Australian Government
Australian Transport Safety Bureau

Pilot incapacitation and collision with terrain involving Kawasaki Heavy Industries BK117, VH-JWB

9 km west of Ulladulla, New South Wales, on 17 August 2018

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Addendum

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Safety summary

What happened

On the afternoon of 17 August 2018, the pilot of a Kawasaki Heavy Industries BK117 helicopter, registered VH-JWB, was conducting fire-bombing operations approximately 9 km west of Ulladulla, New South Wales (NSW).

The pilot was on the third flight for the day and was conducting repeated water bombing of a fire on Plot Road, Woodburn, NSW. On the fifth fire-bombing circuit, at this location, the pilot filled the slung Bambi Bucket (bucket) without incident from a nearby dam and departed towards the fire area. Shortly after, the aircraft diverted off course, the bucket and longline became caught in trees and the helicopter collided with terrain. The pilot was fatally injured and the helicopter was destroyed.

What the ATSB found

The ATSB found that it was likely the pilot suffered an incapacitating medical event. As a result, the pilot unintentionally diverted off track, leading to the bucket becoming tangled in the trees and causing the helicopter to collide with terrain.

The pilot's post-mortem identified a focus of acute inflammatory change in the heart muscle, a condition known as lymphocytic myocarditis. This condition is capable of causing sudden impairment or complete incapacitation. The pilot is unlikely to have known they suffered from this condition. There are no risk factors for the development of this condition and it cannot be detected by medical screening.

The pilot's post-mortem also identified coronary heart disease which is also capable of causing sudden impairment and incapacitation. This condition was being effectively managed by medication.

Despite the pilot suffering from these two heart-related conditions, there was insufficient evidence to determine if they contributed to the accident.

The ATSB also determined that the pilot was known to use an over the counter medication for the treatment of hay fever that, although labelled as non-sedating, was not approved for use while conducting flying operations.

Finally, the pilot did not wear the upper torso restraint correctly. Although on this occasion the accident was unsurvivable, the use of such a shoulder harness restraint generally reduces the likelihood of fatal head injuries.

Safety message

Pilots are reminded that some medical conditions may be undetectable by the normal aviation medical screening process. Pilots should remain vigilant for any medical symptoms which may be the precursor to a more serious medical event.

Pilots should also exercise caution when using over-the-counter medications as their availability does not mean they are automatically safe for use while conducting aviation activities.

Contents

The occurrence

On 17 August 2018, a Kawasaki Heavy Industries BK 117 (BK 117),[1] registered VH-JWB (JWB), was performing aerial work in the Ulladulla area, New South Wales (NSW). The operator had been tasked by the NSW Rural Fire Service (RFS) to support fire-fighting activities in the Bombaderry area, near Nowra, on 15 August 2018, then in the Ulladulla area from the afternoon of 16 August 2018 (Figure 1). The fire-bombing operations were being flown out of the Milton Showground during the day, with the fire-bombing aircraft flown back to Nowra, for overnight parking.

Figure 1 - Accident location

Source: Google Earth, annotated by the ATSB

On the morning of 17 August 2018, JWB departed Nowra for the Milton Showgrounds. The pilot was the sole occupant and conducted a number of flights that day, refuelling from the showground at 1030 Eastern Standard Time[2] and again at 1225.

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1 The Kawasaki Heavy Industries BK 117 is a twin-engine medium utility–transport helicopter jointly developed and manufactured by Messerschmitt-Bölkow-Blohm of Germany and Kawasaki of Japan.

2 Eastern Standard Time (EST): Coordinated Universal Time (UTC) + 10 hours.

In the afternoon, JWB and another BK 117, VH-FHB (FHB), were tasked to assist ground-based fire crews extinguish fires near Plot Road, Milton (Figure 2). Both helicopters were operated with a Bambi Bucket[3] (bucket) on a longline.[4] The operation involved flying circuits between the fire area and a nearby dam, where the buckets were re-filled with water.

Figure 2 - Area of operations

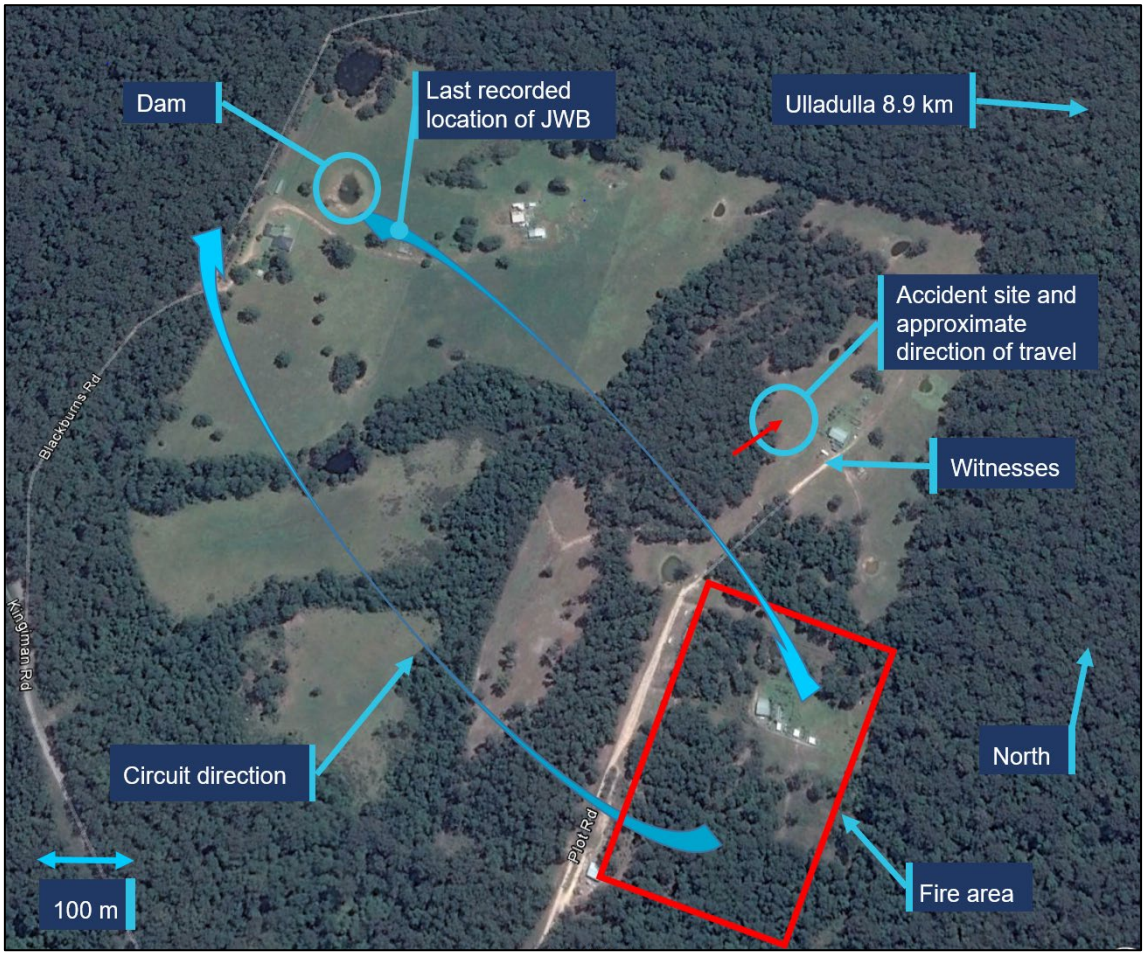

Figure 2 shows the area of operations with circuit direction arrows that are indicative of the average track of JWB during the previous 4 circuits.
Source: Google Earth, annotated by the ATSB

At 1400 the RFS Air Attack co-ordinator conducted an 'operations normal' radio call with all aircraft operating in the Ulladulla fire area. The pilot of JWB responded normally and did not report any difficulties.

At about 1407, the pilot of FHB observed JWB's pilot fill the bucket at the dam before releasing a small quantity of water, consistent with normal operations. JWB then departed the dam in a south-easterly direction towards the fire.

The pilot then moved FHB over the same dam to fill its bucket. On completion of filling the bucket, the pilot looked for JWB but could not sight the helicopter.

A witness on Plot Road, approximately 100 m east of the accident site, observed JWB tracking in a north-easterly direction, contrary to the established flight pattern. A number of witnesses in the

[3] A Bambi Bucket, also known as a helicopter bucket, is a specialised bucket suspended on a cable carried by a helicopter to deliver water for aerial firefighting

[4] A longline is a long cable suspended from a hard point on the belly of the aircraft and connected to an external load such as a Bambi Bucket.

same area then observed the bucket and longline become tangled in trees at the edge of a clearing, and the helicopter collide with terrain (Figure 3). The pilot was fatally injured and the helicopter was destroyed.

Context

Pilot information

General information

The pilot was a New Zealand citizen who had flown in several countries and had experience on numerous helicopter types. They held a valid Commercial Pilots Licence (Helicopter) that was initially issued by the Civil Aviation Authority of New Zealand, in June 1987 and then converted to an Australian licence by the Civil Aviation Safety Authority in October 1998.

The pilot held a Class 1 aviation medical certificate, valid until 5 June 2019, with a restriction requiring reading correction to be available whilst exercising the privileges of the licence.

The pilot's logbook, combined with the operator's flying record, showed a total flying experience of approximately 7,750 hours. The pilot had approximately 1,300 hours experience operating the BK117 and in excess of 3,000 hours of longline experience.

The pilot last completed an aerial application rating proficiency check on 9 August 2018, which was valid until 31 August 2020, and included Bambi Bucket operations. The pilot was qualified to conduct helicopter fire operations and had a low-level rating and a sling operations endorsement. The pilot's logbook contained evidence of fire operations first being conducted in 1997. The pilot obtained an Agricultural Pilot (Helicopter) Rating Grade 2 from the Civil Aviation Safety Authority Australia in March 2003.

Fatigue assessment

The ATSB assessed whether the pilot may have been fatigued at the time of the accident. The pilot's start times, rest time available, accommodation facilities, environmental factors and workload associated with the task were all reviewed. From the evidence available it was considered unlikely that the pilot was experiencing a level of fatigue known to affect performance.

Meteorological information

Bureau of Meteorology data was available from an automatic weather station located on the coast at Ulladulla, approximately 9 km east of the accident site. One minute observations at the time of the accident indicated that the wind was from the south-east, between 8-10 kt.

The other pilot operating in company with JWB at the time of the accident similarly reported the wind to be about 10 kt from the south-east, which was roughly in the direction of the up-wind leg of the fire-bombing circuit.

Visibility was estimated to be in excess of 5 km by another pilot operating in the same area. Photographs taken shortly after the accident were consistent with that visibility assessment. Other pilots reported that the conditions were good for fire-bombing operations, with no turbulence or visibility issues.

Aircraft information

General

The Kawasaki Heavy Industries BK117 helicopter is a multi-purpose, twin-engine, skidded, medium helicopter with ten seats in the basic configuration.

Airworthiness and maintenance

The helicopter was built in 1994 and operated in Japan before being imported to Australia in 2015. A Certificate of Airworthiness inspection was completed on 24 September 2015. JWB had a

current maintenance release, issued on 5 September 2017 and was valid for a period of 300 hours or 12 months, whichever occurred sooner.

The helicopter was maintained in accordance with an approved System of Maintenance. A general maintenance review was conducted on the helicopter's history since being imported into Australia. This review did not identify any anomalies with the aircraft's maintenance. At the time of the accident, there were no outstanding defects or maintenance requirements.

Weight and Balance

It was calculated that at the time of the accident the aircraft's weight and balance were within the operational limits for the helicopter.

Engines

The helicopter was powered by two Lycoming (now Honeywell) LTS101-750B-1 engines. The engines were initially examined on site by the ATSB and also subject to detailed disassembly and technical examination by the manufacturer (see the section titled *Wreckage examination*).

Hydraulic System

The hydraulic system consists of two independent subsystems of which construction, function and performance are identical.

Bambi Bucket

JWB utilised a Bambi Max bucket that is a lightweight, low-power draw, quick-operating multiple drop valve Bambi Bucket. The bucket was attached to the helicopter cargo hook via a 130 ft (40 m) longline. The pilot controlled the bucket using a push button switch mounted on the cyclic.[5]

Cargo Hook

JWB was fitted with an Indraero Siren Equipment cargo hook. The hook allows external cargo to be released via a collective[6]-mounted electrical switch. In addition, a foot-activated manual release lever was located to the right of the pilot's tail rotor pedal. This lever was used to release cargo in the event of an emergency or failure of the electrical release system.

During the course of the investigation, the ATSB was informed that the pilot sometimes operated with the circuit breaker for the electrical hook release pulled. The operator advised that the company procedure was to fly with the circuit breaker in and the electrical hook switch armed during flight. Additionally, even if the pilot had flown with this circuit breaker pulled, they would still have had the foot-activated manual release lever available in the event of an emergency.

Operational information

The pilot of FHB commented during interview that each time JWB was overhead the fire-bombing area there was a substantial level of clearance between the bucket and the trees. This pilot estimated that water was consistently dropped from JWB at about 6-9 m above the trees.

None of the ground or airborne crews heard any radio transmissions from JWB immediately before the accident. During water bombing operations it is standard practice to make a radio call when leaving the circuit for any reason, to inform other airborne assets of the helicopter's tracking.

Ground fire-fighting crews were also operating in the immediate area. Those personnel advised that there were no other spot fires in the immediate area. Additionally, the crew of the air attack

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[5] Cyclic: a primary helicopter flight control that is similar to an aircraft control column. Cyclic input tilts the main rotor disc, varying the attitude of the helicopter and hence the lateral direction.

[6] Collective: a primary helicopter flight control that simultaneously affects the pitch of all blades of a lifting rotor. Collective input is the main control for vertical velocity.

helicopter reported to the ATSB that when they came in to land at the accident location minutes after the accident they did not see any fire in the area that may have caused JWB to turn away from the circuit.

Fuel

JWB and the other helicopters on task, had all refuelled using Jet A1 fuel from the same onsite tanker based at the Milton Showgrounds. In addition, other helicopters operating in the area were using fuel from the same source and there were no reported issues with fuel quality. Fuel records confirmed the fuel on-board the tanker conformed to the relevant specification.

JWB had refuelled twice from the tanker on the day of the accident with the last refuel of 435 litres conducted approximately 2 hours and 20 minutes prior to the accident. Considering the helicopter's fuel consumption rate, there was adequate fuel onboard at the time of the accident.

Wreckage and accident site information

Accident site

The accident site was located 9 km west of Ulladulla, New South Wales. The wreckage of JWB was approximately 200 m from the average circuit path and the aircraft final track was estimated to be 90° off the circuit direction (Figure 2).

The main cabin of the helicopter was found inverted in a clearing with the bucket and longline still attached (Figure 3). The bucket and longline were caught in a 22 m tall tree at the edge of the clearing.

Rub marks from the longline were found on the trunk of the tree that the bucket was hanging from. These marks indicated the bucket snagged the tree at least 13 m down from the top of the tree.

In the later part of the circuit the helicopter bucket would normally have a minimum of 6–9 m clearance above the tree tops. Taking this into account, and the tree contact 13 m below the canopy, the bucket was at least 19–22 m lower than expected when it snagged the tree and brought the helicopter down.

Figure 3 - Accident site and wreckage

Source: ATSB

The bucket, while suspended from the tree, still contained a large quantity of water. After removal, examination of the bucket showed that the cable required to operate the drop valve had broken at the attaching point to the motor, either during the accident sequence or as the bucket was removed from the tree. However, during post-accident repairs the main valve was tested and found to be serviceable.

Wreckage examination

The ATSB examined the wreckage and did not identify any pre-existing aircraft defects that may have contributed to the accident sequence. The aircraft and all its components were accounted for at the accident site. There was no evidence of fire.

There was extensive damage to the fuselage with heavy vertical compression evident. One main rotor blade detached, while the other three remained attached to the head, with varying degrees of damage due to contact with the airframe and terrain. The vertical fin, including the tail rotor assembly, intermediate and tail rotor transmissions, fractured from the tail boom at the lower section of the vertical fin. The horizontal and vertical stabilisers had been struck by the main rotor blades multiple times.

Consistent with normal firefighting operations, the pilot door was not fitted at the time of the accident. The cabin doors were forced from their closed position due to impact forces.

All flight controls were observed to be connected at the time of the accident and did not indicate any pre-existing defects. There was no visible damage to the cockpit controls.

Several circuit breakers in the overhead panel were found in the ‘tripped’ position, including the cargo hook, annunciator warn and main rotor RPM warning. However, due to the nature of the accident sequence, these circuit breakers may have tripped due to impact forces.

The serviceability of the cargo hook mechanical release mechanism was verified after disconnecting the cargo hook from the helicopter. This was necessary due to the damage at the hook end of the actuating cable.

The ATSB tested the hook assembly electrically with the use of another BK117 and it was found to be serviceable. The hook was cycled a number of times and released and relatched without any anomalies observed.

Each engine assembly was examined on-site and found to be complete, with no evidence of pre-accident defects that influenced the accident.

Both engines were removed from the wreckage and shipped to the manufacturer in the United States for detailed examination under the supervision of the United States National Transportation Safety Board.

The disassembly and examination of the engines identified that the type and degree of damage was indicative of both engines rotating and operating normally at the time of impact. No pre-existing conditions were noted that would have affected their operation.

Examination of the tandem hydraulic unit assembly showed three of the four filter bypass indicators in the ‘popped’ condition. An examination of the filters in each location showed them to be clear of blockages and debris. Consequently, the ‘popped’ indicators were probably impact related. The fluid level indicators for each reservoir showed that both systems had adequate fluid to operate.

While moving the wreckage upright, approximately 100 litres of fuel leaked from JWB. This fuel was clear in appearance and indicated sufficient fuel on-board for use.

Recorded information

The aircraft was not fitted with a flight data recorder or a cockpit voice recorder and neither were required.

A Spidertracks system was installed in the helicopter. Spidertracks provides a real-time flight tracking service using satellite communications. The device reports position and groundspeed at a pre-set time interval, in this case every 2 minutes.

The last recorded point for JWB was at 1408 (Figure 2). At that time, the helicopter was departing the dam, where it had just taken on water, and was heading towards the fire ground. This was consistent with previous circuits.

Medical and pathological informational

Post-mortem examination

The forensic pathologist who conducted the post-mortem examination concluded that the pilot succumbed to injuries sustained during the accident sequence. The examination also identified a widespread area of acute lymphocytic myocarditis, likely of viral origin, and ischaemic (coronary) heart disease. The examining pathologist noted that the myocarditis and/or coronary heart disease found during the post-mortem may have caused sudden incapacitation.

The post-mortem also identified injuries to the pilot's left arm and both hands. Specialist opinion was that this injury pattern evidence was inconclusive in determining whether the pilot was manipulating the flight controls at the time of the accident.

No witness marks were identified during the examination to indicate the pilot was wearing the available upper torso restraints over the shoulders and the time of the accident.

Finally, toxicological examination identified that a level of 5 per cent carboxyhaemoglobin was present in the pilot's blood (see the section titled *Carbon monoxide* below). No other substances were identified that were likely to have impaired the pilot's performance.

Lymphocytic myocarditis

Lymphocytic myocarditis (myocarditis) is an inflammatory change in the heart muscle, usually caused by an acute viral infection. Acute viral myocarditis can involve a period with mild early symptoms which can be followed by chest pain, heart rhythm abnormalities, heart failure, or sudden cardiac death. Myocarditis may also have a sudden onset with no early mild symptoms. The signs and symptoms of myocarditis vary, depending on the cause of the disease. Common myocarditis signs and symptoms include:

- chest pain
- rapid or abnormal heart rhythms (arrhythmias)
- shortness of breath, at rest or during physical activity
- fluid retention with swelling of the legs, ankles and feet
- fatigue
- other signs and symptoms of a viral infection, such as headache, body aches, joint pain, fever, sore throat and/or diarrhoea

The ATSB engaged two external aviation medicine specialists (consultants A and B), to provide advice regarding the pilot's health, medications and medical conditions in relation the accident sequence.

The consultants advised that the standard aviation medical examination procedure would not have detected myocarditis. Myocarditis cannot be detected by medical screening, and there are no risk factors for the development of viral myocarditis. The only avenue for prevention is for pilots to self-monitor for any symptoms or signs of illness prior to and during each flight.

Advice was sought from the medical consultants as to the likelihood of the pilot having symptoms of the condition based on the post-mortem report. Consultant A, in conjunction with a cardiologist, reported that the presence of a focus of acute myocarditis in the pilot was a finding 'likely to have functional significance for the risk of sudden impairment or sudden complete pilot incapacitation.' Consultant A also stated that viral infections of all kinds are often characterised by quite severe illness developing suddenly, sometimes with early mild symptoms. They also advised that the risk of cardiac arrhythmia due to viral myocarditis and the apparent cessation of pilot control inputs were strongly suggestive of severe and sudden loss of situational awareness and/or loss of consciousness occurring as a result of myocarditis in the final moments of the flight.

Consultant B reported that it was possible the myocarditis was an incidental finding in the post-mortem and did not cause any symptoms. However, they also advised that it was equally possible the pilot was suffering some medical incapacitation from this condition, however there was no evidence for this prior to the flight.

Coronary heart disease

Coronary heart disease describes a condition where narrowing of the coronary arteries by fatty deposits in the artery walls, or hardening of the arteries, causes a reduction of the blood to the heart muscle, reducing the oxygen supply. If this condition causes a blockage to one of the major arteries supplying blood to the brain, a stroke can occur. Depending on the part of the brain affected, sudden incapacitation and the inability to operate an aircraft may result.

Common symptoms of this disease include:

- chest pain
- dizziness
- shortness of breath
- decreased ability to function normally

The ATSB medical consultants advised that the pilot had undergone an aviation medical examination, including an electrocardiogram, by an aviation medical examiner three months prior to the accident and was found to be fit to fly. In addition, consultant A advised that the pilot's medical examination and medical certification processes were appropriate and took into account the effective management of cardiovascular risk factors.

Opinion was sought from the consultants on the potential for the condition to have influenced the accident. They commented that coronary artery disease of the level found at post-mortem is often found in healthy people and can be regarded as part of the normal degenerative process of aging. The presence of calcification indicated that the pilot's heart disease was longstanding and would not necessarily have caused symptoms.

Consultant A also commented that coronary artery narrowing without evidence of inadequate blood supply was reported at post-mortem, but the changes were longstanding and unlikely to have caused symptoms.

Observed behaviour

Several people were interviewed as part of the investigation who had contact with the pilot on the day of the accident and during the days immediately preceding the accident. With one possible exception, all commented that the pilot was generally well and in good spirits.

Following a lunch break on the 16 August, the pilot was observed having difficulty writing down the latitude and longitude of a new task location. The pilot was passed the latitude and longitude three times over the radio and the pilot was observed to write part of the numbers correctly, part incorrectly or just stop writing mid sequence. The latitude and longitude was described as being passed via the radio very clearly.

The observer knew the pilot in a professional capacity and had witnessed the pilot landing, taking off and attending briefings that day and the previous day with no indications the pilot was having any difficulties. The observer made comment that, when the pilot had difficulty writing down the latitude and longitude, nothing in the pilot's movement, speech or facial expression appeared unusual.

With regard to this observation of apparent impairment, consultant A commented that it may have been associated with myocarditis-related arrythmia or transient ischaemic attack.

Consultant B commented that this apparent episode of confusion was non-specific and while it could be attributed to myocarditis, or the effects of heart disease, it could also have been unrelated.

Medication

During the wreckage examination four prescription medications and one over the counter antihistamine medication were found with the pilot's possessions. It was confirmed with the pilot's designated aviation medical examiner (DAME) that all four prescription medications had been taken by the pilot for a number of years and were consistent with their age and health. It was reported by a family member that the pilot did not suffer any side effects from the prescription medications.

Opinion was sought from medical consultant A, in conjunction with an aviation cardiologist, whether the medications could have influenced the accident. The potential for side effects such as sedation and drug interactions, were all considered and excluded by these specialists. The potential for cardiac irregularity due to an interaction between one of the antihypertensive drugs and the antihistamine was also assessed as very unlikely.

The antihistamine medication was for the treatment of hay fever and the pilot's DAME was not aware of its use. The active ingredient of this medication is listed in the CASA guidance as prohibited. It was reported that the pilot was known to suffer from hay fever and used this medication to treat the symptoms.

Medical opinion regarding the possible sedating side effects of this medication was that, while some people experience sedation when taking this non-sedating antihistamine, this was recognisable on taking the first dose. The pilot was known to have been taking this medication regularly, so any adverse effects on the day of the accident were considered unlikely.

Carbon monoxide

Carbon monoxide (CO) is a colourless, odourless and tasteless gas. It is the by-product of the incomplete combustion of materials containing carbon. The Agency for Toxic Substances and Disease Registry (2012) stated that CO is produced from both human-made and natural sources.

When inhaled, CO is absorbed into the bloodstream where it readily binds with the haemoglobin to form carboxyhaemoglobin (COHb). The binding affinity of CO for haemoglobin is 200-300 times stronger than that for oxygen. Therefore, CO reduces the oxygen carrying capacity of the blood.

An individual's COHb levels increase as the duration and intensity of the CO exposure increases.

Normal levels of carbon monoxide and effects

There have been a considerable number of studies examining CO exposure, though very few regarding such exposure in helicopters.

Hampson et al. (2007) cited various publications that indicated that there were differing views regarding the correlation between COHb levels and a patient's clinical symptoms.

Further, when comparing the COHb levels detected in individuals, Rathore and Rein (2016) highlighted that it was important to note that 'both the concentration and length of time are key distinguishing factors. It is vital to note however that individuals exposed to the same source

simultaneously can exhibit differing levels of COHb'. Taking this into consideration, when discussing the normal levels of CO contained in an individual's blood, Consultant B stated that:

> Normal levels of carbon monoxide in non-smokers are less than 2-3%. Smokers may have elevated levels around 3-5% or even as high as 9%, depending on number of cigarettes smoked and time since last cigarette smoked.

A police forensic pharmacologist involved in a previous ATSB investigation[7] reported similar levels, where a non-smoker's maximum COHb level would be around 5 per cent, while smokers could have levels up to 10 per cent and up to 16 per cent for heavy smokers.

While the research shows some variability in what was considered to be the normal production of CO without occupational exposure, generally less than 3 per cent COHb saturation was considered normal for non-smokers. For smokers, levels up to 10 per cent, or even more were expected.

Recognising the potential for variability, physical symptoms and cognitive effects of CO exposure generally start to occur at COHb levels of around 10 per cent. These include headaches, nausea, dizziness, confusion, and disorientation.

ATSB report AO-2017-118 contains further details on the effects of CO.

Possible sources

Aviation fuels contain carbon so exhaust gasses are a source of carbon monoxide that can potentially enter the cabin during flight. Piston engines produce the highest concentrations of CO, however turbine engines also produce CO (Salazar).

Based on the configuration of the helicopter, with the engines above and behind the cabin as well as the cabin doors closed, it was considered unlikely for significant exhaust gasses to enter the cabin, even with the pilot door removed.

Carbon monoxide is also produced during combustion from bushfires. Studies have been conducted regarding the effect of the smoke on firefighters on the ground, however there is no data in relation to pilots conducting airborne firefighting. One study conducted by Reinhardt and Ottmar (2004) found 5-10 per cent of firefighters exceeded exposure standards for respiratory irritants, of which carbon monoxide is one, while attending bushfires.

In a study conducted by MacSween et al (2019) it was noted that emissions and subsequent exposure levels were highly variable over the duration of a burn. Carbon monoxide levels present during fire-fighting activities depend on numerous variables, including fuel properties, temperature, moisture, ventilation of the area and proximity to the fire (De Vos, et al, 2008). The pilot was operating at varying altitudes and proximity to the fire and considered to be further from the fire source than ground-based firefighters.

The pilot's smoking history was also examined. The pilot had been a non-smoker for more than 20 years and it was considered by consultant B to not be a factor in the elevated levels of CO found in the toxicology.

In summary, the source of the pilot's slightly elevated CO could not be determined.

Medical opinion

The forensic pathologist, who performed the post-mortem, considered the level of carbon monoxide found in the pilot's blood was unlikely to have had an effect on the pilot's ability to fly the helicopter.

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[7] See AO-2017-118 at www.atsb.gov.au

Consultant B reviewed the results of the CO testing and the post-mortem report. Taking into account the circumstances of the accident and the CO level found in the pilot's toxicology, they similarly concluded it was extremely unlikely that the level of CO in the pilot's blood would have affected their operation of the helicopter.

Survival aspects

Due to the inverted nature of the accident and resulting vertical compression of the fuselage, the accident was not considered survivable.

It was noted, however, that evidence from the first responders showed the upper torso restraint (UTR) was worn incorrectly. The UTR was fastened around the pilot's waist rather than over the shoulders, meaning the upper torso was unrestrained. A photograph from a previous flight also showed the pilot with the UTR being worn in the same manner as found in the accident flight.

Related occurrences

The ATSB report *Pilot incapacitation: Analysis of medical conditions affecting pilots involved in accidents and incidents* examined medical conditions and incapacitation events between 1 January 1975 and 31 March 2006. This report concluded that the majority of pilot incapacitation events do not involve a chronic or pre-existing medical condition. That is, they are largely unforeseeable events, often involving acute illnesses or injury. Of the 10 accidents that resulted in fatalities, all involved single-pilot operations and in half of these, heart conditions were identified as a significant contributing factor.

The ATSB safety education publication *Pilot incapacitation occurrences 2010–2014* (AR-2015-096) documents recent pilot incapacitation occurrences in high capacity air transport, low capacity air transport, and general aviation to help educate industry about the causes and risks associated with inflight pilot incapacitation. Part of the safety message reminded pilots to assess their fitness prior to flight. Assessment of fitness includes being aware of any illness or external pressures they may be experiencing.

ATSB investigation AO-2015-145: Flight crew incapacitation – Lake Macquarie Airport, NSW, on 15 December 2015

On the morning of 15 December 2015, a SOCATA TBM 700, aircraft, registered VH-YZZ, departed Gold Coast Airport, Queensland for Lake Macquarie Airport, New South Wales. On board were the pilot and one passenger.

The flight to Lake Macquarie was uneventful. However, when the aircraft was just about to land on the runway the pilot started to feel 'woozy' and, shortly afterwards, lost consciousness. The aircraft impacted the runway, bounced and impacted the runway a second time before the pilot regained consciousness. The pilot and passenger were not injured during the accident and exited the aircraft. Medical tests and monitoring after the accident found that the loss of consciousness was due to a previously undiagnosed heart condition.

Safety analysis

Introduction

During daytime fire-bombing operations the aircraft deviated off track without making a radio call, flew too low and caught the bucket in trees resulting in a collision with terrain.

Site and wreckage examination did not identify any defects or anomalies that might have contributed to the accident. The following analysis will focus on possible reasons why the aircraft diverted off track as well as medical and survivability aspects.

Pilot incapacitation

The pilot of JWB was familiar with the area of operations and the conditions on the day, having flown several circuits in the area that afternoon. No weather or mechanical issues were identified during the course of the investigation that could have influenced the accident.

The absence of any communication by the pilot after filling the bucket for the final time was unusual as it was standard practice to make a radio call when leaving the circuit for any reason and was a simple action to perform.

At any time during the flight the pilot had the option to dump the water and/or release the bucket and longline in total from the aircraft hook should circumstances have required it. However, this action was not completed by the pilot. Had the observed flight deviation been the result of the pilot responding to a mechanical issue, dumping the water and/or releasing the bucket would have increased the aircraft performance and made dealing with a mechanical malfunction easier.

If the pilot was attempting an emergency landing then it would be expected that they would have tracked for one of the nearby suitable landing areas and, depending on the emergency, dumped the water and/or released the bucket and made a radio call. The area the accident occurred in was not a suitable emergency landing site due to the slope of the terrain and surrounding obstacles. In addition, the pilot did not perform any of the expected actions associated with an emergency. Therefore, it was considered unlikely that the pilot was attempting an emergency landing at the time of the accident.

The on-site assessment indicated that JWB was at least 19–22 m lower than expected at the time the bucket caught in the trees. The bucket and longline contacted the tree at least 13 m below the top of the tree. The pilot was aware of terrain having completed four circuits in the area and was on the fifth at the time of the accident. In addition, the pilot had been observed flying with a substantial level of clearance between the bucket and the trees on previous circuits.

With the pilot's extensive experience working with a longline and at low level, as well as several standard pilot actions that were missing, it is unlikely that the pilot knowingly diverted off track, did not make a radio call and flew significantly lower than was safe resulting in the bucket snagging in the trees and the helicopter colliding with terrain.

In the absence of any mechanical issue, and considering the significant, unannounced tracking and height deviation from the normal operating procedure, the evidence indicated that the pilot probably suffered an incapacitating event. Due to this event the pilot unintentionally diverted off track, was unable to make a radio call and was unable to react to the low altitude of the helicopter. This led to the bucket becoming tangled in the trees and caused the helicopter to collide with terrain.

Possible sources of incapacitation

Although 5 per cent carboxyhaemoglobin was present in the pilot's blood, the level was considered by medical specialists to be too low to have affected the pilot's ability to operate the helicopter. Recognising the potential for individual variability, the conclusions of the specialists

were consistent with research that indicated about 10 per cent carboxyhaemoglobin was generally required to produce adverse effects . As such, it was considered unlikely that carbon monoxide was the source of pilot incapacitation.

Lymphocytic myocarditis

Both medical consultants engaged by the ATSB agreed that myocarditis may have a sudden onset with no initial mild symptoms. In addition, the signs and symptoms of myocarditis vary depending on the cause of the disease and can include sudden incapacitation.

However, the consultants' opinion differed in relation to the strength of the link between this specific condition and the outcome of the flight. Consultant A stated that the presence of a focus of acute myocarditis in this pilot was a finding likely to have functional significance for the risk of sudden impairment or sudden complete pilot incapacitation. However, consultant B concluded that it was possible that the pilot was suffering some medical incapacitation from myocarditis or heart disease or other causes that were not identified.

Due to the variation between the specialist conclusions, the ATSB was unable to determine if the effects of myocarditis contributed to the accident.

Coronary heart disease

Both medical consultants commented that the level of coronary heart disease found at the post-mortem examination was likely typical of a large proportion of the population of similar age to the pilot and was not known to produce symptoms.

The pilot had undergone and passed a Class 1 aviation medical within 3 months prior to accident which included an electrocardiogram.

Due to the pilot's current effective management of their cardiovascular risk factors and a lack of any other evidence linking this condition to the outcome of the flight, it was considered unlikely to have influenced the accident.

Over the counter medication

During the examination of the wreckage, the ATSB found an over the counter antihistamine in the pilot's possessions and it was reported that the pilot regularly took this medication for the treatment of hay fever. The Civil Aviation Safety Authority (CASA) provides guidance on medications that are approved, hazardous and prohibited for flight. CASA notes that just because a medication is available over the counter does not mean it is automatically safe for aviation. CASA also recommends that a pilot should always consult their designated aviation medical examiner or CASA about the safe use of medication.

The active ingredient of this medication is listed in the CASA guidance as prohibited in aviation. While the label stated it was non-sedating, it is classed by CASA as a sedating antihistamine. ATSB medical consultant A commented that the sedating effects of this medication would be recognisable on taking the first dose. The pilot had been taking this antihistamine for some time and had not reported any side effects. Therefore, any adverse effect on the day of the accident was considered unlikely.

Upper torso restraint

The pilot was found to have not been wearing the upper torso restraint correctly at the time of the accident. The ATSB medical consultant commented that had this been an un-inverted impact, or an impact with significant longitudinal aircraft deceleration, the absence of the shoulder harness restraint would have increased the likelihood of head injuries, with possible fatal consequences in an otherwise survivable accident.

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.

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 collision with terrain involving Kawasaki Heavy Industries BK117, VH-JWB, which occurred 9 km west of Ulladulla, New South Wales, on 17 August 2018.

Contributing factors

- While conducting fire-bombing operations, the pilot likely experienced an incapacitating event resulting in deviation off track, entanglement of the bucket in trees and subsequent collision with terrain.

Other factors that increased risk

- The pilot had acute lymphocytic myocarditis which is known to affect heart rhythm and/or blood pressure. This can cause dizziness, impaired consciousness, and incapacitation.
- The pilot had coronary heart disease which is known to reduce the supply of blood to the heart muscle. This can cause chest pain, dizziness, shortness of breath and possible incapacitation.
- The pilot used an over the counter medication for the treatment of hay fever that, although labelled as non-sedating, was not approved for use while conducting flying operations.
- The pilot did not wear the upper torso restraint correctly. Although this accident was unsurvivable, the absence of such a shoulder harness restraint generally increases the likelihood of fatal head injuries.

General details

Occurrence details

Date and time:	17 August 2018 1409 EST	
Occurrence category:	Accident	
Primary occurrence type:	Collision with terrain	
Location:	9 km west of Ulladulla, New South Wales	
	Latitude: 35º 22.065' S	Longitude: 150º 22.646' E

Aircraft details

Manufacturer and model:	Kawasaki Heavy Industries BK117	
Registration:	VH-JWB	
Operator:	Sydney Helicopters	
Type of operation:	Air work	
Activity:	Fire fighting	
Departure:	Milton Showground, New South Wales	
Destination:	Milton Showground, New South Wales	
Persons on board:	Crew – 1	Passengers – 0
Injuries:	Crew – 1 (fatal)	Passengers – 0
Aircraft damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Civil Aviation Safety Authority (CASA)
- operator
- pilot's and crew of other helicopters airborne in the area
- New South Wales Police Service and Rural Fire Service
- aircraft and engine manufacturers
- maintenance organisation for VH-JWB
- Airservices Australia
- next of kin
- medical consultants
- accident witnesses
- recorded data from Spidertracks

References

Civil Aviation Safety Authority's aviation medicine guidance, *Medication*, available from the CASA website.

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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 parties:

- operator
- maintenance organisation
- other airborne aircrew
- the witness of pilot behaviour from 16 August 18.
- CASA
- aircraft and engine manufacturers
- Japan Transport Safety Board
- next of kin
- medical consultants
- New South Wales State Coroner's Court

Submissions were received from:

- next of kin
- CASA
- The witness of pilot behaviour from 16 August 18
- A medical consultant

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

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.