compared to the thin aluminium alloy sheet from which NFO's vertical fin was constructed.

The BK117 was equipped with a four-blade rigid rotor system with a diameter of 11 m.[8] The blades were constructed of reinforced fibreglass with a stainless steel leading edge. The rotational speed of the main rotor during flight was 385 RPM (or 6.41 revolutions per second) and the direction of rotation was anticlockwise when viewed from above.

8 By way of comparison, the diameter of the main rotor blades in the AS.350B helicopter was 10.69 m.

Personnel information

The pilot of NFO had a Commercial Pilot (Helicopter) Licence (CPL(H)) and 18,500 hours flying experience, including more than 4,000 hours in firefighting operations. His experience on AS.350 helicopters was about 4,000 hours. At the time of the occurrence, he had been on task for about 2 hours 15 minutes.

The pilot of LXC had an Airline Transport Pilot (Helicopter) Licence (ATPL(H)) and about 6,500 hours flying experience in helicopters, including about 1,500 hours in aerial firefighting. His experience on BK117 helicopters was about 400 hours. At the time of the occurrence, he had been working on the fire for about 3 hours.

Meteorological information

The pilots reported that there was significant smoke and reduced visibility east of the fire front, but conditions were clear and there was visibility up to 5,000 m to the west.

The position of the sun was determined via the Geoscience Australia website at www.ga.gov.au and that position at 1851 on 8 December 2009 was:

- Azimuth[9] – 251° 9′
- Elevation[10] – 13° 4′.

Recorded information

Recovered global positioning system data

Data was recovered from the global positioning system (GPS) units that were fitted to each helicopter.

NFO was fitted with a Garmin GPSMAP 295 unit that retained position, altitude and time information in its non-volatile memory. A Lowrance AirMap2000C unit was fitted to LXC. The non-volatile memory of that unit retained position information, but not time (and therefore speed) or altitude information.

Without time information from the Lowrance AirMap2000C, it was not possible to determine the collision tracks solely from the retained data. However, information from both pilots allowed that determination by the deduction of the probable collision tracks, including that the:

- collision occurred after the pilot of LXC had refilled its bucket from the smaller west dam (the last three circuits completed by LXC were from that dam)
- pilot of NFO completed two or three more circuits after the collision before he departed to refuel
- collision did not occur on the last circuit before LXC departed for the refuelling base

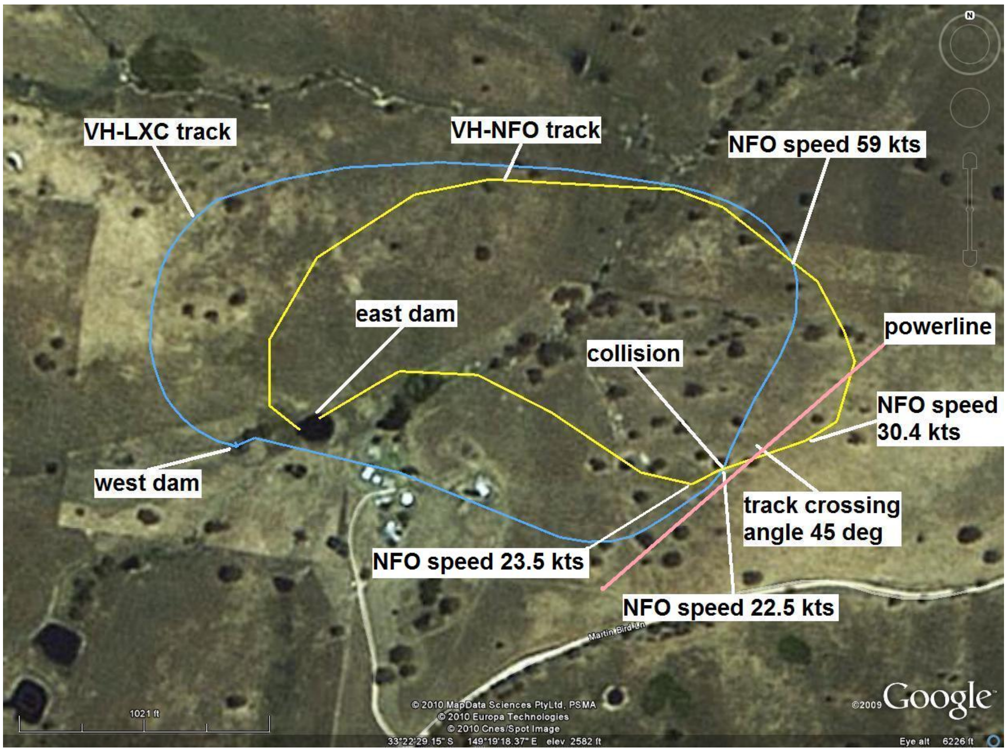
9 The clockwise angle from the sun to true north, measured in degrees.

10 The vertical angle to the sun from an ideal horizon, measured in degrees.

- collision occurred around the time both helicopters were about to ‘bomb’ the fire, implying that the speed of both helicopters had reduced to about 20 kts
- tracks crossed so that, after crossing, LXC’s track was left of NFO’s track (consistent with the sighting by the pilot of NFO of an object passing to his left)
- pilot of NFO conducted a right turn very shortly after the collision.

Figure 5 shows the track combination of NFO (yellow) and LXC (blue) that best fits the above conditions. The recorded data showed that, subsequent to these circuits, NFO and LXC each completed two more circuits before departing the fire area.

Figure 5: Probable track combination for NFO (yellow) and LXC (blue) showing the location of the collision and the track crossing angle



The recorded data provided the following details regarding the helicopters’ tracks:

- The recorded speed of NFO at the collision point of 22.5 kts (41.8 km/h) was the minimum recorded speed for that circuit (except for the acceleration and deceleration segments at the dam).
- The crossing angle between the helicopters’ tracks was about 45°.
- The distance between the probable collision point and NFO’s right turn at 23.5 kts was about 35 m. The time interval between those data points was 3 seconds.

GPS accuracy

The manufacturers of the Garmin and Lowrance units published the following performance data for their respective products:

- Garmin GPSMAP 295. Position accuracy of 15 m standard positioning during normal operations. Velocity accuracy 0.1 kts RMS (root mean square[11]) error steady state.
- Lowrance AirMap2000C. Position accuracy of 10 to 20 m. Velocity not recorded.

Both the Garmin (NFO) and the Lowrance (LXC) GPS unit tracks accurately showed the helicopters departing the dams from which each was operating. The eastern dam measured about 45 m in diameter, and the western dam about 22 m in diameter. That information indicated that both units were functioning properly.

Global positioning system position accuracy is a function not only of the GPS receiver and antenna, but also a function of the geometry and status of the satellites, the surroundings of the antenna and of the ionospheric conditions/modeling. At the same location with the same receiver and antenna, the daily RMS error of horizontal position has been seen to vary by 1 m or more. Because of this, one should never depend on a belief that the RMS error or any other error statistic is known more accurately than within a couple of metres.

Vertical GPS error was typically about twice the horizontal error. One reference[12] stated that vertical errors of 10 to 20 m were not uncommon because, in part, satellite constellation selection for vertical determinations by GPS units was not consistent.

There was also the question of whether there was a relative error between the Garmin and Lowrance units. The resolution of the recorded data for each unit was different. The Lowrance recorded to six decimal places, while the Garmin recorded to five decimal places. That meant that while the Lowrance had a resolution (ignoring any errors introduced by the GPS calculation and transmission process) of 20 cm, the Garmin had a resolution of about 1.5 m. Because the two units would likely have been receiving from the same satellites, and the aircraft were in the same location, the relative error would have been minimised but not eliminated. Even if it were possible for both units to have had zero error, the Garmin unit could have moved up to 1.5 m and still record the same location.

Organisational and management information

Rules for the prevention of collision

The Civil Aviation Safety Authority published rules for the prevention of collision. Those rules[13] stated that an aircraft that was being overtaken had the right of way and that the overtaking aircraft ‘shall keep out of the way of the other aircraft’ and

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11 Square root of arithmetic mean of squares of all possible values of a given function.

12 http://weather.gladstonefamily.net/gps_elevation.html

13 1998 Civil Aviation Regulations – Reg 162 (3).

‘no subsequent change in the relative positions of the two aircraft shall absolve the overtaking aircraft from this obligation until it is entirely past and clear’.

Aerial firefighting procedures – aircraft separation and communications

Aerial firefighting in Australia had expanded significantly in the previous 10 years. In 2009, the NSW Rural Fire Service (RFS) worked with a combination of about 120 aeroplanes and helicopters and up to 400 pilots that were spread amongst about 50 operators and were available for firefighting activities via its Call When Needed Register. Some operators were single aircraft/sole pilot operators, while others operated several aircraft and employed several pilots.

In this occurrence for example, the pilot of NFO, while not the aircraft operator was the only pilot who flew that helicopter. The pilot of LXC held an Air Operator’s Certificate and operated several helicopters and employed several pilots.

The RFS was a state authority and did not hold an air operator’s certificate, or own or operate any aircraft. However, there was an RFS system for hiring aerial firefighting assets to conduct various firefighting activities. That system included Bushfire Aviation Standard Operating Procedures (SOPs), which detailed the legislative responsibilities and operating guidelines ‘to provide as safe a working environment as possible for aviation personnel and the transportation of fire personnel and equipment’. The RFS advised that, while the SOPs set standards that provided a higher level of risk mitigation than that provided by the Civil Aviation Regulations, the RFS ‘seeks in no way to subrogate the authority and responsibility of the Commonwealth including CASA [Civil Aviation Safety Authority] and Airservices Australia.’

The preface to the SOPs included the following statement:

> The SOPs are intended to give broad guidance and of necessity have been kept relatively brief. It is essential that operations and planning staff, together with Incident Managers, seek specialist advice and assistance when planning or conducting air operations. The SOPs complement Agency Aviation Operating Procedures, which contain more comprehensive information and detailed procedures. (SOPs page 3)

The NSW RFS specified certain requirements that aircraft operators had to meet to be accepted for firefighting activities. Those requirements were published in the NSW RFS Expression of Interest for Call When Needed Helicopters and Fixed Wing Aircraft to Support Emergency Operations 2009/2010 document. For helicopters, they included:

> **Digital Photographs of Aircraft**
>
> It is imperative that each operator include in their EOI [Expression of Interest] digital photos of each aircraft. The photos need to clearly show the aircraft’s colour scheme and any markings...
>
> **Blade paint scheme**
>
> This should be in accordance with manufacturer’s recommendations to produce a strobing, high visibility, anti-collision effect by contrasting blade painting. If the

> manufacturer does not allow the blades to be painted it would be desirable that the aircraft itself be painted in a high visibility paint scheme.
>
> **Visibility**
>
> Sufficient lights must be provided to permit direct viewing of light from any position above the aircraft, within the same horizontal plane as the aircraft, and below the aircraft.
>
> The agency may require the operator to temporarily modify colour schemes to achieve maximum visibility during operations.

For helicopter firebomber pilots, the NSW RFS Expression of Interest for Call When Needed Helicopters and Fixed Wing Aircraft to Support Emergency Operations 2009/2010 document required operators to ensure that their pilots possessed the following minimum criteria:

- an Australian Commercial Pilot Licence
- a night visual flight rules rating (desirable)
- low-flying approval and experience
- a crew resource management (CRM) certificate
- 1,500 hours pilot in command, including 500 hours turbine experience and 100 hours on aircraft type
- 50 hours fire operations experience
- a sling (external load) endorsement
- water-bucketing experience
- long line experience (desirable).

The intention was that individuals who met those criteria would possess the airmanship skills necessary to conduct firefighting activities safely and efficiently within the broad framework provided by the SOPs. Operators were required to submit copies of relevant documents to demonstrate that the specified criteria for each pilot and helicopter were met.

Aircraft separation at fire locations

The RFS advised that it was neither authorised nor qualified to provide a separation function for aircraft that were engaged in aerial firefighting activities. In non-controlled (Class G) airspace and visual flight rule conditions that were stipulated by the RFS for all aerial firefighting activities, the pilot in command was responsible for maintaining separation from other traffic using see-and-avoid.

The RFS SOP Section 1.3.1 IMT [Incident management team] Aircraft Unit, described how NSW Fire Agency aviation support staff fitted into the incident controller's fire incident management team. The Aircraft Unit included an Air Operations Manager whose responsibilities included oversight of the Air Attack Supervisor(s) (AAS). SOP Appendix 1.3.1A was titled *Triggers Matrix, Guidelines to assist in the establishment of Aircraft units*. It included a list of requirements for the provision of an AAS (Table 1). In situations where an AAS was present, the AAS set priorities to attack the fire, coordinated with ground personnel regarding the application of fire suppression agents, and assisted pilots with the identification of hazards and water sources.

Table 1: Requirement for the provision of an AAS

Aircraft involvement	1 aircraft	2 aircraft	3 aircraft	4+ aircraft
Provision of an AAS	Consider	Yes	Yes	Yes

Note 2 to the matrix stated that 'For all Fixed Wing operations, AAS should also be deployed.'

SOP 2.2.1 titled *Air Attack Supervision* described 'the command, control and coordination of tactical aircraft conducting Air Attack operations for NSW Fire Agencies (FA)'. The SOP included the following information:

- aircraft that were tasked to fires may initially be required to work without the supervision of an AAS
- the use of an AAS would be considered for all air attack operations in conjunction with the Triggers Matrix
- an AAS should be used where possible for fixed wing attack operations
- pilots were ultimately responsible for the safe operation of their aircraft and had the final say on all aircraft operations
- an aircraft may be tasked in direct support of a ground commander without AAS support.

When no AAS was present, pilots were expected to mutually arrange and maintain separation by exercising their airmanship and communications experience skills. The SOPs did not contain any guidelines or procedures for handover/takeover when the AAS departed the fire and pilots of other aircraft remained to continue firefighting operations.

The overview to SOP Sub-section 1.7 titled *Communications* included the following statement:

> Overview
>
> Communications are critical to aviation safety and maximise the efficient and effective use of aerial firefighting. Efficient communications planning and the availability of appropriate equipment at all levels are required.

SOP 1.7.2 was titled *Communications – Aviation* and covered 'the use of all communications systems that are used to support aviation operations during training, firebombing operations and other emergencies.' SOP 1.7.2.1 that:

> Flexible and high quality radio communications that provide a continuous means of contact with [pilots of] all aircraft in operations are essential for the safe and efficient operation of aircraft.

The sub-section did not suggest any communications procedures or phraseology for use by a pilot when engaged in firebombing operations.

Industry views

The pilots involved in the occurrence, along with several other rotary and fixed wing pilots with extensive firefighting experience, were universal in their view that the aerial firefighting environment was not conducive to standard procedures, including radio calls, to ensure aircraft separation at a fire. They did not consider that aircraft separation in firefighting operations was a significant safety issue. There appeared to be a high level of awareness amongst the group of the importance of knowing where other aircraft were in the traffic pattern. Specifically:

- All pilots agreed that good communications were essential for safe operations. One pilot stated that 'the most important thing was for pilots to always know where the other traffic was.' Another commented 'never take separation for granted – if you lose sight of other traffic – ask – always'. Another pilot stated that his process was to look to where he thought the other traffic was. If he could not sight the traffic, he immediately asked the other pilot via radio to state his position.
- The pilot of the following aircraft was responsible for keeping any traffic ahead informed of where he was and what he was doing.
- All of the pilots reported that, with very few exceptions, other pilots they worked with were generally very good in terms of arranging and maintaining separation and making appropriate broadcasts for traffic separation purposes, as well as advising of hazards such as powerlines.
- Most pilots said that they made broadcasts when they were departing a water source after refilling the bucket. Some also broadcast when they arrived at the water source to refill.
- Some pilots considered that 'into the water' and 'out of the water' broadcasts should be standard procedure.
- Some pilots broadcast where on the fire front they were tracking for a drop.
- Most pilots considered that the number of radio frequencies[14] that they were required to monitor while on firefighting operations was problematic. It was easy to miss hearing some radio broadcasts because of the amount of chatter on the different frequencies.
- All pilots agreed that operating with an AAS enhanced safety.
- All pilots agreed that the dynamic nature of bushfires meant that it was difficult to prescribe standard procedures for aircraft that were engaged in firebombing operations.

Pilot standards

The minimum standards for pilots on the RFS's *Call When Needed Register* were embodied in the qualification and training criteria for acceptance on to the register. Aside from a module on 'situational awareness' in the CRM Certificate training that pilots were required to have undertaken, there was no specific training directed at separation assurance during firebombing operations.

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[14] Pilots can have up to four frequencies to monitor for communications with other aircraft, air traffic services, ground crews, fire control, and national parks.

The pilots of NFO and LXC had completed CRM training that satisfied the RFS requirement. They considered the courses to have been of value, even though they were not tailored specifically towards aerial firefighting.

The RFS advised that it had worked with a number of CRM training providers to specifically tailor their courses for aerial firefighting, and actively encouraged aircraft operators and their pilots to attend those courses. Each year, the RFS coordinated several CRM courses that included a mix of operators, pilots and RFS personnel. In general, the RFS accepted that the industry standard CRM qualification met the minimum standard for acceptance on to the *Call When Needed Register*.

Procedures of other organisations

For comparative purposes, the investigation examined the firebombing procedures employed by another Australian state organisation, and by an overseas organisation.

State Aircraft Unit of Victoria procedures

The State Government of Victoria's State Aircraft Unit published State Aircraft Unit Procedure SO 4.07, titled *Firebombing Operations.* That procedure applied 'to all firebombing operations conducted by the participating Agencies' to 'ensure Agency firebombing operations are conducted safely and efficiently.'
Part 2- *Departmental Firebombing Procedures* included the following information:

> All Departmental firebombing operations on wildfires shall be supervised by an authorised Air Attack Supervisor.
>
> The incident controller may authorise firebombing to be conducted without direct supervision of an Air Attack Supervisor in circumstances where:
>
> (a) An authorised Air Attack Supervisor is not immediately available, and
>
> (b) Fire control objectives would be adversely compromised if firebombing was delayed until an authorised Air Attack Supervisor was available, and
>
> (c) The Incident Controller has ensured that systems and procedures are in place to ensure the safety of ground and air personnel, and
>
> (d) The incident controller has taken reasonable steps to ensure that any environmental risks, particularly any risks to streams, watercourses or other key environmental assets are assessed and appropriately managed.

Procedures of the United States Department of Agriculture, Forest Service, Technology & Development Program

The United States Department of Agriculture, Forest Service, Technology & Development Program published a 129 page document titled *Professional Helicopter Pilot Guide*. The document included, at Exhibit 1 – Helicopter Firefighting and Safety, a section titled *Safety and Radio Communications* that included the following information:

> **Flight Safety**
>
> Firefighting air operations are often in steep canyons and mountain terrain under conditions of reduced visibility due to smoke. In this environment the danger of a wire strike or a mid-air collision is always present.
>
> **Air to Air Communications**
>
> Whether there are two or two dozen aircraft working on a fire, the safe and efficient coordination of air operations demands dependable radio equipment and the use of a common VHF frequency by all aircraft on the fire. This is usually in addition to other frequencies on agency radios. Helicopter pilots should make the following radio calls to aid in maintaining a mental picture of each other's whereabouts:
>
> Examples: "15 Lifting" (Helicopter-15 lifting off helibase); "15 Final for drop" (Helicopter- 15 on final for a drop); "15 Clear" (Helicopter- 15 clear for [of] target area); "15 Final for Pad 1" (Helicopter-15 on final for pad 1 at the helibase)
>
> **Other Aircraft**
>
> In addition to good radio communications and frequent position reporting it is an absolute necessity to keep your head and eyeballs on a constant swivel.

Additional information

Water bucket operations – long line and short line

Information from NSW RFS and helicopter operators confirmed that most helicopter pilots who conducted water bucket firebombing for the RFS operated with long lines. Issues associated with those operations included:

- Long lines enabled helicopters to conduct firebombing and to refill buckets while remaining further above trees and other obstacles, compared to short lines. The greater operating heights also offered potential benefits in terms of better wind conditions.
- Long lines were advantageous for extinguishing 'hot spots' such as burning logs beneath tree canopies.
- Long line operations involved a higher pilot workload and demanded increased pilot finesse than for short line operations. Pilots referred to the concept of 'flying the bucket' where the pilot leaned out of the cockpit door and manoeuvred the helicopter as required by the in-flight behaviour of the bucket (Figure 6). The pilot's attention was directed primarily below the helicopter. Compared with short line operations, long line operations required more attention to 'flying the bucket', and reduced the level of attention the pilot could devote to looking out for other traffic. The level of pilot attention directed

towards ‘flying the bucket’ was highest during the run in for ‘the drop’, when accurate bucket tracking in terms of drop accuracy and obstacle avoidance were required.

- In the case of short line operations, the pilot was able to observe the behaviour of the bucket via a mirror that was attached to the lower forward fuselage and visible through the aircraft’s chin window. Bucket behaviour was more predictable and required less attention to control. Consequently, the pilot could devote much of his attention to looking out for other traffic, compared to the long line situation.
- Because of the magnitude of their main rotor downwash and its likely affect on fire behaviour, larger helicopters such as the BK117 were restricted to using long lines to achieve a greater distance between the fire and the helicopter.

Figure 6: Showing LXC operating with a long line, with the pilot leaning outwards through the door opening, looking downwards, and ‘flying the bucket’

Human performance

Inattentional blindness

Inattentional blindness can be defined as the inability to perceive something that is within one's direct perceptual field because one’s attention is directed to something else. Research has demonstrated that, under a number of different conditions, if subjects were not attending to a visual stimulus but were attending to something else in the visual field, a significant percentage of those subjects were ‘blind’ to something that was right before their eyes. Inattentional blindness is involuntary.

Human visual attentiveness, or what captures an individual's attention, is determined by four factors:

- *Conspicuity.* A high degree of contrast against the background is the most important determinant of conspicuity. Brightness contrast is more important than colour contrast. However, bright colours, movement, and flicker do not necessarily ensure conspicuity.
- *Mental workload and task interference*. An individual is more likely to experience inattentional blindness if part of that person's attention is diverted to other tasks, particularly other visual tasks.
- *Expectation.* Our ability to pay attention and notice information is influenced greatly by expectation. Errors occur when new or unusual circumstances arise in familiar situations.
- *Capacity.* Our capacity to focus attention is dependent on age and mental aptitude. Attention can also be affected by distractions, fatigue and alcohol.

'Missionitis'

The term 'missionitis' has been used in aviation safety literature to describe situations in which pilots place more emphasis on mission accomplishment or task achievement and less on safety. It often involves an unwarranted – and sometimes obsessive – drive to accomplish flight objectives. Terms synonymous with 'missionitis' include 'press-on-itis' and 'get-home-itis'. 'Missionitis' typically involves poor risk management leading to unsafe conditions. Human performance related issues such as stress and fatigue are often associated with 'missionitis'. There are many recorded instances in which the drive to accomplish flight objectives has been identified as a contributing factor to an accident.

See-and-avoid

In 1991, the Australian Transport Safety Bureau (ATSB - then the Bureau of Air Safety Investigation) published a research report titled *Limitations of the See-and-Avoid Principle.*[15] Relevant information from that report includes:

> The time spent scanning for traffic is likely to vary with traffic density and the pilot's assessment of the collision risk.
>
> Vision can be considered to consist of two distinct systems, peripheral and foveal vision.[16] Some important differences between the two systems are that colour perception and the detection of slow movement are best at the fovea, while detection of rapid movement is best in the periphery.
>
> [Visual] acuity in daylight is dramatically reduced away from the direct line of sight, therefore a pilot must look at or near a target to have a good chance of detecting it.

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15 Available at http://www.atsb.gov.au/publications/1991/limit_see_avoid.aspx

16 Peripheral vision, or side vision, is that part of vision that detects objects outside the direct line of vision. Foveal vision is used for scrutinizing highly detailed objects, whereas peripheral vision is used for organizing the broad spatial scene and for seeing large objects.

Most aircraft cockpits severely limit the field of view available to the pilot. Visibility is most restricted on the side of the aircraft furthest away from the pilot and consequently, aircraft approaching from the right will pose a particular threat to a pilot in the left seat.

... although a comfortable and alert pilot may be able to easily detect objects in the ‘corner of the eye’, the imposition of a moderate workload, fatigue or stress will induce ‘tunnel vision’. It is as though busy pilots are unknowingly wearing blinkers.

The human visual system is particularly attuned to detecting movement but is less effective at detecting stationary objects. Unfortunately, because of the geometry of collision flightpaths, an aircraft on a collision course will usually appear to be a stationary object in the pilot’s visual field. If two aircraft are converging on a point of impact on straight flightpaths at constant speeds, then the bearings of each aircraft from the other will remain constant up to the point of collision. From each pilot’s point of view, the converging aircraft will grow in size while remaining fixed at a particular point in his or her windscreen.

There have been frequent suggestions that the fitting of white strobe lights to aircraft can help prevent collisions in daylight. At various times BASI and the NTSB [United States National Transportation Safety Board] have each recommended the fitting of white strobe anticollision lights. Unfortunately, the available evidence does not support the use of lights in daylight conditions. The visibility of a light largely depends on the luminance of the background and typical daylight illumination is generally sufficient to overwhelm even powerful strobes.

ANALYSIS

Overview

It was apparent from the damage to the fin of VH-NFO (NFO) that impact from the main rotor blade tip(s) of VH-LXC (LXC) was the source of the damage. Only the slimmest of margins prevented the collision becoming a catastrophe involving the destruction of both helicopters and the likely loss of life of the pilots. The accident sequence began when the system of traffic separation in the circuit between the water sources and the fire front broke down. Subsequently, the sole remaining line of defence, ‘see and avoid’, also failed. Chance then determined the severity of the outcome.

Operational aspects

In the operating environment at the time, the sole means of ensuring that the helicopters remained clear of one another was by see-and-avoid, including mutual arrangement between the helicopter pilots. The lack of any radio communication of the helicopters’ positions after each pilot broadcast departing their respective water sources, meant that neither pilot could assure himself of the position of the other helicopter as they flew the circuit that culminated in the midair collision.

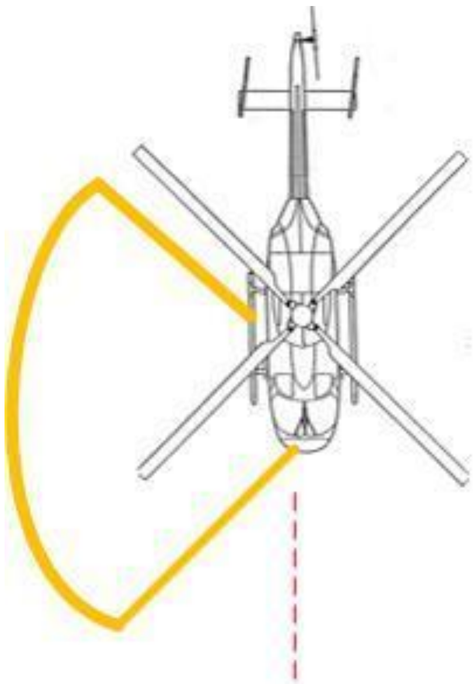
Both pilots were aware that NFO departed the east dam before LXC departed the west dam. Irrespective of the exact track taken by each helicopter, the proximity of the dams to one another meant that the departure sequence placed LXC behind NFO in the circuit pattern. After the pilot of NFO turned towards the north at the commencement of his circuit, LXC would no longer have been visible to him. Under those circumstances, the responsibility for collision avoidance rested solely with the pilot of LXC. In the absence of any broadcast or other signal from the pilot of LXC to the contrary, the pilot of NFO was entitled to believe that LXC would remain clear of NFO. In the event, the pilot remained unaware that the pilot of LXC was not aware of NFO’s position.

In the reported clear conditions that existed to the west of the fire front, and with the sun 13° above the western horizon, NFO was probably within the visual field of the pilot of LXC as he manoeuvred his helicopter from the right control position. However, there were several possible reasons (separately or collectively) associated with visual attention, see and avoid, and workload that could explain why the pilot of LXC neither saw, nor broadcast that he could not see NFO. Those included:

- The possible attentional focus of the pilot of LXC towards the threat posed by the ‘spot over’ as a priority target. The amount of attention that the pilot could devote towards remaining separated from (that is, looking out for) NFO may have been compromised because of that focus.
- The potential that, because the pilot of LXC did not have visual contact with NFO, the significance to him of separation assurance between LXC and NFO was repressed within his attentional focus.
- The attention required to ‘fly the bucket’ was likely to have significantly reduced the amount of attention the pilot of LXC could devote to looking out for the other traffic.

- The pilot's seating position in LXC meant that he had a largely unobstructed view to the right and ahead of the helicopter, while his view to the left was restricted by the cabin frame. However, during the periods when he was attentive to 'flying the bucket', his view ahead and level with the helicopter was likely to have been limited. Figure 7 is illustrative of the pilot's field of view while 'flying the bucket'.
- The collision occurred close to the drop position, which meant that the pilot of LXC at that stage would have been increasingly focused on the drop with less attention devoted to looking out for other traffic.
- Because the pilot of LXC had been engaged in long line operations for more than 2 hours, his performance may have been affected by fatigue associated with the workload involved in long line operations.

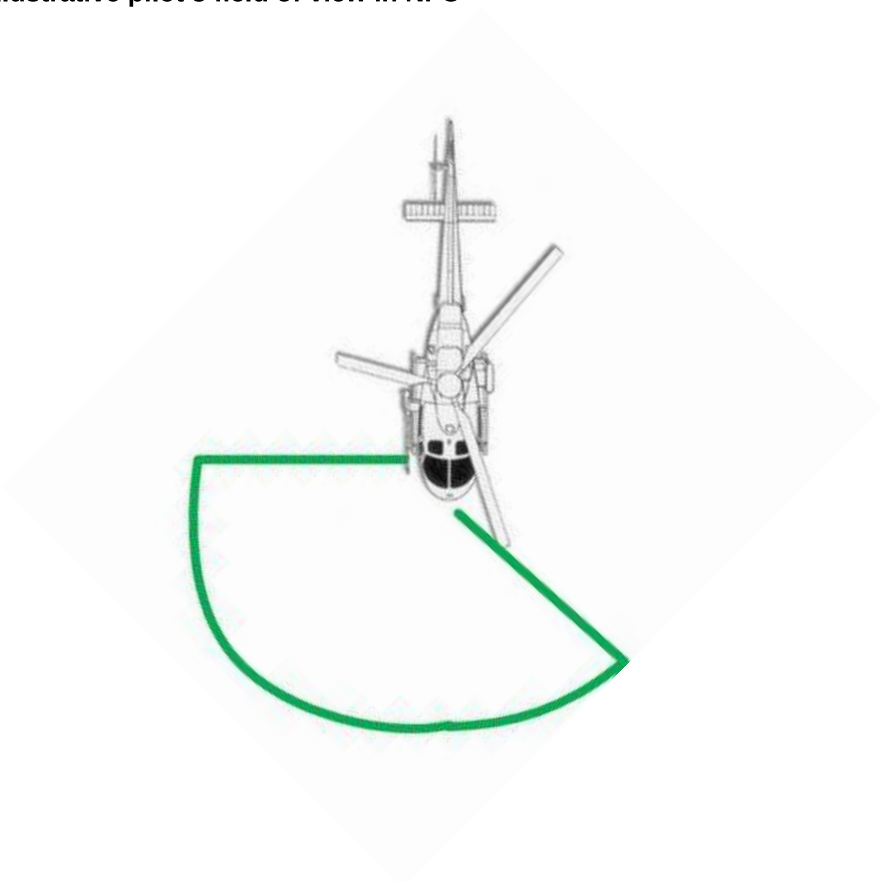
Figure 7: Illustrative pilot's field of view from LXC while 'flying the bucket'



With respect to the pilot of NFO:

- Because he was not using a long line, the pilot's workload was lower than that of the pilot of LXC, and therefore allowed him more spare capacity that could have been devoted to lookout.
- The pilot's seating position meant that he had a largely unobstructed view right and ahead of the helicopter, while his view to the left was restricted by the cabin frame (see illustrative view in Figure 8).
- The collision occurred close to the drop position, which meant that he would have been increasingly focused on the drop with less attention devoted to lookout.

Figure 8: Illustrative pilot's field of view in NFO



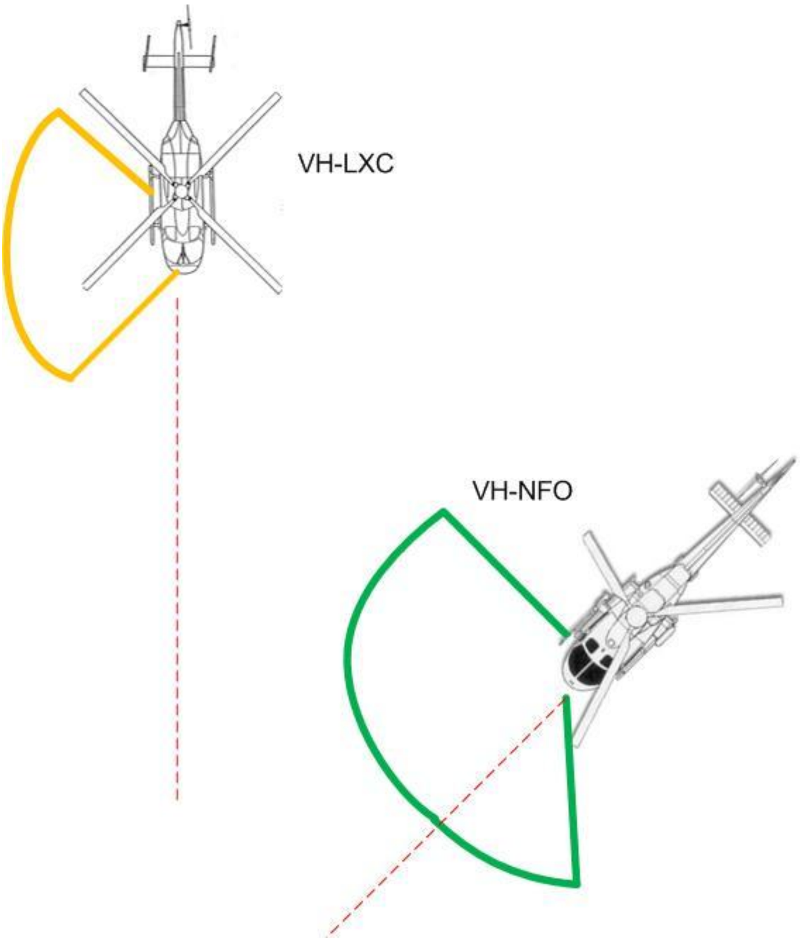
Probable collision geometry

The horizontal and vertical errors associated with Global Positioning System (GPS) measurements, and the different data parameters employed by the respective GPS units, precluded a precise analysis of the collision geometry. However, some conclusions can be drawn from the likely track combination and the recorded GPS data during the period immediately before and after the collision:

- The recorded speed of NFO where the tracks crossed was consistent with the pilot's evidence that he had slowed to drop speed and was about to conduct the drop at the time of the collision.
- There were no sudden changes in the track or speed of NFO for at least 15 seconds before the tracks crossed.
- There were no sudden changes in the track of LXC for at least 15 seconds before the tracks crossed.
- The recorded speed of NFO of 22.5 kts when the tracks crossed, coupled with the information from the pilot of LXC that he had slowed his speed to 'about 20 kts', suggested that the helicopters did not have a significant speed differential at the time of the collision.
- From the probable track combination, the likelihood of the pilot of LXC seeing NFO was low because of his field of view as determined by his seating position, and of the attentional focus involved in 'flying the bucket' (Figure 9).

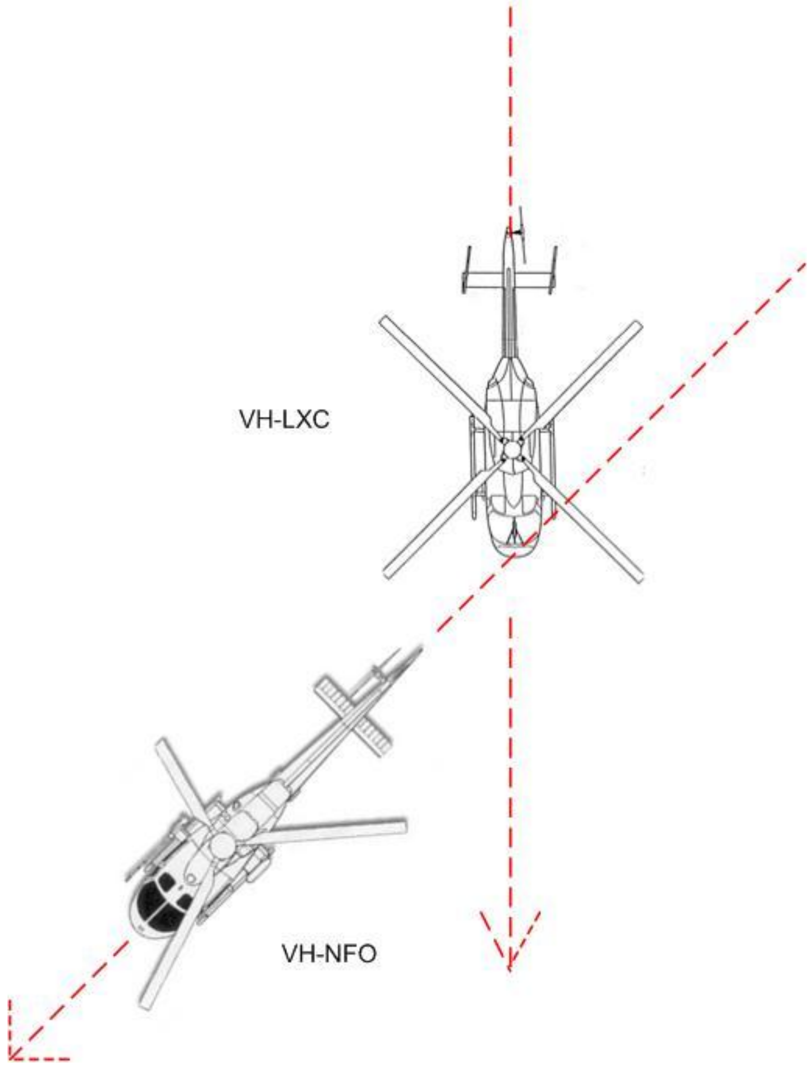
- In comparison, the pilot of NFO had a greater capacity for lookout because he was not required to 'fly the bucket' and LXC would have been to his right as the flight paths converged. However, his focus of attention would have been the target drop area ahead of the helicopter. Unless LXC had been forward of an approximate abeam position relative to NFO, there was little likelihood of the pilot of NFO seeing LXC (Figure 9).

Figure 9: Converging helicopter tracks and illustrative pilots' fields of view



If LXC was sufficiently behind the right abeam position in respect of NFO to have been outside the field of view of NFO's pilot, it was entirely plausible that neither pilot became aware of the other helicopter prior to the collision. That was consistent with the evidence from both pilots that neither saw the other helicopter prior to the collision, and indicated that the collision occurred as LXC passed behind NFO as the tracks crossed (Figure 10).

Figure 10: Showing probable collision geometry



Scenario advanced by the pilot of LXC

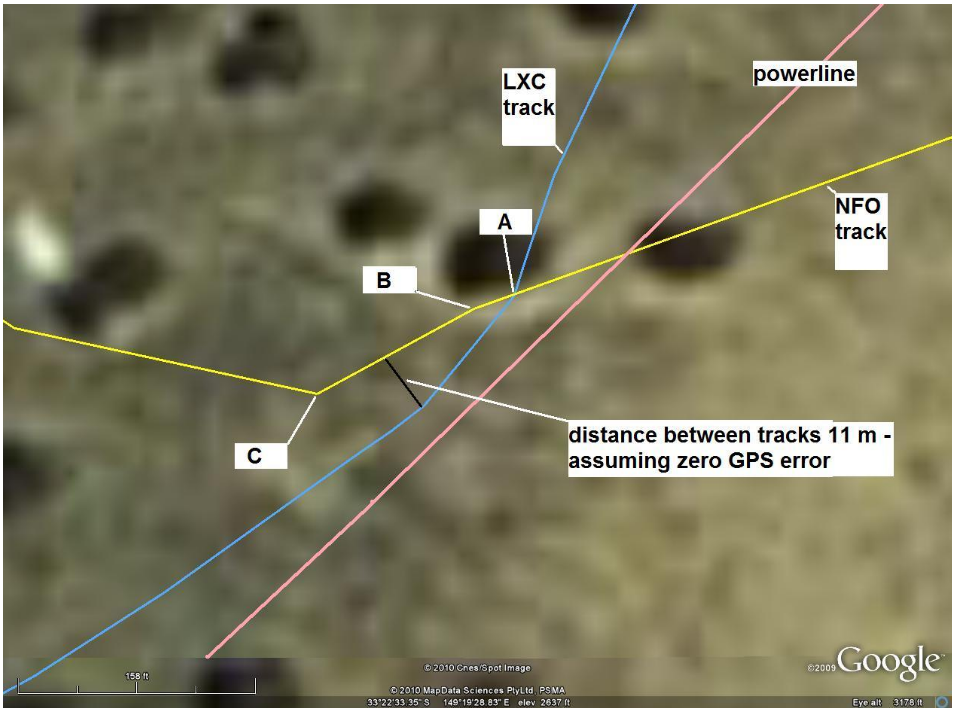
The scenario advanced by the pilot of LXC suggested that the collision occurred shortly after the tracks crossed, as the pilot of NFO was attempting to avoid a collision as NFO overtook LXC from astern. To assist in the analysis of this scenario, the pilot of LXC proposed a sequencing diagram (Figure 11). That figure shows an expanded view of the helicopters' recorded GPS tracks in the area of the collision, and does not include any GPS error. Nevertheless, the data does provide an indication of the relative track positions and shows a divergence between the tracks after the crossing point (location A). From NFO's recorded speed data, the time taken for NFO to travel from A to B was about 1 second, and from B to C about 3 seconds.

Acceptance of the pilot's scenario depended on the soundness of at least the following aspects:

- The recorded speed of NFO, and the reported similar speed of LXC, meant that the extent of any speed differential between NFO over LXC was likely to have been very low and probably less than 5 kts (about 9 km/h). Also, the probable focus of attention of NFO's pilot in the period immediately before the collision was ahead of his helicopter. In those circumstances, it is highly likely that the pilot of NFO would have seen LXC or its bucket before NFO arrived at location C. In that scenario, the track data evidence of the turn away from LXC would have been expected in the area of locations A and B, rather than at location C.
- The notion that the pilot of NFO 'kicked in right rudder' as he turned away from LXC, 'flicking the tail fin of NFO into LXC's rotor disc' implied a counter-intuitive control input by the pilot of NFO. For a highly-experienced pilot, such an action was considered unlikely.
- For the tail fin of NFO to have contacted the main rotor of LXC as NFO turned right (location C) as suggested, NFO would had to have passed very close to LXC between locations B and C. Under those conditions, there was a strong possibility that the main rotor systems of the helicopters would have enmeshed.

In summary, there were aspects of the scenario proposed by the pilot of LXC that were not robust. The investigation considered that, compared to the probable collision geometry developed earlier in this analysis, the scenario proposed by the pilot of LXC did not offer the same level of conviction.

Figure 11: Expanded view of GPS track data



On the basis that the relative speed between the helicopters at the time of the collision was low, it is possible that more than one blade tip passed through the area of damage on the fin of NFO. Although it was apparent that the damage was the result of an impact from the right to left side of the fin, it was not possible to ascertain how many blade strikes might have occurred, or whether the blade(s) struck the fin at an angle of 90° (implying that both helicopters were in straight and level flight at the time and/or not banked relative to one another), or at some other angle (implying that the helicopters were banked relative to one another).

The loss of the plastic anti-collision light cover from the top of NFO's fin may have been the result of load or shock transfer during the collision.

Aircraft separation assurance at fire locations

For pilots engaged in aerial firefighting, the run in and drop was a high workload period because of the attentional focus required to position the aircraft for an accurate drop. If other factors such as terrain, obstacles and smoke were present, that workload would be elevated further. In such circumstances, a pilot's capacity to look out for other traffic was likely to be less than optimal. Therefore, to mitigate the midair collision risk, separation assurance had to be achieved before a pilot arrived at the fire front to commence his drop run. Visual sighting, in conjunction with radio communications between the involved pilots, were likely to be the sole means of achieving separation assurance.

The criteria governing the use of an air attack supervisor (AAS) in the NSW Rural Fire Service (RFS) and State Air Unit of Victoria procedures recognised the importance of the AAS in the safe management of air assets at fires. As a practical necessity, the procedures also included provision for situations where an AAS was not available. However, the RFS Standard Operating Procedures did not include any communications procedures or phraseology regarding separation from other aircraft, and no guidance to operators and pilots regarding separation assurance when an AAS was not present. That contrasted with the United States Department of Agriculture, Forest Service, and Technology & Development Program procedures, which prescribed minimum radio broadcasts and included specific references to the danger of collision and the importance of lookout.

While the absence of standard radio broadcasts for pilots operating at fires in the NSW RFS procedures was based on the need to provide a flexible operating environment for pilots, it had the potential to downplay the relative importance to separation assurance of good communications. Further, the use of ad hoc procedures, as described by industry pilots interviewed during the investigation, potentially exposed pilots to different procedures, including radio broadcasts and phraseology, at different stages of the circuit from one fire to another, or even on the same task when other aircraft arrived or departed. Such operating environments had the potential to create confusion and/or misinterpretation amongst pilots. The prescription of a system to confirm traffic separation would:

- provide a level of consistency and standardisation to ensure pilots received a minimum amount of essential traffic information at specific stages of circuit activity
- act as a prompt to pilots regarding separation assurance.

In this occurrence, while both pilots had agreed on the circuit pattern, and had broadcast when they were departing their respective water sources, there was no subsequent activity with respect to traffic disposition before either pilot commenced their bombing run. Had, for example, the procedures included a requirement for pilots to confirm traffic separation before they entered the drop run, the pilots would likely have become aware of the confliction and been able to avoid the collision.

FINDINGS

Context

From the evidence available, the following findings are made with respect to the midair collision that occurred 20 km south-east of Orange, New South Wales on 8 December 2009 and involved Aerospatiale AS.350B helicopter, registered VH-NFO (NFO) and Kawasaki BK117B-2 helicopter, registered VH-LXC (LXC), and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- There were no published communications procedures or phraseology for use by pilots during firebombing operations to provide separation assurance at fire locations when there was no air attack supervisor present. *[Minor safety issue]*
- The pilot of LXC flew the circuit pattern and positioned the helicopter to drop on the fire without any awareness of the position of the other helicopter, which was ahead of him in the circuit pattern.
- The probable collision path of the helicopters meant that sighting by either pilot of the other helicopter was unlikely.
- The performance of the pilot of LXC with respect to his awareness of NFO during the circuit from the water source to the fire front may have been influenced by inattentional blindness, ‘missionitis’, and the limitations of see-and-avoid.

Other key findings

- The nature of data recorded by the Global Positioning System unit on LXC limited the extent of analysis that could be conducted on the recorded GPS tracks.
- Global Positioning System accuracy precluded a precise analysis of the collision geometry, but did allow a high level of confidence that the track accuracy of both helicopters was to within a few metres.
- The main rotor blade tip(s) of LXC struck the trailing edge of the vertical fin of NFO above the tail rotor arc.

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Civil Aviation Safety Authority

Regulation, approval and oversight of firefighting operations

Although no safety issue was identified in respect of the regulation, approval and oversight of firefighting operations, on 11 February 2010 the Civil Aviation Safety Authority (CASA) advised of proactive safety action in response to this occurrence. That action is discussed in the following paragraphs.

CASA highlighted that the aerial firefighting industry has expanded considerably in recent years, outgrowing its agricultural industry roots, and developing into a distinct industry sector. It now encompasses light aircraft on spotting and incendiary dropping duties, through specialist helicopters, to converted airliners dropping large quantities of fire control agents. The fire authorities are becoming more aviation focussed, and have set up their own central aviation agency, the National Aerial Firefighting Centre (NAFC).

In addition, CASA advised that following the 2009 summer bushfire season, Australian state fire authorities raised several issues with CASA concerning the regulation, approval, and oversight of operators engaged in firefighting operations. One issue was that the existing Pilot Training and Competence Rules for firefighting were not considered adequate.

A Firefighting Review was commenced by CASA on 20 July 2009. In a report dated 13 August 2009, a number of recommendations were made, including:

> Recommendation 6 - Standard Operations Manual Sections for Firefighting:
>
> That a project be set up in conjunction with National Aerial Firefighting Centre (NAFC) to develop a standard operations manual section for firefighting operations.
>
> The anticipated benefits from the development of a standard operations manual for firefighting operations included:
>
> - Improved standardisation between state fire authorities thus reducing potential confusion for operators moving between authorities;
> - Improved and standardised training and experience requirements for pilots;

- Improved standards of operators procedures; and
- Standardised refuelling hand signals.

A Firefighting Operations Manual project team was established including five CASA staff, one fire authority staff member, 11 industry representatives and one consultant to draft a proposed manual. The project was expected to run from 16 November 2009 to 7 May 2010.

On 11 February 2010, CASA advised that the project team was consulting with stakeholders on a draft operations manual and on an implementation plan for the manual. CASA approval, and NAFC acceptance of the plan preceded its release to the various firefighting agencies for their consideration.

On 7 October 2010, CASA advised of the following additional progress in the development of the Firefighting Operations Manual:

> Firefighting Operations Manual project team has completed a draft manual which is currently being reviewed by the fire agencies.
>
> The team has attempted to address the safety concerns raised by this occurrence by providing standard radio procedures to be used by pilots to help them maintain safe separation. The following is an extract from the firebombing section of the draft manual:
>
> "Pilots must communicate on the nominated frequency to maintain separation as required and should establish a pattern were possible to reduce the need for radio calls. The nature of broadcasts required will depend on the number of aircraft on site, terrain and other conditions. While suitable broadcasts must be made, pilots should try to minimise radio traffic as much as possible. The following radio calls are recommended as a minimum:
>
> (a) Departing water - helicopters only
>
> (b) Final for drop
>
> (c) Drop complete
>
> (d) Feet wet - helicopters only"
>
> The concern with long line operations reducing the level of attention devoted to looking out for other aircraft is highlighted in the long line operations section of the draft manual:
>
> "Pilots should avoid over concentration on 'flying' the bucket and ensure that they give adequate attention to look out for aircraft and obstacles.”
>
> The project is currently being delayed by the fire agencies' review. Consultation with all firefighting operators is yet to commence.

New South Wales Rural Fire Service

Conduct of aerial firefighting operations

Although no general safety issue was identified as a result of the investigation in regard to the conduct of aerial firefighting operations, in April 2010, the New South Wales Rural Fire Service (NSW RFS) sent the following letter to all aircraft operators with whom it had contractual or call when needed arrangements:

> **AERIAL FIREFIGHTING SAFETY CONSIDERATIONS**
>
> For the NSW Fire Agencies, the 2009/10 fire season was prolonged with periods of very intense activity. In all, over 18,000 hours was flown between fire and flood incident and emergency operations. The season was also marred by a number of accidents. Sadly, one accident resulted in the loss of life of a National Parks & Wildlife Service employee. Also a number of aircraft were destroyed or damaged in a series of other accidents. The accidents and incidents highlight the dangerous environment in which incident and emergency operations are often undertaken, and this should bring safety considerations for all tasks undertaken on fire operations to the fore.
>
> The Service is still in the process of finalising accident reports and ensuring that improvements and appropriate lessons are embedded into our aerial firefighting capability, procedures and training programs.
>
> The RFS has investigated all four accidents that occurred over the summer. The investigations utilised the services of external consultants to provide industry expertise, and all investigations were undertaken by a multi-agency investigation team. The ATSB and the NSW Police (on behalf of the NSW Coroner) have also investigated a number of the accidents. Any safety considerations/actions from these investigations will be included into fire agency operational procedures.
>
> In a desire to continuously improve the safety of aerial firefighting within NSW, a number or reviews are currently underway. These include:
>
> - A review of the NSW Fire Agencies - Bushfire Aviation Standard Operating Procedures
>
> The review not only updates the existing SOP's but will also encompass a number of new SOPs. These new SOP's will provide clearer guidelines to aircraft operators and firefighting agencies detailing the procedures undertaken after an accident or incident has occurred (this includes guidelines on Aviation Company Stand-down procedures and reactivation processes). Other new SOP's include a review of briefings provided to and from pilots prior to task initiation both by the SAD and when tasked at an incident.
>
> - Enhancements to the contractual arrangements in the Call When Needed Expressions of Interest for the provision of aircraft to support Emergency and other operations.
>
> Enhancements include, but are not limited to, the following:
>
> - o Enhanced requirements to aircraft configurations and pilot standards (including NVFR ratings, and Wire Strike Kits for all helicopters),
>
> - o Increased accountability by Chief Pilots when submitting pilots for EOI approval,

- Enhanced roll out of in-field auditing program (this program audits compliance against the requirements of the EOI).
- Inclusion of aircraft tracking and monitoring systems.

▪ Review of the aviation training program incorporating best practice procedures into aviation specialist training packages.

The recommendations of the various reviews will be incorporated into the training programs of the Agency aviation specialist roles carried out in support of aerial firefighting operations. This includes an increased focus on separation of aircraft at incidents.

▪ Fire Agency and Aircraft Operator specific recommendations aimed at improving safety of aerial firefighting operations and management.

Changes to the above systems will be finalised prior to the fire season and incorporated into the 2010/11 Call When Needed documentation. It will also be detailed in the pre season aviation briefings for aircraft operators to be held in August, 2010.

I look forward in conjunction with aircraft operators to improving the safety and management of aerial firefighting operations in NSW. If you have any concerns, I am happy to discuss any safety issues with you at any time.

Communications guidance in the absence of an air attack supervisor

Minor safety issue

There were no published communications procedures or phraseology for use by pilots during firebombing operations to provide separation assurance at fire locations when there was no air attack supervisor present.

Action taken by the NSW RFS

On 8 October 2010, the NSW Rural Fire Service advised that it had developed a Draft standard operating procedure that particularly addresses ‘Mission Management’ including the use of standard terminology for aerial firefighting activities (Figure 12).

The RFS advised that in November 2010, and on behalf of NSW Fire Agencies, it would be conducting ‘a series of workshops for aviation specialists to pass on these changes’.

Figure 12: NSW RFS Draft SOP – Mission Management

Appendix 1
DRAFT SOP - Mission Management

Scope

This SOP provides procedures for general mission management over an incident. The control of the airspace remains under the control of Air Services Australia and CASA. Pilots are to ensure at all times that maintain aircraft separation whilst airborne. Safety is paramount

1.1.1.1. Procedures

1.1.1.1.1. Responsibility

a) The Incident Controller is responsible for ensuring that appropriate mission management procedures are enacted for all incident operations under their control.

1.1.1.1.2. Requirement

a) The Incident Controller and/or State Air Desk shall ensure to the best of their knowledge when dispatching aircraft to an incident that the pilot is aware of other aircraft allocated to the incident and the assigned Fire Common Traffic Advisory Frequency (FCTAF).

b) Where more than one aircraft is deployed at an incident the pilots are to confer and, where appropriate establish communications on a FCTAF allocated by the State Air Desk. The Incident Controller is required to ensure that processes are in place to facilitate decisions on mission management.

c) Where more than one aircraft is deployed at an incident the pilots are to confer and establish flight procedures covering circuit patterns, altitude levels, approach & departure directions and separation to ensure a high level of safety is maintained.

1.1.1.1.3. Procedures

a) All aircraft transiting to or from an incident shall do so under VFR procedures.

b) All altitudes quoted in this SOP are Above Ground Level (AGL). The Air Attack Supervisor or first arriving aircraft will ensure a common QNH for aircraft over the area of operations which must suit the terrain and operating environment. This will form part of the established flight procedures for the incident.

c) All aircraft needing to enter area of an incident are required to give a 5Nm inbound call on the FCTAF to establish contact with other aircraft and or the AAS on the incident and advise intentions & confirm the established flight procedures.

d) Where **no** Air Attack Supervisor (AAS) is over the incident the first arriving aircraft shall assume the role for advising all further aircraft wishing to enter past the 5Nm point to area of tasking.

e) Where an AAS is established over the incident all aircraft wishing to enter past the 5Nm point to area must advise the AAS prior to entering. If no contact can be established the tasked aircraft is to remain outside the 5Nm radius.

f) As a general rule fire bombing helicopters operating within the 5Nm radius of an incident or area of tasking (5Nm zone) will generally operate not above 1000ft AGL in accordance with the established flight procedures for the incident.

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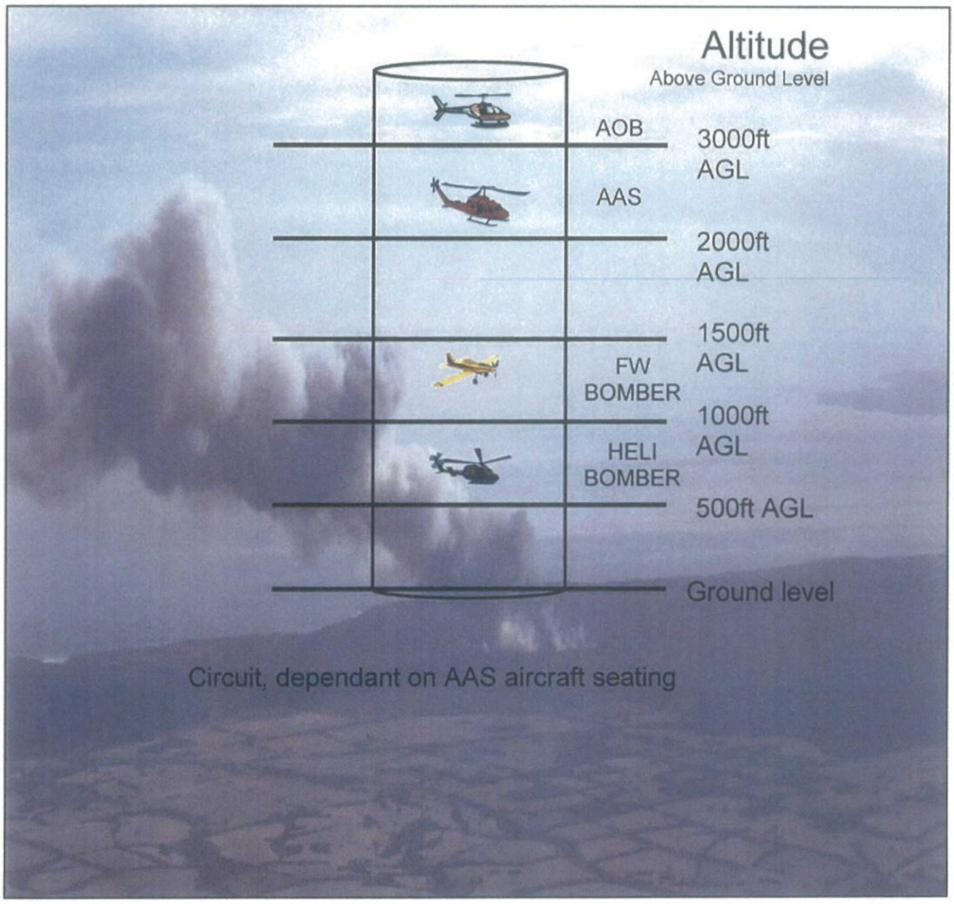
g) As a general rule fixed wing bombers operating within the 5Nm zone, should entered the zone at 2000ft AGL and descend to 1500ft AGL to join orbit over the proposed drop zone. Once drop instructions have been received the fixed wing bomber should then descend in accordance with the drop instructions and established flight procedures for the incident.

h) As a general rule the AAS aircraft operating within the 5Nm zone, should enter the zone at a minimum of 3000ft AGL and operate in the altitude range between 2500ft AGL and 2000FT AGL. The AAS may descend below this altitude for tactical purposes for short durations only in accordance with the established flight procedures for the incident.

i) As a general rule all non fire bombing aircraft operating within the 5Nm zone, should enter the zone at a minimum of 3000ft AGL and maintain this altitude for the duration of operations within the zone. Non firefighting aircraft should coordinate with e AAS or other aircraft, prior to entering the area..



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Mission Communications

The general premise is to "see and be seen, speak up and listen out". This will avoid confusion and facilitate separation of air traffic. All pilots are to maintain good situational awareness through visual contact with traffic and judicious use of the radio. Pilots should arrange separation through confirmed visual contact with each other's aircraft where there is a potential for conflict or through physical separation by height, and/or location, and/or heading.

All FCTAF radio communications are to be related to the aircraft operations, to the task at hand or to the safety of aircraft operations.

The pilot of an inbound aircraft should listen out on FCTAF and make the inbound call at about 5nm and when there is a definite break in radio traffic; being careful not to disrupt important communications that may be in progress unless there is an over-riding safety concern. Separation between aircraft within the FCTAF is the responsibility of each pilot. An AAS or ground supervisor is only to provide instructions for attacking the fire not to arrange separation of aircraft.

Pilots and ground supervisors making calls or giving instructions should be careful to provide intermittent pauses to enable others to make important transmissions. All calls are to be directed to a specific station or made as a general broadcast as appropriate. All communication are to be mission related to avoid radio congestion.

Atmospheric Pressure (Q) at Nautical Height (QNH) within the FCTAF should be called by the first arriving aircraft or the on scene Air Attach Supervisor and is set in hectopascals. The QNH should be derived from the reported area or local QNH if available).

	Circumstances	Phraseology
		General
1	Inbound to the incident *[pilot broadcast or request]* FCTAF Frequency	*[address station...AAS or all stations]* HT/FB... IS 5 NM *[direction from]* INBOUND AT *[altitude]*, REQUEST FIRE GROUND QNH & JOINING INSTRUCTIONS
2	*AAS instructions*	HT/FB/Bomber.... QNH IS... *[hectopascals]* RECOMMEND MAINTAIN .... AGL AND JOIN A *[circuit direction]*
3	Instruction *[from AAS or other aircraft on scene]*	CIRCUIT DIRECTION IS CLOCKWISE, A/C IN THE CIRCUIT ARE.... ????...**REPORT SIGHTING...**
4	Report when sighting other aircraft	HT/FB/Bomber...,... *[other A/C in circuit or AAS]* SIGHTED
5	A/C joining the circuit	HT/FB/Bomber... JOINING THE CIRCUIT BEHIND *[nominate preceding A/C]*
6	Lost Contact with other aircraft	HT/FBBomber ... IS AT .... FT , BUGGING OUT **(heading, climbing to ____ ft to hold)**
7	Any aircraft approaching the airbase.	HT/FB/Bomber is 3 miles ....(direction from) inbound for ....(reason---refuel, re-load, shut-down, crew drop off/pick-up)
8	A/C approaching the fire for water drop	BOMBER... ON THE DROP heading ....
9	A/C departing after conduction water drop	HT/FB... OFF THE DROP heading ...
10	Departing the incident	HT/FB... DEPARTING.... FOR..... *[fuel, staging, etc]*

HELICOPTERS		
11	Lifting from the fuel/staging area	ALL STATIONS FIREBIRD.... LIFTING FROMTHE FUEL
12	Departing the fuel/staging area	ALL STATIONS FIREBIRD... DEPARTING THE FUEL FOR THE FIRE GROUND
13	A/C making an approach to the water hole	HT/FB.... INTO THE DIP heading ....
14	A/C departing the water hole	HT/FB.... OUT OF THE DIP heading ....
FIXED WING BOMBERS		
15	Air base position	Bomber # 2 in the queue for the load hose
FLOAT PLANE		
16	A/C approaching water scooping	BOMBER... ON THE WATER
17	A/C departing water	BOMBER... OFF THE WATER

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ATSB assessment of response/action

The ATSB is satisfied that the action by the NSW RFS adequately addresses the safety issue.

APPENDIX A: SOURCES AND SUBMISSIONS

Sources of Information

Sources of information during the investigation included:

- the pilots and operators of VH-NFO and VH-LXC
- the New South Wales (NSW) Rural Fire Service
- State Forests NSW
- the State Aircraft Unit of Victoria
- the United States Department of Agriculture, Forest Service, Technology & Development.

References

Inattentional blindness: What captures your attention? Posted: 06/15/2009; ISMP Medication Safety Alert. 2009;14(4) © 2009 Institute for Safe Medication Practices

Inattentional blindness. Daniel J. Simons (2007), Scholarpedia, 2(5):3244.

Limitations of the See-and-avoid Principle, Australian Transport Safety Bureau, Research Report, April 1991

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the Civil Aviation Safety Authority (CASA), the NSW Rural Fire Service (RFS), the pilots and operators of the helicopters and State Forests NSW.

Submissions were received from CASA, one of the pilots, State Forests NSW and the NSW RFS. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.