Australian Government

Australian Transport Safety Bureau

Wirestrike and collision with terrain involving Robinson R44, VH-HNF

69 km south-east of Hay Airport (Steam Plains), New South Wales, on 31 July 2020

ATSB Transport Safety Report

Aviation Occurrence Investigation (Defined)

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Addendum

Page	Change	Date

Safety summary

What happened

On 31 July 2020, the pilot of a Robinson R44 Raven I helicopter, registered VH-HNF and operated by Riverina Helicopters, was conducting aerial weed spraying at Steam Plains, 69 km south-east of Hay Airport, New South Wales.

During the fifth spray load of the morning, the pilot turned the spray off and conducted a climb to clear a stand of trees. At 1057 Eastern Standard Time, as the helicopter descended to continue spraying, the top of the left skid struck a powerline that crossed the flight path.

The helicopter entered uncontrolled flight and collided with terrain about 120 m beyond where it struck the wire, resulting in fatal injuries to the pilot. The helicopter was substantially damaged.

What the ATSB found

The ATSB found that the pilot knew the wire existed and overflew a small section of the target area earlier that morning, but did not conduct an aerial inspection to identify hazards and verify the location of the powerline on the accident flight. Without the aerial hazard check, the pilot was reliant on seeing the wire during the flight, but was unable to do so in time to avoid the wirestrike.

The pilot's injuries were consistent with flailing due to the left-side impact, but it could not be determined whether the pilot slipped out of, or was not wearing, the shoulder sash portion of the 3-point harness.

Although the pilot was wearing a helmet, it did not attenuate the impact to survivable levels. Either the impact forces exceeded the helmet design specifications, or the helmet was not fitted, worn or maintained correctly.

The pilot was not effectively managing severe obstructive sleep apnoea, which has been shown can cause impairments in cognitive functions including attention and short-term memory, and increased the risk of the pilot suffering the effects of fatigue. It could not be determined whether the pilot was experiencing any impairments associated with the condition. The condition had also not been disclosed to the Civil Aviation Safety Authority, which prevented oversight of any ongoing safety risk associated with the condition.

What has been done as a result

The ATSB has released a safety advisory notice to strongly encourage pilots conducting low-level operations to wear a flight helmet, ensuring that it is:

- fit for purpose
- custom fitted to the pilot’s head
- properly secured by using the chin strap
- maintained in accordance with the manufacturer’s instructions.

Safety message

The risk of wirestrike in low-level operations is well-documented. Uncontrolled flight often follows a wirestrike, which increases the risk of serious and fatal injuries. For pilots conducting low-level operations, pre-flight identification of hazards is essential. As more up-to-date mapping and powerlines data is made available, and more wires carry visible markers, pilots have improved access to tools for planning and strike prevention. The ATSB encourages landowners who engage pilots to conduct aerial application operations to mark powerlines that may pose a hazard.

However, only by conducting an aerial inspection at a safe height, can the pilot be assured of the location of hazards.

Although planning for hazard avoidance is key, pilot limitations remain, including the ability to see a wire or obstacle, attention, memory and distraction. In these situations, survivability features including 4-point pilot seat restraints and flight helmets, significantly improve survivability of helicopter accidents and should be used. It is also important to remember that a helmet will only meet its design specifications if it is fitted properly, worn correctly and maintained in accordance with manufacturer's instructions.

Common symptoms of obstructive sleep apnoea (OSA) include snoring, excessive daytime sleepiness and poor concentration. It can also have complex and significant physiological, neurological, cognitive and psychological impacts, and increases the risk of accidents. The Civil Aviation Safety Authority's *Obstructive sleep apnoea and aviation safety fact sheet* advises pilots who have symptoms of OSA or suspect they may have it, to see a general practitioner. A diagnosis of OSA must be reviewed by a Designated Aviation Medical Examiner.

Contents

The occurrence

What happened

On 31 July 2020, the pilot of a Robinson R44 Raven I helicopter, registered VH-HNF and operated by Riverina Helicopters, was preparing to conduct aerial weed spraying along a perimeter fence and adjacent track at Steam Plains Station, 69 km south-east of Hay Airport, New South Wales.

At 0911 Eastern Standard Time,[1] the pilot ferried the helicopter from the station airstrip to the loading site, where the loading truck was positioned. The Riverina Helicopters' chief pilot was performing the role of loader for the day, transferring chemical from the truck into the helicopter's spray tank.

Prior to loading the helicopter with chemical for the first load, the loader briefed with the pilot. The briefing included a review of the day's task, the map of the property and hazards associated with the operation. The identified hazards included a 19.1 kV single wire earth return powerline, which crossed the perimeter fence line once in the target area. The powerline had been identified as a hazard and highlighted on the pilot's map during initial planning with the station manager 2 days prior.

After loading at 0931, recorded GPS data indicated the pilot flew the helicopter to the property boundary to spray the track adjacent to the fence line, operating 2.5 to 5 m above the ground, before returning to the loader. The pilot sprayed four loads over a 76-minute period and departed with the fifth load at 1047 (Figure 1).

The GPS data showed that the pilot flew the helicopter to the fence line and began spraying the fifth load. About 370 m before reaching the position where the previously-identified powerline crossed the fence, the pilot turned the spray off and manoeuvred the helicopter to climb over an area of trees 12 to 15 m high. At the end of the treed area, the helicopter descended, likely to recommence spraying. During the descent, the helicopter struck the powerline. The electricity provider reported that the fault to the powerline occurred at 1057. This was consistent with the time of the last recorded GPS position of the helicopter, about 300 m prior to the powerline.

The helicopter subsequently collided with terrain about 120 m beyond the powerline, resulting in fatal injuries to the pilot. The helicopter sustained substantial damage.

Post-accident actions

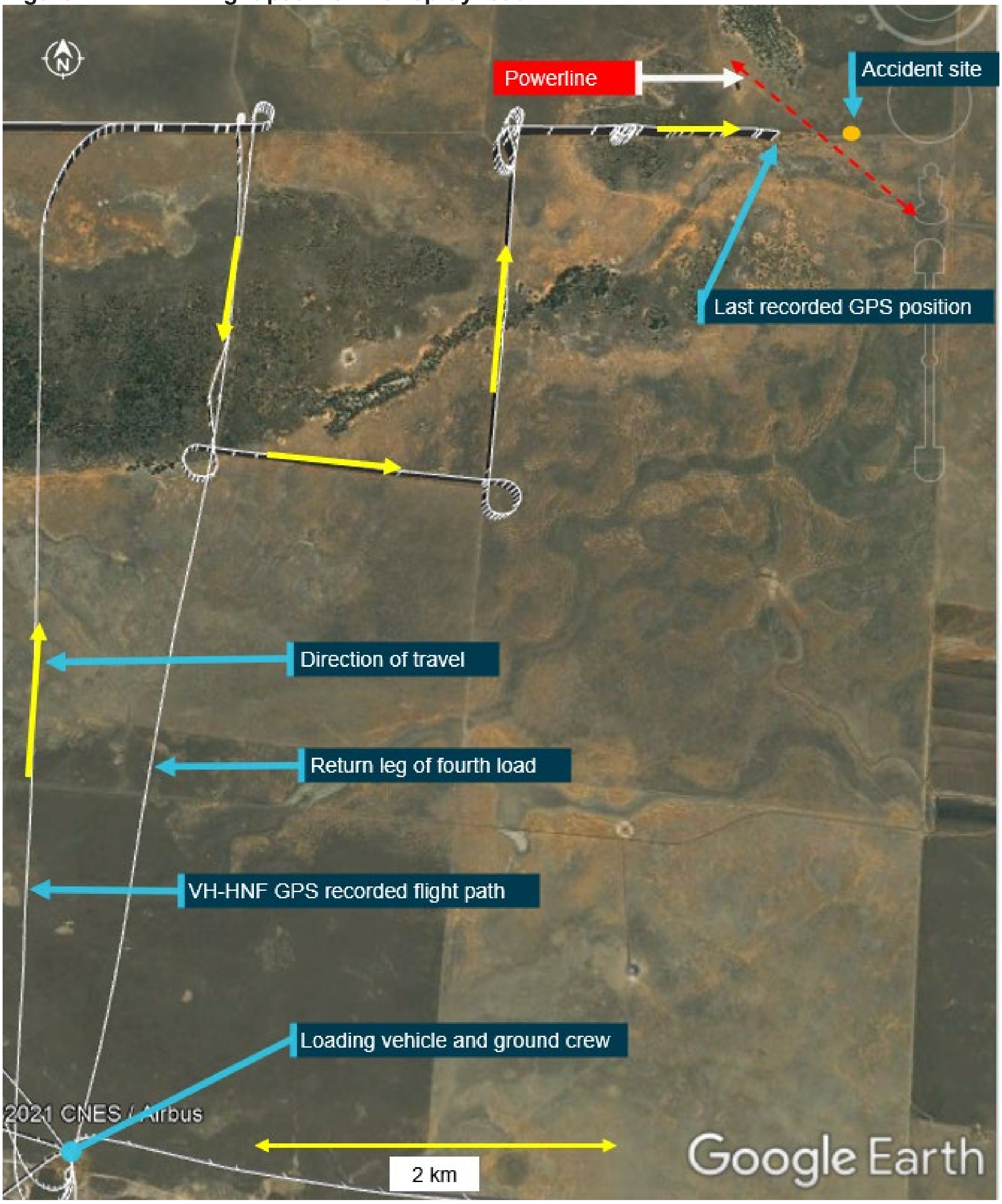
At 1140, the loader contacted the station manager and reported the helicopter overdue from the last load. Aware that the helicopter was operating in the vicinity of the powerline, the station manager drove to the accident site, advised the loader of the accident, and called emergency services. The station manager advised the emergency services call operator that the powerline was coiled over the fence and the helicopter, and requested the power be switched off as a priority. From a distance, the station manager assessed that the pilot was breathing but unconscious.

The emergency services operator advised Essential Energy and the system controller isolated that section of the electrical network. Field workers were dispatched to check power to the area had been effectively isolated and to ensure it was safe prior to first responders accessing the site.

Police and ambulance crews arrived on the scene and about 1 hour later, the Essential Energy workers arrived and tested the wires to verify they were not live. The pilot was then extricated from the helicopter and airlifted to hospital, where they remained on life support until the morning of 3 August.

[1] Eastern Standard Time (EST): Coordinated Universal Time (UTC) + 10 hours.

Figure 1: VH-HNF flight path for fifth spray load



Source: Google Earth and GPS data, annotated by the ATSB

Context

Pilot information

Qualifications and experience

The pilot held a Commercial Pilot Licence (Helicopter) and a Private Pilot Licence (Aeroplane) issued under Civil Aviation Safety Regulations Part 61 on 10 February 2015, granted on the basis of Civil Aviation Regulations Part 5 licences issued in 2010. The pilot held the following helicopter ratings: single engine class, aerial application, low level, sling and aerial mustering.

The pilot's Class 1 Medical Certificate was valid to 27 August 2020. At the pilot's last medical examination with a Civil Aviation Safety Authority (CASA) Designated Aviation Medical Examiner in August 2019, no issues were raised by the pilot or apparent to the doctor. Following issue of the medical certificate, there was no further communication between CASA and the pilot.

The pilot was inducted into Riverina Helicopters in July 2015 with about 2,000 hours of aeronautical experience, 1,600 of which was in Robinson R22, and 30 was in R44 helicopters.

The pilot's Aerial Application Association of Australia (AAAA) Spraysafe accreditation was current and in June 2019, the pilot had successfully completed the association's *Crew resource management, hazards and human factors* course. In August 2019, the pilot had completed an annual CASA flight review/proficiency check.

On 27 May 2020, the chief pilot of Riverina Helicopters conducted an (annual) agricultural pilot and air work proficiency check and assessed the pilot 'competent to carry out Agricultural and Aerial Work operations for Riverina Helicopters'. According to the pilot's logbook, as of that date the pilot had accrued 3,730.3 hours of aeronautical experience and there were no further entries.

72-hour history

On 29 July, the pilot had left Griffith at about 0700 and driven the loading truck 1.5 hours to the Steam Plains property. That day, the pilot had been performing the loader duties (not flying) from 1138 to 1715. The pilot and chief pilot had stayed in accommodation at the property for the next 2 nights, going to sleep at about 2130 each night.

On 30 July, the pilot woke up at 0700 and conducted the daily inspection on the helicopter. The pilot started the helicopter at 0917 and commenced spraying operations at 0925 on the neighbouring property, finishing there at 1413. The loader then relocated the vehicle, and the pilot ferried the helicopter to Steam Plains, commencing spraying operations there at 1501. The pilot finished the day's work and shut down the helicopter at 1743.

On the morning of the accident flight, the chief pilot reported that they had woken up at about 0700 and there had been no hurry in getting started as there was dew and they had to wait for the vegetation to dry before spraying.

Obstructive sleep apnoea

On 23 January 2020, the pilot attended a sleep clinic and completed a sleep study. On referral, the pilot had a STOP-Bang score[2] that indicated a high risk of obstructive sleep apnoea (OSA) and an Epworth Sleepiness Scale[3] score in the higher normal range for daytime sleepiness. At that time, the pilot's only reported symptom was loud snoring. The resulting polysomnography report identified fragmented sleep with oxygen saturation reducing to a minimum of 81 per cent. The diagnosis was severe OSA, with accompanying moderate oxygen desaturations.

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2 The STOP-Bang questionnaire assesses a candidate's risk of obstructive sleep apnoea.

3 The Epworth Sleepiness Scale is a self-administered questionnaire with 8 questions. Respondents are asked to rate, on a 4-point scale (0-3), their usual chances of dozing off or falling asleep while engaged in eight different activities.

The diagnosis of OSA is made when repetitive pauses in breathing occur during sleep, last at least 10 seconds, and occur due to the airway collapsing. These pauses reduce blood oxygen levels and lead to awakening or shifting into a lighter sleep.

The severity of OSA is based on the number of partial or complete pauses in breathing per hour. Severe OSA is defined as more than 30 events per hour. The pilot recorded 42.5 events per hour on average during the study. In response, the reviewing specialist recommended an urgent trial of a continuous positive airway pressure (CPAP) machine. A CPAP machine provides pressurised air, which opens the airway to ensure adequate delivery of oxygen. However, it does not cure OSA and compliance is a known limitation with CPAP treatment (Caldwell 2006).

CASA's *Obstructive sleep apnoea and aviation safety fact sheet* stated that a CPAP should be used at least 5 hours per night for 6 nights per week and 'must be used during the sleep period just prior to flight'. CASA may issue or reissue medical certification where compliance and effectiveness of CPAP treatment can be used to demonstrate control of OSA.

The ATSB obtained a detailed compliance report of sleep data automatically uploaded from the pilot's CPAP machine. Between 21 February and 16 July 2020, the pilot had used the CPAP machine for at least 4 hours on 71 per cent of nights. The pilot's CPAP usage had been frequent in March and April, then decreased. The CPAP had not been used between 8 and 15 July and the last recorded use was 16 July, 15 days prior to the occurrence flight. The pilot had not taken the CPAP machine to the accommodation at Steam Plains.

The effects of sleep apnoea on aviation outlined in the CASA fact sheet included reduced attention and concentration, and degraded cognition.

Fatigue risk

The US Federal Aviation Administration (FAA) pilot safety brochure *Fatigue in aviation* stated that typically fatigue 'occurs with someone who does not get sufficient sleep over a prolonged period of time (as with sleep apnoea, jet lag, or shift work) or someone who is involved in ongoing physical or mental activity with insufficient rest'. It further stated:

> Any fatigued person will exhibit the same problems: sleepiness, difficulty concentrating, apathy, feeling of isolation, annoyance, increased reaction time to stimulus, slowing of higher-level mental functioning, decreased vigilance, memory problems, task fixation, and increased errors while performing tasks.

Research has also found that sleep deprivation can impair decision making and increase risk-taking behaviour to avoid additional effort (Shingedecker and Holding 1974 as cited in Battelle Memorial Institute 1998; Harrison and Horne 2000; Killgore and others 2006). If a person has 20 or more apnoeas per hour, both health and daytime alertness will suffer (Caldwell 2006). When present, excessive daytime sleepiness is inversely correlated with vigilance, but not all people with OSA display excessive daytime sleepiness (Seda and Han 2020).

Circadian rhythms are the body's internal clock that regulates the sleep-wake cycle and repeats roughly every 24 hours. An individual's alertness, sleep tendency and human error have been shown to follow this 24-hour pattern (CASA 2016). According to the International Civil Aviation Organization's *Fatigue management guide for airline operators* (ICAO 2015), there are two times of peak sleepiness within 24-hour cycle. The main peak is in the early morning between 0300-0500 known as the window of circadian low, another smaller peak is around 1500-1700 known as the afternoon nap window. During the afternoon nap window, someone who has had restricted or disturbed sleep can find it harder to stay awake.

Other factors that can increase the fatigue risk level include early shift start times (before 0600), when regular breaks have not been taken, and when shifts are longer than 8 hours (CASA 2012). Twenty per cent of accidents where fatigue was attributed were in the 10th or more hour of duty (Goode 2003).

Effects of sleep apnoea

Sleep apnoea can have significant physiological, neurological, cognitive and psychological impacts, and can affect multiple cognitive domains (Seda and Han, 2020). Several studies have shown that OSA has an adverse effect on inductive and deductive reasoning, attention, vigilance, learning, and memory (Lal and others 2012). These impairments are measurable in neurological and cognitive assessments, but they may not be readily evident during flying operations or medical examinations. Deficits in neurocognitive functioning have been shown to occur with a high frequency in OSA sufferers, but the exact prevalence is unknown.

Investigation findings regarding sleep apnoea

A search of the US National Transportation Safety Board database revealed 29 aviation accidents between 1997 and 2019 with 'sleep apnea' included in the analysis text, with 9 accidents where it was concluded that OSA had some contribution.

There were 8 accidents in which a pilot had OSA, and the OSA itself or in combination with other diseases and medications contributed to the accident. A further accident involved a fuel truck driver with OSA who fell asleep and the truck collided with an aircraft.

In one investigation there was no evidence that the pilot suffered sleep apnoea, in another it was unlikely that the pilot's effectively-treated OSA contributed to the accident. For the other 17, the pilot either had, or was at risk of, OSA but it could not be determined whether the pilot was suffering from any effects of OSA and/or whether these contributed to the accident.

The Transportation Safety Board of Canada published a list of all their investigations with fatigue-related findings from 1990 to 2018. One of 34 aviation occurrences where fatigue was listed as a causal or contributory factor or a source of risk, mentioned OSA. Following diagnosis of OSA and initial effective CPAP treatment, the pilot subsequently rarely used CPAP therapy. The investigation found that although the pilot was therefore at risk of fatigue, there was no indication that fatigue contributed to the occurrence.

One ATSB investigation report into a fatal accident involving a collision with terrain during landing practice in a solo training flight (*AO-2016-112*) identified that the pilot had 'a history of health and chronic pain issues including sleep apnoea'. The investigation found that:

> Fatigue and level of experience likely affected the pilot's ability to respond to the demands required to correct the aircraft's departure from controlled flight during the landing attempt and subsequent go-around.

Post-mortem and toxicology results

The post-mortem report documented multiple impact-related injuries, including spinal fractures, with the cause of death identified as severe traumatic head injury. This was as a result of diffuse cerebral injuries, while only relatively superficial contact injuries to the head were noted. These included bruising consistent with a left-side impact to the head. There was also bruising consistent with the pilot being restrained during the accident by the lap belt, but not from the accompanying shoulder sash.

The only substance identified in toxicological examination was almost certainly administered by emergency/hospital personnel.

Aircraft information

VH-HNF was a Robinson Helicopter Company R44 Raven I helicopter, powered by a six-cylinder Lycoming O-540-F1B5 engine, manufactured in 2018 and first registered in Australia in April 2018.

The helicopter's current maintenance release was issued on 21 January 2020 and was valid for 12 months or 100 hours, whichever occurred sooner. A 50-hourly inspection had been conducted on 26 March 2020, at 353.8 hours, and no defects were recorded on the maintenance release.

Prior to the commencement of flying on 31 July 2020, the aircraft had accrued 388.5 hours total time in service.

The helicopter was fitted with a Helipod III Agricultural Spray System, which included a single fibreglass belly tank attached to the landing gear and a spray boom and nozzle arrangement located towards the front of the helicopter. Pilot control of the system was via a cyclic-mounted switch. For the system fitted, the maximum chemical tank load was 285 L or 285 kg. With the Helipod system installed, the helicopter was to be operated in the Restricted category and in accordance with a special certificate of airworthiness.

The exact quantity of fuel and chemical on board at the time of the accident was unable to be determined. However, the helicopter would have been within the weight and balance limitations through the range of empty to full fuel and spray tanks.

The R44 helicopter was not fitted with wirestrike protection. The most common aircraft-mounted wirestrike protection systems (WSPS) are passive and comprise deflectors to guide a struck wire to a fixed wire cutter consisting of sharpened blades. They are designed to reduce the likelihood of adverse outcomes resulting from a wirestrike, including entanglement, damage to flight controls, the airframe and injuries to occupants. To be effective, the system relies on the wire entering the cutter with sufficient force and at a suitable angle to cut it. ATSB research report *Wire-strike accidents in general aviation: Data analysis 1994 to 2004* stated that smaller rotary-wing aircraft including Robinson (R22 and R44) helicopters 'generally have no structural hard points to fit a WSPS and are generally too light and, in many instances, travel too slowly for WSPS to be effective'.

Meteorological information

Witness reports indicated the weather was fine and sunny with calm to mild winds. Bureau of Meteorology observations at 1100, from the nearest recorded weather stations, indicated the temperature was between 10 °C and 12 °C and the wind 0 to 4 kt.

Site and wreckage examination

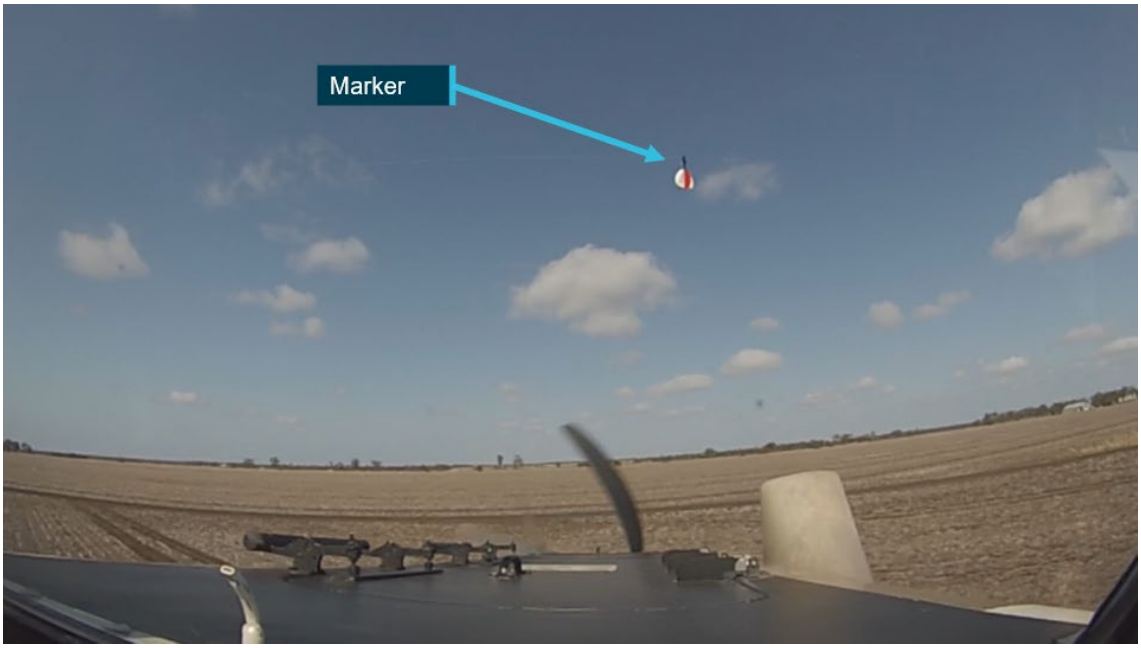
Powerline

The 19.1 kV single wire earth return powerline spanned 305 m and was supported by two power poles, one located 144 m north-west and the other 161 m south-east of the fence. It crossed the fence line at a gate. Between the poles, the wire drooped parabolically from about 10 m at the pole to 6 m mid span when new, but had likely stretched due to its age and was therefore about 5 m above the ground mid span, where it was struck. The wire was pulled off several poles and broken in two places.

The powerline was not marked and was not required to be, according to Australian Standards 3891.1 and 3891.2.[4] Following a wirestrike of a powerline owned by Essential Energy, field workers assess the risk of another strike. If it is considered likely, at least one aerial marker (Figure 2) is fitted to the wire. It was assessed at the time that a subsequent wirestrike was unlikely to occur due to the remoteness of the location and because the helicopter was spraying weeds along the perimeter fence rather than crop spraying. As a result, no markers were fitted to the wire when it was restrung or subsequently.

[4] Australian Standards AS 3891.1 *Permanent marking of overhead cables and their supporting structures for other than planned low level flying*, and AS 3891.2 *Marking of overhead cables for planned low level flying operations,* addressed the requirements for marking overhead cables, including powerlines.

Figure 2: Example of a wire aerial marker



Source: Balmoral Engineering

Accident site

The accident site was in flat, open farmland, about 7 km north-east of the loading vehicle. The main fuselage was located about 120 m beyond the powerline, in the direction of travel.

Wire abrasion marks were evident down the front of the forward left strut and along the top of the left skid, ending with a distinct friction mark near the tip of the skid (Figure 3). The powerline remained entangled in the wreckage.

Examination of the ground scars, damage and distribution of the wreckage indicated:

- the main rotor had impacted the tail boom during the accident sequence, resulting in loss of control of the helicopter
- the helicopter collided with the ground on its left side in a nose-down attitude of about 30°
- the main rotor blade and landing gear dug into the ground, resulting in the helicopter bouncing, rotating about 180°, and coming to rest on the right side.

Figure 3: Wire marks on VH-HNF's left skid

Source: ATSB

The ATSB examined the helicopter and did not identify any evidence of in-flight breakup, birdstrike, or pre-existing defects that may have contributed to the wirestrike. Consistent with normal agricultural operations, the pilot door was not fitted at the time of the accident. Significant structural deformation of the helicopter's left front quarter and seat was consistent with a heavy impact on that side, to the extent that there was no occupiable space for the front left seat. On the right (pilot's) side, there was crushing of the seat lower box section (as designed, to absorb vertical impact loads) and some right-side roof deformation, associated with the left-front impact. Although compromised, occupiable space on the right side of the fuselage remained.

There were no issues identified with the flight controls, and examination of the engine found no anomalies that would have affected the engine's performance. Evidence that the main rotor was being driven under power included that one of the main rotor blades showed significant chordwise bending and, from the other blade, a section of blade tip, measuring 850 mm and weighing 5.3 kg had fractured as a result of ground impact and was thrown approximately 300 m from the accident site.

The loader had recorded uplift of 40 L of Avgas prior to the start of the fifth load. A large quantity of fuel remained in the left fuel tank, and testing indicated no evidence of water or contaminants. There was no post-impact fire.

The chemical holding tank had been compromised and no visible herbicide remained, but a strong odour indicated that a quantity had leaked and soaked into the ground where the aircraft had come to rest. The pilot-controlled spray switch was in the on position.

Operational information

Helicopter operator

Riverina Rotor Work, trading as Riverina Helicopters, was the registered owner and operator of VH-HNF. Riverina Helicopters held a CASA-issued Air Operator's Certificate to conduct aerial work and aircraft charter operations. Of relevance to this occurrence, the Riverina Helicopters Operations Manual included:

Specialised operations [including aerial spraying]

> Protective helmets shall be worn for all specialised operations.

Low level operations

> Before descending to conduct low level operations, the pilot in command shall conduct a reconnaissance of the area and identify the hazards noted from the study of the charts and to make a note of other hazards not indicated on the charts.

Agricultural operations – helicopters

> The Company shall be responsible for supplying pilots with up to date maps and charts of the various treatment areas, clearly displaying all hazards associated with those areas. However, prior to the commencement of operations, the pilot in command shall become familiar with the task by personal inspection and briefing by drawing a 'field map' of each area to be treated. Pilots should be aware that any locally supplied information is often incorrect but it does at least provide a guide and can be verified during aerial inspection of the area. A copy of the applicable field map(s) should be taken by the pilot on each sortie…agricultural pilots are required to carry out a preliminary aerial inspection of the area to be treated including the adjacent manoeuvring areas in all directions, paying particular attention to the location of obstructions including those, if any, outside the actual treatment area.

In addition, the operator's Management System procedure – *Conduct an application,* included that:

> The pilot will conduct a pre-application aerial inspection of the target ensuring that they have confirmed the following with their work order:
>
> iii. Power Lines, Towers, Aerials, moisture probes & other obstacles are located and identified

Steam Plains task

The station manager had previously engaged Riverina Helicopters for aerial work in 2010, 2012, 2016 and March 2020. Commencing on 29 July 2020, the station manager had contracted Riverina Helicopters to spray weeds along the fence and adjacent track at Steam Plains and a neighbouring property as a firebreak. The pilot conducted the same task during the 2016 engagement.

Pre-flight planning

On the morning of 29 July (day 1 of the 3-day task), the chief pilot was delayed leaving Griffith in the helicopter due to fog. The pilot drove the loading truck and the station manager reported that it arrived at about 0800. The station manager met the pilot at the truck and gave the pilot a briefing of the task. This briefing included discussing the chemicals that would be used for spraying, the application rate of the chemicals, areas to be sprayed, flight path and hazards. The station manager provided the pilot with maps of Steam Plains and the adjacent property. The maps had been provided to the property owner on purchase in 2008, at which time the property owner had assessed by ground vehicle that the markings on the maps appeared to be correct.

The spray application path had been drawn on the map in red marker pen by the station manager. Using the map, the station manager briefed the pilot about the location of crops, stock and people working in the area. The pilot used a blue pen to over-mark the powerlines (Figure 4). When the chief pilot arrived later that morning, the pilot passed on the details from the briefing, including the powerlines.

The station manager met with the pilot and chief pilot on the morning of 31 July, at about 0650. They discussed the day’s plan including reviewing the map. Before commencing operations, the pilot and chief pilot briefed on the day’s operation again, including the task, map and powerline location.

Prior to the fifth (accident) load, the pilot fuelled the helicopter and discussed with the chief pilot the shape of the boundary fence to be sprayed on the next sortie and the location of the powerline.

Figure 4: Map of Steam Plains Station showing spray path (red) and powerline (blue)

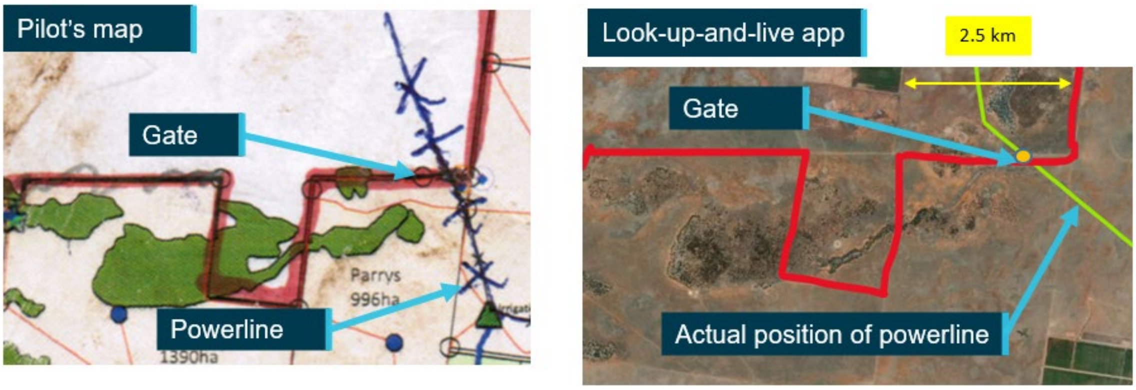
Source: Station owner, marked by the station manager and pilot, and annotated by the ATSB

Mapped powerline location

Figure 5 shows a comparison between the powerline marked on the pilot's map and its actual location taken from Essential Energy's *Look-up-and-live* app. On the pilot's map (left image), the powerline is depicted close to the fence corner and beyond the (marked) gate. The powerline's actual location was exactly overhead the gate and about 300 m further west of the fence corner than depicted on the pilot's map.

In addition to the commentary in the Riverina Helicopters Operations Manual about the possibility of incorrect locally-supplied information, training also emphasised possible inaccuracies. The instructor who conducted the pilot's annual flight review and proficiency check in 2019 commented that pilots are trained to expect that planning information may be inaccurate, and reinforced the importance of verifying it by conducting an aerial inspection.

Figure 5: Map location compared with actual powerline location



Source: Helicopter operator, Google earth and Essential Energy, annotated by the ATSB

Spraying procedures

The AAAA *Aerial Application Pilots Manual* (AAAA 2011:166) advised that:

> all application pilots should be trained to carry out an extra "wind and wires" check before commencing each run, to refresh short-term memory and refocus on any wires.

When spraying a crop or paddock, hazards in the whole area are identified before spraying and the hazards then generally remain fixed. However, the operator reported that, to retain identified hazards in working memory when spraying along a fence line on a large property, a pilot may conduct an aerial reconnaissance of a section of the target spray path before spraying that section, then repeat as the helicopter progresses along the fence line.

In addition, the AAAA *Aerial Application Pilots Manual* (AAAA 2011:151) stated:

> Recollection of precise locations of power lines based on the [application management plan] AMP and a confirming aerial survey is critical to safe application. High situational awareness and an accurate mental map of the treatment area must remain front of mind for the pilot throughout the application…The aerial inspection is the last chance for the pilot to build defences and manage risk.

Aerial inspection and GPS data

Two GPS systems recorded data from the helicopter for the accident flight: Spidertracks and TracMap. Spidertracks data was recorded at 2-minute intervals. The TracMap GPS data associated with the spraying system included speed, altitude and whether the spray system was on or off. Due to buffering from incomplete shutdown associated with the collision, the last TracMap data that was recorded was above the trees with the spray off, before the helicopter descended and about 300 m before it struck the wire.

The TracMap data was compared for the 3 days of the task.

On the first day, the chief pilot reported conducting short inspection flights in the target area ahead, then spraying that section with a good understanding of the hazards present. This was evident in the GPS data for the day, where most tracks were flown twice – once 50 to 100 ft higher with the spray off, then from a lower height with the spray on. Where the intended spray path was along or across a powerline, the helicopter tracked to the wire with the spray off before descending and commencing spraying.

On the day prior to the accident, the pilot was operating on the property neighbouring Steam Plains and the chief pilot was performing loader duties. The GPS data showed that on that day, the helicopter had overflown a powerline several times, including before descending to spray along the wire and perpendicular to it. This was consistent with what the chief pilot observed when the helicopter was operating in sight of the loading truck – short inspection flights conducted before spraying.

On the accident day, the GPS data showed only one small segment of the southern perimeter was flown twice – at the end of the first and start of the second loads. There was no further duplication of any of the tracks and no aerial inspection conducted. The helicopter had not overflown the powerline before the wirestrike.

Previous wirestrike

In 2018, the pilot was operating a helicopter that struck a powerline during spraying operations. The pilot conducted an aerial inspection prior to commencing the task and was aware of the powerline. However, a moisture probe that stood above the crop canopy momentarily distracted the pilot's awareness of the powerline.

The day after that occurrence, the chief pilot had a debrief with the pilot and recalled discussing the sequence of events leading up to the accident, the wirestrike and the post-accident period. A subsequent follow-up discussion with the pilot included techniques to remain situationally aware and understanding the danger of distraction. Following the accident, the pilot completed an AAAA course in cockpit resource management and wire awareness, and a Robinson Helicopter Safety course.

Survivability aspects

The following section is largely based on a report provided by The Royal Australian Air Force Institute of Aviation Medicine. The report included advice regarding the use of helmets and restraints in helicopter accidents and their role in reducing the risk of fatal injuries in an otherwise survivable accident, as well as analysis specific to this accident.

Survivability and injuries

The FAA report *Analysis of rotorcraft crash dynamics for development of improved crashworthiness design criteria* (Coltman and others 1985) defined a survivable accident as one in which the acceleration forces were within the limits of human tolerance and sufficient occupiable space remained for well-restrained occupants. Accidents in which impact injuries of the head or upper torso resulted from striking a surface, and could have been prevented by proper restraint, were deemed potentially survivable.

Injuries from aircraft accidents arise from three distinct sources:

- excessive acceleration forces (internal injuries)
- direct trauma from contact with hard surfaces
- exposure to environmental factors such as fire, smoke, water, and chemicals.

Acceleration forces

Significant research has been conducted into human tolerance of impact forces. Survivable velocity/acceleration envelopes have been determined based on analyses of helicopter accidents, including the injuries sustained by occupants, and the vertical, longitudinal and lateral impact forces (Coltman and others 1989, Coltman and others 1985). A large proportion of the studied US civilian helicopter wirestrike accidents (1974–1978) were classified as non-survivable due to the uncontrolled flight that followed the strike, and 65 per cent of the wirestrike accidents resulted in serious or fatal injuries.

Due to the compound forces on the helicopter (VH-HNF) when it impacted the ground, including a vertical component that resulted in seat crushing (as designed), lateral impact on the left front side and rotational forces, the ATSB was unable to accurately determine the velocities in each plane, to assess whether the acceleration forces were survivable.

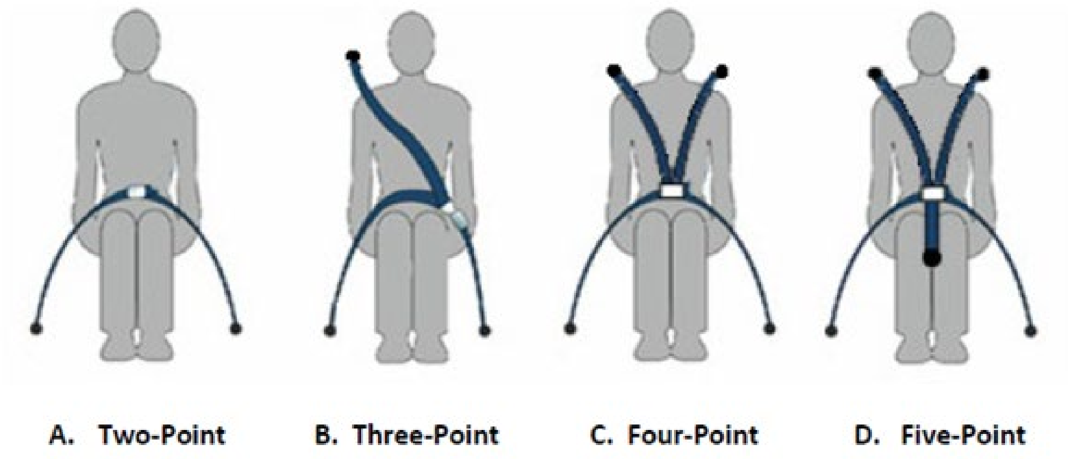
Trauma injuries

In US Army helicopter accidents from 1979 to 1985, trauma injuries from striking the aircraft structure occurred at least five times more frequently than acceleration injuries (Shanahan and Shanahan 1989). The potential for trauma injuries can be reduced by using restraint systems that decrease the area the body can move around in. That is, by reducing the 'flail zone' or 'strike envelope'.

Restraints

The Australian Civil Aviation Safety Order 20.16.3 required at least one pilot crew member to wear a seat belt or safety harness at all times during flight. Civil Aviation Safety Regulation Part 137.225 required fitment of a 4-point harness to fixed-wing aeroplanes operating in the Restricted category – for example, when fitted with 'role equipment' such as a spray system – however, this requirement did not apply to helicopters operating in the Restricted category. CASA advised that a proposal to amend Part 137 to include Rotorcraft was expected to commence by the end of 2022. Civil Aviation Safety Regulations Part 90.105 required helicopters to be fitted with a safety harness that 'must consist of a lap belt and at least 1 shoulder strap' (3-point harness). Figure 6 illustrates 2-, 3-, 4- and 5-point harnesses.

Figure 6: Aviation restraint types



Source: Department of the Interior and United States Forest Service (2021)

The US Federal Aviation Regulation 137.31 for helicopters conducting aerial application was consistent with Australian regulations in requiring a minimum of a lap belt and shoulder harness for pilots. Some operators have higher standards to reflect their risk associated with their type of operation. For example, the US Department of the Interior, responsible for a large fleet of aircraft conducting land-management-related tasks, required the use of a 4-point restraint (with an inertia reel) for front seat occupants of helicopters. Military standards in the US and Australia mandate the use of a 5-point harness,[5] due to the risks associated with their requirement to fly at low altitudes, in close proximity to obstacles and hazards.

Upper torso restraints serve two purposes: to reduce upper body flailing and subsequent contact with aircraft structures and strike hazards, and to distribute acceleration forces across a larger body area to reduce local transmission of force. Although the shoulder sash of a 3-point harness (the design basis for the common seat belt in cars) provides restraint in a forward direction, it provides lateral restraint in only one direction. If the occupant moves in a lateral or diagonal direction away from the shoulder restraint, it is possible to slip out of the shoulder sash.

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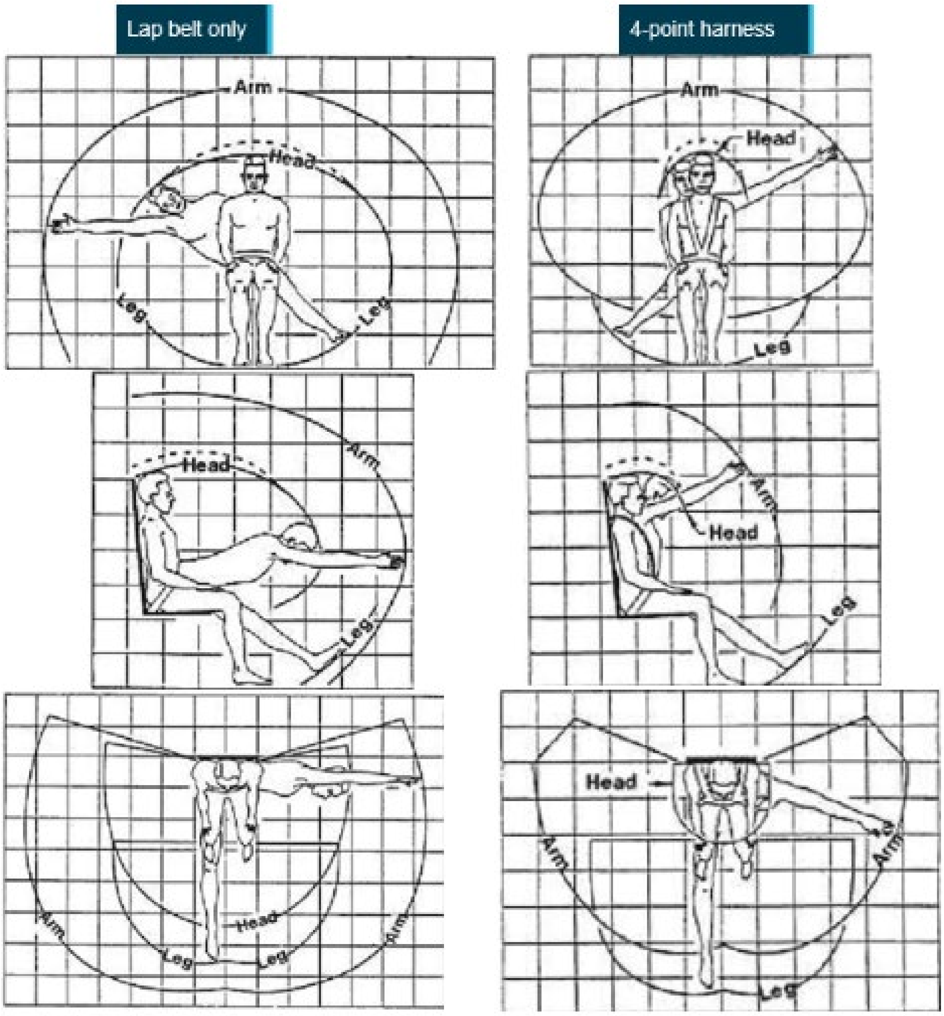
5 A 5-point harness is a 4-point harness with an additional crotch strap that prevents 'submarining', in which the occupant slides down under the lap belt.

The limited aviation research for occupants in 3-point restraint systems subjected to oblique impact forces, indicates a risk of head and abdominal injuries from deceleration forces (Snyder and others 1969). Automotive accident research indicates the potential for greater flailing in oblique (60°) impacts compared to completely lateral (90°) impacts due to torso rotation and reduced engagement of the shoulder (Forman and others 2013). Therefore, if deceleration forces have large lateral or oblique components on the opposite side of the 3-point harness, there would likely be reduced protection provided to the upper torso and head in that direction. In a helicopter accident, crash deceleration forces on the occupant may be from multiple directions as the helicopter impacts the ground and rotates.

The front seats of VH-HNF were fitted with 3-point harnesses. The pilot’s shoulder sash was installed to cover the right shoulder. After the initial front-left impact, the helicopter rotated and came to rest on its right side. The pilot was found in the right seat, with the lap belt still attached across the waist, but the pilot’s upper body was outside the right side of the cabin, in front of (unrestrained by) the shoulder sash. The seat and seat belt were intact. This suggests the pilot may not have been wearing the shoulder sash at the time of the accident. Alternatively, the pilot may have slipped out of it during the uncontrolled flight following the wirestrike or during the crash sequence. In the latter case, the pilot would also have had to slip back underneath the sash to end up in front of it. The operator reported that the company pilots always wore the fitted restraint and specifically that they had observed this pilot to always wear the restraint correctly. However, it could not be determined whether the pilot was wearing the shoulder sash at the time of the accident.

A comparison between the flail zone for an occupant wearing a lap belt only (2-point harness) and a 4-point harness is depicted in Figure 7. These images show that the maximum head strike distance is reduced to 50 per cent with the 4-point restraint. Reducing the flail zone significantly reduces injury risk by reducing the number of objects that could cause strike injuries. In particular, this reduces the risk of potentially fatal head injuries, which was the most common cause of death in aircraft accidents (Crowley and others 1992).

Figure 7: Lap belt only (2-point harness) and 4-point harness flail zone



Source: Aircraft Crash Survival Design Guide, US Army Aeromedical Research Laboratory, annotated by the ATSB

Flight helmets

Benefits and requirements

Helicopter accident investigations conducted by the US Army in the 1980s determined that aircrew lives were being lost to head injury in otherwise survivable accidents (where the deceleration forces were within human tolerance). The outcome of this was the introduction and ongoing development of helmet standards. In an analysis of 'severe accidents', it was determined that occupants not wearing a helmet were significantly more likely to sustain severe and fatal head injuries (Crowley and others 1992). This finding was also consistent in civilian flying studies (Taneja and Wiegmann 2003). The introduction of protective helmets into military aviation has significantly reduced the incidence of head injury (Lewis 2006).

The Civil Aviation Safety Regulations did not require pilots to wear flight helmets. However, it was often mandated by aircraft operators for pilots engaged in aerial work, and necessary to meet federal- and state-legislated workplace, health and safety requirements. The AAAA code of conduct required a commitment to wear suitable personal protection equipment including a flight helmet. The pilot of VH-HNF was a member of AAAA and the company operations manual required a flight helmet to be worn.

Standards

Helmets are designed primarily to provide impact protection – attenuating force and distributing it over a larger surface area – and penetration resistance. Helmets primarily consist of a composite shell that encases an 'impact cap', made from a layer of rigid foam that crushes on impact, and an inner liner/padding for fitment and additional energy absorption. The helmet should also include support for the retention system (including chin strap), visor(s) and communication equipment, as well as noise attenuation. The helmet must be retained on the head following an impact to protect against injury in subsequent impact/s.

There are specific standards for each of these domains and many commercially available helmets for civilian helicopter operators meet these to varying degrees. There was no Australian Standard for flight helmets, however helmet manufacturers used relevant standards that included the US Department of the Interior (DOI)/US Forest Service (USFS) Aviation Helmet Standard, US Military Standard and the European Standard (EN-966) Helmets for Airborne Sports.

The pilot of VH-HNF wore a MSA LH250 helmet (Figure 8). The manufacturer's brochure indicated that the helmet was for pilots/flight crew of helicopters, transport and training aircraft without ejection seats. The helmet was reported to meet or exceed:

- impact resistance to US Air Force (USAF) MIL-DTL-87174A, DOI/USFS Aviation Helmet Standard
- penetration resistance to USAF MIL-DTL-87174A EN-966, DOI/USFS Aviation Helmet Standard
- retention to EN-966:2012 and EN-966:2006, DOI/USFS Aviation Helmet Standard.

The US military standards had different requirements for helmets used in helicopters and aeroplanes. Helicopter and aeroplane helmets were required to be impact tested at five sites (front, rear, left and right sides, crown), but helicopter helmets also required impact testing at two additional sites: the left and right ear cups. The MIL-DTL-87174A standard described helmet performance for use in fixed wing aircraft (aeroplanes) and therefore helmets qualified to that standard may not provide adequate protection for helicopter occupants.

Figure 8: MSA LH250 helmet

Source: Flight Helmets Australia

To meet the specifications a helmet is designed for, it must be fitted correctly, worn properly and maintained in accordance with the manufacturer's requirements. The manufacturer of the pilot's MSA LH250 helmet advised wearers of the following.

- To provide sufficient protection, the helmet must be fitted and adjusted to the head size of its wearer.
- The helmet is made in such a way that any energy received during an impact is absorbed by the destruction of or partial damage to the shell and impact cap; even if this damage is not immediately apparent, replacement of the whole helmet is recommended after a major impact.

- The helmet must be inspected for damage after obvious or suspected impact, or where routine maintenance reveals indications that suggest impact damage may have occurred. Helmet users are responsible for reporting known or suspected damage to helmets and to arrange further assessment, including if the helmet had sustained any impact in a previous accident. If the helmet has sustained a major impact, it should be replaced even if damage is not apparent.

Fitment and maintenance

The pilot purchased the helmet new in 2010. The shell was within its 15-year warranty period at the time of the accident. The pilot had purchased a new chin strap and edge roll (padding) in 2015, and earcup pieces and edge roll in 2017. There was no evidence of the helmet having been serviced by the distributor from which it was purchased.

The LH250 helmet comes in two shell sizes, which can be personalised with pads to fit the wearer's head. The manufacturer advised that the pads degrade over time and should be replaced to ensure optimum fit. The fit of the helmet was not able to be assessed in this instance. The helmet was fitted with a chin strap and locking buckle, which met US DOI and US Military standards. The chin strap was noted by the ATSB to be worn and frayed (Figure 9). This was indicative of the chin strap being worn securely fastened over a long time.

The pilot had very likely been wearing the same helmet during a helicopter accident in 2018, in which the pilot sustained facial injuries. It could not be determined whether the helmet sustained an impact in that accident, or whether any subsequent inspection or maintenance was conducted, although it was confirmed that the helmet had not been sent to the distributor from which it was purchased.

Figure 9: Helmet chin strap

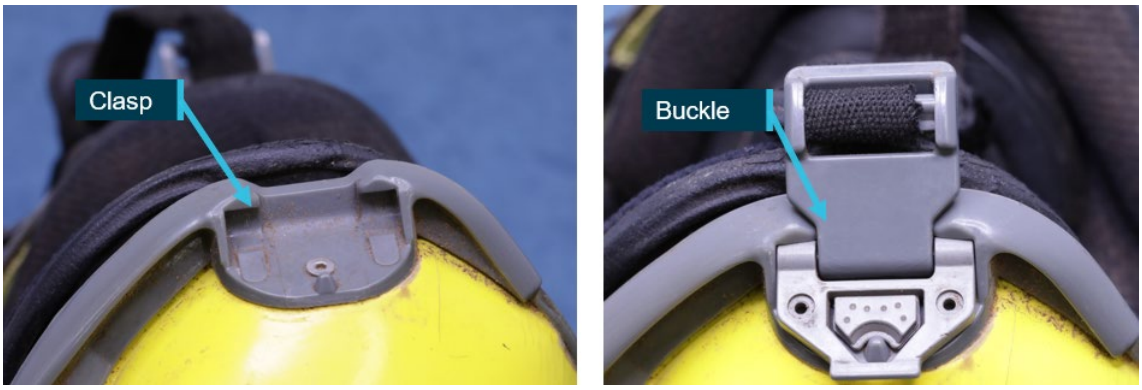
Source: ATSB

Effectiveness

The helmet was found at the accident site, on the ground on the left side of the helicopter, the opposite side to the final resting position of the helicopter on its right side and the pilot in the right seat. The helmet sustained extensive structural damage, with significant cracking of the shell on the top and on the left side. The structure around the left ear and visor attachment was crushed and there was a dent in the shell above the left eye. Most of the outer visor and track had broken off from the right side, and there was paint transfer and scrape marks on the top of the helmet.

The chin strap was found undone with dirt lodged in the clasp. The chin strap fastened on the right-hand side of the helmet (Figure 10). The post-mortem report did not identify chin injuries to indicate that the helmet had been forcibly removed with the chin strap properly adjusted and secured. However, any such injuries may have been obscured by facial hair. Post-accident testing of the helmet by the ATSB found it was possible to undo the clasp with a relatively small 'bump' applied to the clasp. As the clasp was on the right side, this force needed to be applied opposite the (left) side of the initial impact. Although there was no evidence of damage to the clasp or scuff marks near the latch to indicate contact, the damage to the right side of the helmet was consistent with a secondary impact on that side. There was also no documented history of this latch coming undone in accidents.

Figure 10: Helmet clasp and buckle



Source: ATSB

Risk of injuries

The ATSB considered whether wearing a helmet may increase the risk of cervical spine injury, given those sustained by the pilot in this accident. The Royal Australian Air Force Institute of Aviation Medicine indicated that there was limited data on this specific risk from helicopter accidents, however the considerable data from motorcycle and all-terrain vehicle accidents demonstrated clear benefits for helmet use in reducing head injury and no difference in regard to neck injuries.

Wirestrikes

Visibility of wires and poles

Powerlines, particularly unmarked wires, may be impossible to see due to the size of the wire, camouflage with the background and limitations of the eye.

Imagery taken from the ATSB's remotely piloted aircraft (RPA), while following the helicopter's estimated flight path at about the same time on a subsequent day, found that the wire would have been extremely difficult to see (Figure 11 and Figure 12).

Figure 11: RPA image 50–75 m prior to the powerline showing the accident location, taken at 1028 on 4 August 2020, with powerline highlighted

Source: ATSB

Figure 12: RPA image 50–75 m prior to the powerline showing the accident location, taken at 1028 on 4 August 2020, noting powerline visibility

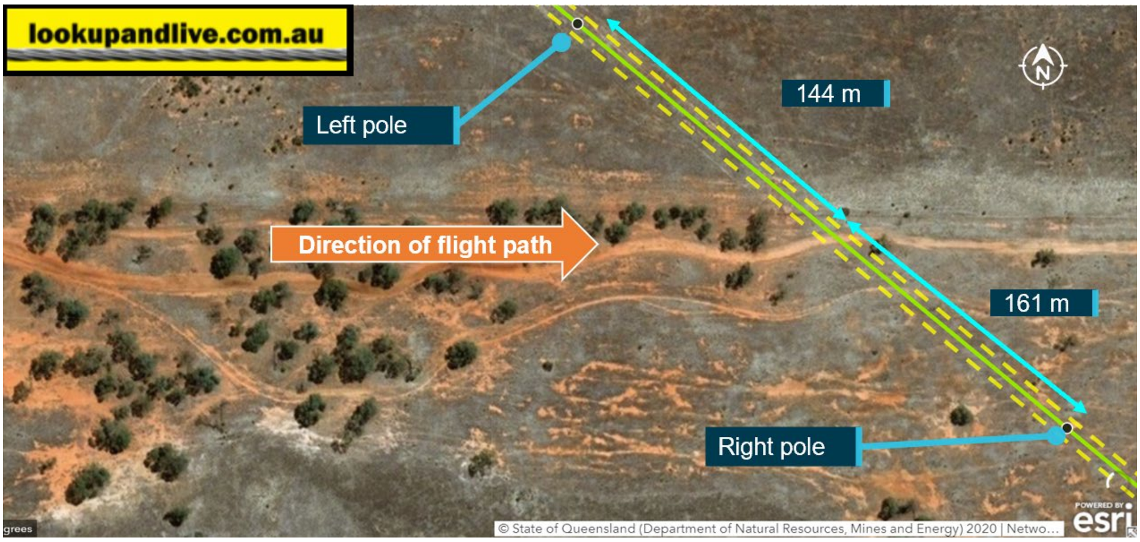
Source: ATSB

During agricultural operations, pilots must retain the position of a powerline in their memory, and are taught to use other visual indications of the presence of a wire, such as a group of trees, power pole, building or feature. The AAAA *Aerial Application Pilot's Manual* (AAAA 2011:151) stated:

> …the background to the wires – trees, hills etc. – may often provide a poor contrast. Poles may be concealed by intervening obstacles or by being located so far towards the periphery of the pilot's visual field that they are not noticed.

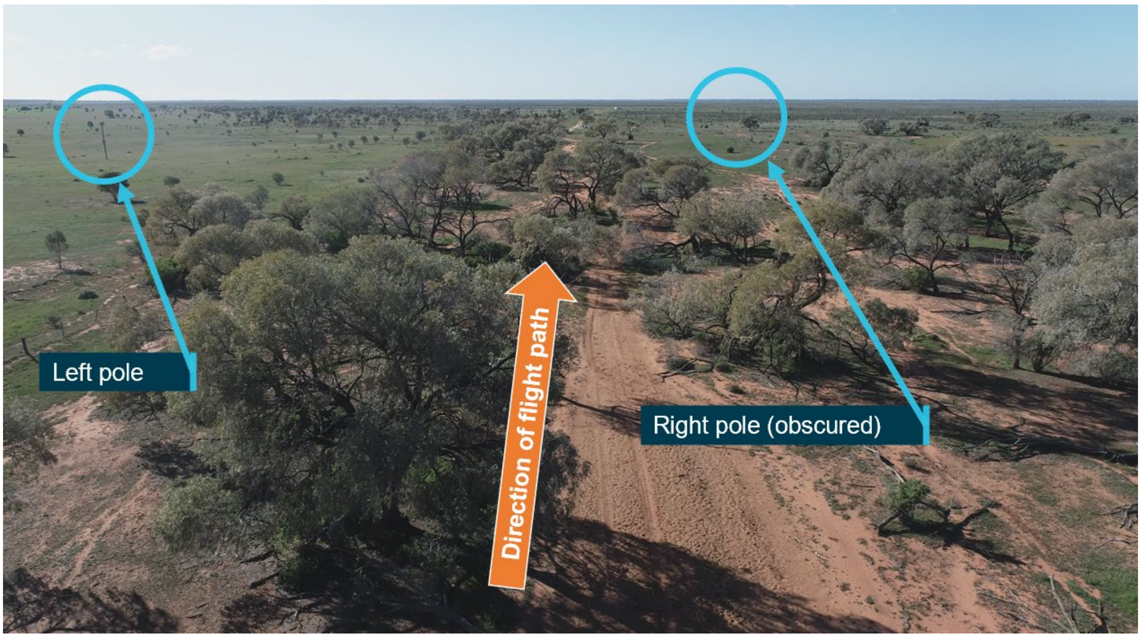
Figure 13 shows the two closest power poles located either side of the helicopter's flight path. From ATSB RPA footage taken along the estimated flight path, at times, both poles were obscured by trees and lacked contrast and texture variation from their background (Figure 14 and Figure 15). The two power poles should have been visible within the pilot's peripheral vision, however it is likely that the pilot's visual acuity was affected by contrast sensitivity, resulting in the pilot being unable to discriminate the poles from their background. Additionally, based on the powerline's location on the pilot's map, the pilot may not have been looking for cues at that time.

Figure 13: Power poles either side of flight path



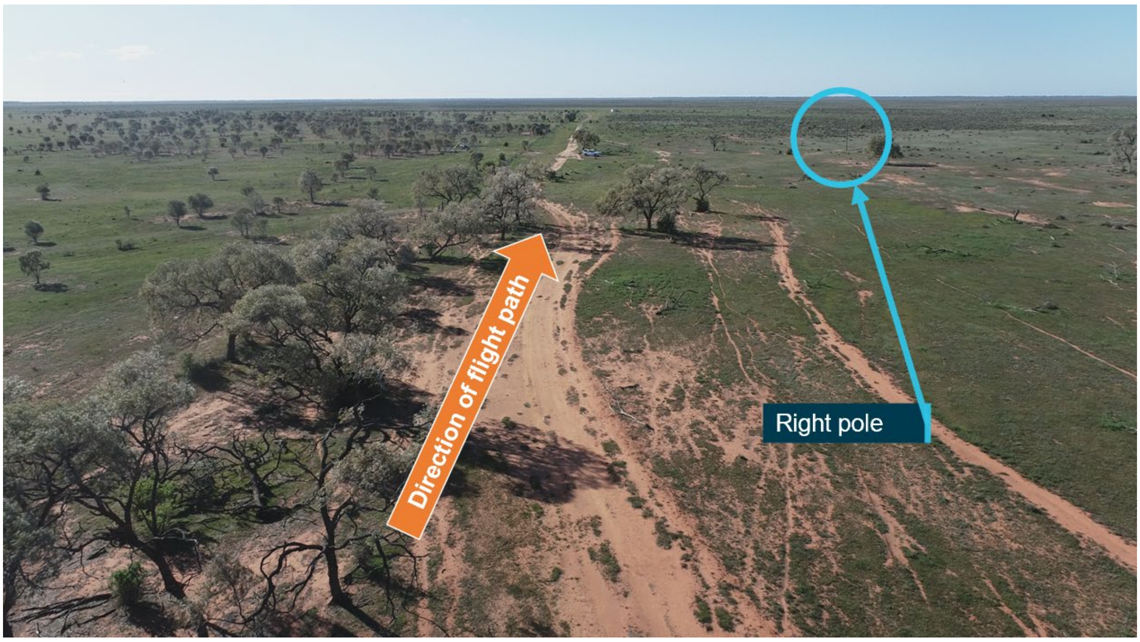
Source: lookupandlive app annotated by the ATSB

Figure 14: RPA footage of reconstructed flight path showing location of poles left and right of track from about 160 and 350 m respectively



Source: ATSB

Figure 15: RPA footage of reconstructed flight path showing right pole from about 240 m



Source: ATSB

Similar occurrences

Research conducted for the ATSB publication *Wirestrikes involving known wires: A manageable aerial agriculture hazard* found that there were 180 wirestrike accidents in the ATSB database for the period between 2001 and 2010. During that period, 55 wirestrikes involved helicopters, 30 of which resulted in an accident and 25 were serious incidents. Of the 55 helicopter wirestrikes, 20 occurred during aerial agricultural operations. Particularly relevant to this accident, the report reminded pilots to:

- have an up-to-date and detailed map with powerlines and other hazards clearly marked
- obtain network maps from the power company if available
- not rely solely on maps and pre-flight briefing
- always conduct an aerial reconnaissance to confirm wire locations and detect other hazards.

For the 10-year period from 2010 to 2020, there were 67 wirestrikes involving helicopters recorded in the ATSB occurrence database, 54 of which were conducting aerial work – 30 of which were during aerial agricultural operations. Of the aerial work occurrences, 23 were classified as accidents and 9 resulted in serious or fatal injuries to the occupants.

Safety analysis

Introduction

The pilot had been employed by the operator since 2015 and was experienced, trained and qualified to conduct the spraying operation. After being involved in a wirestrike 2 years earlier, the pilot underwent additional training and checking with no issues identified.

The weather on the accident day was sunny with mild temperatures and very light winds. After a delayed start because of dew, the pilot had been flying for less than 2 hours, during which time the helicopter had landed five times to reload with chemical and fuel. The pilot appeared in good health and there was no indication of any performance issues with the helicopter.

Aerial inspection and hazard identification

Due to a lack of contrast between the wire and the vegetation as the pilot looked down from the helicopter towards the fence line below and with no markers fitted to the wire, it would have been very difficult for the pilot to visually detect the powerline with sufficient time to avoid the wirestrike.

Had the pilot been relying on the powerline's location depicted on the map, the helicopter would have encountered the wire earlier than expected. Therefore, the remaining defence available to the pilot would have been visual cues along the spray path. In this case, the power poles would likely have been visible, had the pilot been looking for them either side of the flight path. However, as the helicopter approached the wire, the poles would have been difficult to detect in the pilot's peripheral view, if looking straight ahead.

It was clear that the pilot was aware of the powerline from pre-flight planning, and the chief pilot reported having discussed the powerline with the pilot on multiple occasions, including while loading the helicopter prior to the last take-off. However, despite being aware of the wire, and for reasons that were not determined, the pilot had not completed an aerial hazard inspection of the spray path, other than overflying a small section of the southern perimeter at the start of the second load. Doing so would have provided a clearer mental model of the wire's exact location and better equipped the pilot to avoid it.

Pilot restraint

The helicopter was fitted with a 3-point harness, consisting of a lap belt and shoulder sash. The pilot's torso had not been effectively restrained by the shoulder sash as evidenced by:

- the pilot's head injury and damage to the helmet indicating a left-side impact
- the pilot was found secured in the lap belt but positioned out (and in front) of the shoulder sash
- an absence of bruising caused by the shoulder sash.

Based on the pilot's final position in front of the shoulder sash, it was possible that the shoulder sash had not been worn at the time of the wirestrike, although the operator had always observed the pilot to wear it correctly. A right-seat shoulder sash is designed to restrict movement in the forward and right diagonal directions. Its effectiveness for restraint is likely to be significantly reduced with movement to the left. With the initial force sending the pilot leftwards, it is possible that the pilot came out of the sash. If so, the resultant flail zone would have been similar to wearing a 2-point harness (lap-belt only). Either way, not being restrained by the shoulder sash significantly increased the risk of strike injuries and injuries due to the pilot not being retained within the occupiable space.

Had the pilot been wearing a 4- or 5-point harness, which provide lateral stability to the upper torso in both directions, the risk of strike injuries, particularly to the head, would have been reduced. Additionally, the risk of deceleration injuries would also have reduced due to the decrease in relative impact forces for an occupant with the upper torso restrained.

Helmet effectiveness

The damage to the helmet and superficial contact injuries including bruising to the pilot's left cheek, in the absence of skull and facial fractures, indicated that during the initial impact with terrain, the pilot was wearing the helmet and it had protected the head from significant blunt force trauma. Following the initial impact, the helmet completely came off the pilot's head, increasing the risk of injury from subsequent impacts, and potentially reducing its effectiveness in attenuating the initial impact forces.

The chin strap was found intact and attached to the helmet but undone. It could not be determined whether the chin strap came undone during the accident sequence or was not secured at the time. Although the primary impact was on the left side of the helmet, there was also some damage to the right side of the helmet and visor and the chin strap clasp was on the right side. However, there was no visible damage to, or in the vicinity of, the clasp. Although the ATSB found that the clasp could come undone with a direct 'bump' force applied to it, there were no witness marks to indicate the clasp was opened from being caught on something during the impact sequence or directly impacted or bumped. The poor condition of the chin strap may also have resulted in it being uncomfortable to wear secured under the chin. Its poor condition was, however, consistent with the pilot having regularly worn it secured in the past.

It was very likely that the same helmet had been worn in an accident 2 years prior, and the helmet's effectiveness would have been reduced had it sustained damage during that occurrence. There was no evidence to indicate that was the case, however there was also no evidence that the helmet had been inspected or serviced following that accident. An inspection would have provided an opportunity to identify any damage or items requiring maintenance to ensure that the helmet was continuing to function in accordance with its design specifications.

In any event, the diffuse brain injuries sustained by the pilot indicate the helmet did not attenuate the acceleration forces to the brain to a survivable level. It was not possible to determine if the impact forces exceeded the helmet's specifications and/or whether the helmet's effectiveness was compromised by any of the above considerations. However, it is important for pilots to remember that to be fully effective, a helmet must be fitted properly, worn correctly and maintained in accordance with manufacturer instructions.

Obstructive sleep apnoea

Following diagnosis of severe obstructive sleep apnoea (OSA) in February 2020, the pilot had initially managed the condition using a continuous positive airway pressure (CPAP) machine. However, over time, there had been reduced compliance with the treatment, and the CPAP machine had not been used for 2 weeks prior to the accident.

There was no evidence of the pilot having consulted a general practitioner or specialist physician since the diagnosis. This was a missed opportunity for a professional to ensure the CPAP machine's efficacy in the pilot's sleep quality. The pilot had also not reported the condition to a Civil Aviation Safety Authority designated aviation medical examiner, which prevented oversight of any ongoing safety risk associated with the condition.

Untreated, the pilot's condition increased the risk of experiencing the effects of fatigue. However, the pilot had not reported excessive daytime sleepiness at the time of diagnosis. The pilot also had not stayed up late or awoken early and had been operating the helicopter for only about 1.5 hours that morning. Further, the time of day at which the accident occurred, 1057, was not a period of increased risk of fatigue based on the pilot's reported sleep/wake times.

Even in the absence of fatigue, untreated severe OSA can cause inattention and impaired cognitive function and is linked with several other conditions. However, there is no evidence that cognitive impairment affects everyone with OSA or that the severity of OSA predicts its impact (or associated risks). Therefore, although the pilot was at an increased risk of cognitive impairment due to not using the CPAP to treat the severe OSA in the 2 weeks before the accident, it could not be concluded that the pilot was affected by this at the time of the accident.

Further, the ATSB assessed whether the pilot's actions may have been indications that the pilot was experiencing the possible effects of OSA. It was possible that cognitive impairment led to the pilot inadvertently omitting the inspection, however, while the pilot had conducted an inspection the previous day, it could not be determined why the pilot did not do so on the accident day. Having briefed about the location of the wire in pre-flight planning and again immediately prior to the accident load, impaired memory and inattention may have affected the pilot's recollection of the location of the wire and ability to identify it. However, it was equally possible that the pilot recalled the wire hazard but simply did not see the wire or poles. Additionally, numerous wirestrike accidents have occurred in the absence of OSA, in which the pilot was aware of the wire and/or where a hazard inspection was not conducted (ATSB 2006, 2014).

There is limited evidence of aircraft accidents in Australia and the US in which OSA was a contributing factor. This is at least in part because it is extremely difficult for investigators to assess what a pilot's cognitive state was at the time of an occurrence.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include ‘contributing factors’ and ‘other factors that increased risk’ (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition ‘other findings’ may be included to provide important information about topics other than safety factors.

Safety issues are highlighted in bold to emphasise their importance. A safety issue is 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 operating environment at a specific point in time.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the wirestrike and collision with terrain involving a Robinson R44 helicopter, registered VH-HNF, at Steam Plains, New South Wales, on 31 July 2020.

Contributing factors

- The pilot did not conduct an aerial inspection to verify the location of hazards including the powerline identified during pre-flight planning. As the wire was very difficult to see, the pilot was unable to see and avoid the wire before the helicopter struck it.
- The pilot's injuries were consistent with flailing due to the left-side impact, but it could not be determined whether the pilot was not wearing, or slipped out of, the shoulder sash portion of the 3-point harness.

Other factors that increased risk

- The pilot was not effectively managing severe obstructive sleep apnoea, which had not been disclosed to the Civil Aviation Safety Authority. This prevented its oversight of any ongoing safety risk associated with the condition.

Other findings

- The pilot’s helmet did not attenuate the impact to survivable levels. Either the impact forces exceeded the helmet design specifications, or the helmet was not fitted, worn or maintained correctly.
- Untreated severe obstructive sleep apnoea can increase the risk of fatigue and impairment of neurological and cognitive functions which can include impaired memory, vigilance and decision-making.

Safety action

Safety advisory notice to helicopter pilots and operators

SAN number:	AO-2020-040-SAN-01

The Australian Transport Safety Bureau strongly encourages pilots conducting low-level operations to wear a flight helmet, ensuring that it is:

- fit for purpose
- custom fitted to the pilot's head
- properly secured by using the chin strap
- maintained in accordance with the manufacturer's recommendations.

General details

Occurrence details

Date and time:	31 July 2020 – 1057 EST	
Occurrence category:	Accident	
Occurrence categories:	Wirestrike, Collision with terrain	
Location:	69 km south-east of Hay Airport, New South Wales (Steam Plains)	
	Latitude: 35° 1.08996000' S	Latitude: 145° 17.92416000' E

Aircraft details

Manufacturer and model:	Robinson Helicopter Company R44 (Raven I)	
Registration:	VH-HNF	
Operator:	Riverina Rotor Work Pty Ltd	
Serial number:	2524	
Type of operation:	Aerial work – Aerial agriculture	
Activity:	General aviation/Recreational – Aerial work – Agricultural spreading/spraying	
Departure:	Steam Plains, New South Wales	
Destination:	Steam Plains, New South Wales	
Persons on board:	Crew – 1	Passengers – 0
Injuries:	Crew – 1 (fatal)	Passengers – 0
Aircraft damage:	Substantial	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Aerial Application Association of Australia
- Bureau of Meteorology
- Civil Aviation Safety Authority
- New South Wales Police Force
- helicopter maintainer
- helicopter operator and chief pilot of Riverina Helicopters
- recorded data from the GPS units on the helicopter
- Royal Australian Air Force Institute of Aviation Medicine
- Steam Plains Station owner and manager.

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Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section 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 following directly involved parties:

- Riverina Helicopters
- Steam Plains station manager and owner
- the Civil Aviation Safety Authority
- Essential Energy
- the helicopter maintainer
- Royal Australian Air Force Institute of Aviation Medicine.

Submissions were received from

- Riverina Helicopters
- the Civil Aviation Safety Authority.

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Glossary

AAAA	Aerial Application Association of Australia
ATSB	Australian Transport Safety Bureau
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulations
CPAP	Continuous positive airway pressure
DOI	Department of the Interior
EN	European Standard
FAA	Federal Aviation Administration
OSA	Obstructive sleep apnoea
RPA	Remotely piloted aircraft
US	United States
USAARL	United States Army Aeromedical Research Laboratory
USAF	United States Air Force
USFS	United States Forest Service

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- 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, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

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

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining 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. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.