Australian Government

Australian Transport Safety Bureau

Loss of control and collision with water involving Bell UH-1H helicopter, VH-UVC

5 km south-west of Anna Bay, New South Wales, on 6 September 2019

ATSB Transport Safety Report

Aviation Occurrence Investigation (Defined)

AO-2019-050

Final – 23 June 2021

Cover photo: **Mark Watterson**

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Publishing information

Published by: Australian Transport Safety Bureau
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Addendum

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Safety summary

What happened

On 6 September 2019, at 1430 Eastern Standard Time,[1] the pilot of a Bell Helicopter Company UH-1H helicopter registered VH-UVC (UVC) departed Archerfield Airport, Queensland, on a private flight with four passengers for Bankstown, New South Wales.

Following a refuelling stop at Coffs Harbour, New South Wales, the pilot made contact with Williamtown air traffic control (ATC), while north-east of Broughton Island and requested clearance to track south via the visual flight rules (VFR) coastal route. The initial radio calls between the pilot and Williamtown ATC, occurred about 6 minutes prior to the published time of last light. The radio calls indicated that the helicopter was being affected by turbulence and as a result the pilot was having difficulty maintaining a constant altitude. In response, the controller issued a clearance for the aircraft to operate between 2,400 and 3,500 ft.

Once past Anna Bay, and about 11 minutes past published last light, UVC was observed on Williamtown ATC radar to make a left turn to the south, depart the coastal route and head offshore, on a direct track to Bankstown Airport. The turn likely resulted in the pilot losing visual cues and encountering dark night conditions.

The helicopter continued to track offshore to the south-west for about 90 seconds, maintaining between about 2,500 and 3,200 ft before commencing a rapidly descending, left spiral turn. It disappeared from Williamtown radar coverage about 12 minutes after published last light. Attempts by the controller to contact the pilot were unsuccessful and authorities were subsequently advised of a missing helicopter.

On 25 September 2019, wreckage from the destroyed helicopter was located in about 30 m of water, 5 km south-west of Anna Bay. Two of the five persons on board the helicopter were confirmed to have received fatal injuries. The bodies of the pilot and two of the passengers were not found but they were presumed to have similarly not survived the accident.

What the ATSB found

The ATSB found that the pilot continued to fly after last light without the appropriate training and qualifications, and then into dark night conditions that provided no visual cues. That significantly reduced the pilot's ability to maintain control of the helicopter, which was not equipped for night flight.

Once visual references were lost, the pilot likely became spatially disorientated and lost control of the helicopter, resulting in a collision with water.

Further, the pilot did not disclose on-going medical treatment for significant health issues to the Civil Aviation Safety Authority. That prevented specialist consideration and management of the on-going flight safety risk the medical conditions and prescribed medications posed.

Safety message

Various ATSB research and investigation reports refer to the dangers of flying after last light without the appropriate qualifications and experience. The ATSB report, *Avoidable Accidents No. 7,* highlights the risks of visual flight at night. Risks include, reduced visual cues, increased likelihood of perceptual illusions, and spatial disorientation.

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

A VFR flight in dark night conditions should only be conducted by a pilot with instrument flying proficiency as there is a significant risk of losing control if attempting to fly visually in such conditions. If day VFR-rated pilots find themselves in a situation where last light is likely to occur before the planned destination is reached, a diversion or precautionary landing is probably the safest option. Air traffic control assistance with available landing options is also available.

This accident also highlights the importance of aviation medical certificate holders reporting relevant conditions and medications to their Designated Aviation Medical Examiner. A full understanding by the Civil Aviation Safety Authority's aviation medical specialists of a pilot's medical conditions, and use of medications, enables management of the risk for both the individual and flight safety overall.

Contents

The occurrence

On 6 September 2019, at 1430 Eastern Standard Time,[2] the pilot of a Bell Helicopter Company UH-1H helicopter registered VH-UVC (UVC) departed Archerfield Airport, Queensland, with four passengers on board. The pilot was conducting a private flight for the purpose of repositioning the helicopter to Bankstown Airport, New South Wales (NSW).

Witnesses at Archerfield advised that the intent was for UVC to be self-sufficient in terms of fuel requirements during the transit to Bankstown. Pre-flight preparation included the loading and filling of a plastic 400 litre fuel storage tank and a 205 litre drum. A portable, battery-operated transfer pump and hose was to be used to transfer fuel from the on-board storage into the helicopter's fuel tanks, when on the ground. Basic maintenance was also completed in preparation for the flight.

At about 1600, the pilot landed at Coffs Harbour, NSW to refuel the helicopter. A nearby helicopter operator who witnessed UVC land, reported that fuel was transferred from the 400 litre tank until it was empty, and then from the 205 litre drum. The refuelling operation drained the available battery power and the pilot sought assistance from the operator, who supplied a battery power pack to complete the refuelling. Shortly after, the operator noted that fuel was overflowing from the helicopter's fuel tank filling port and called out that the tank was full. The partially-emptied drum was then reloaded into UVC, and the battery pack returned to the operator.

During the refuelling stop, one of the passengers called a Bankstown operator to advise that they were in the process of refuelling. Arrangements had been made with the operator to provide hangar space for UVC. The operator was awaiting their arrival to assist moving the helicopter into the hangar. Following refuelling, the pilot departed Coffs Harbour at about 1648.

At 1652 the passenger advised the Bankstown operator via text message that they were on their way to Bankstown. The operator was aware of the time it would take to fly to Bankstown and that an arrival after last light was now likely. The operator contacted the passenger via a text message and queried whether they were 'night VFR' - a reference to whether the flight could continue at night under the visual flight rules (VFR). [3] The response from the passenger was that the pilot 'is' night VFR rated.

At 1755, the pilot made contact with Williamtown Tower, requesting clearance to track south via the VFR coastal route (Figure 1). The pilot also requested a climb to a higher altitude, to take advantage of more favourable winds. In response, the Williamtown Tower controller advised them to contact Williamtown Approach (Approach) for clearance.

At 1757, the pilot of UVC contacted Approach and requested a clearance. At 1758, the Approach controller identified UVC's position as 7.4 km to the north-east of Broughton Island (Figure 1), and advised the pilot they could operate at whatever altitude was required provided it was not below 2,400 ft.[4] The pilot responded with a request to operate between 3,000 and 3,500 ft. UVC was cleared to track coastal southbound at a block altitude between 3,000 and 3,500 ft.

At 1759, following an inquiry from the Approach controller, the pilot advised that Bankstown was the intended destination. At 1800, the pilot was advised that if any further track or altitude changes were required, to inform Air Traffic Control (ATC) accordingly. While no response was required, the pilot did not acknowledge the transmission.

Published last light for Anna Bay, NSW was 1801. At this time the controller again contacted UVC to offer alternative tracking if required. The pilot responded requesting to remain on the eastern

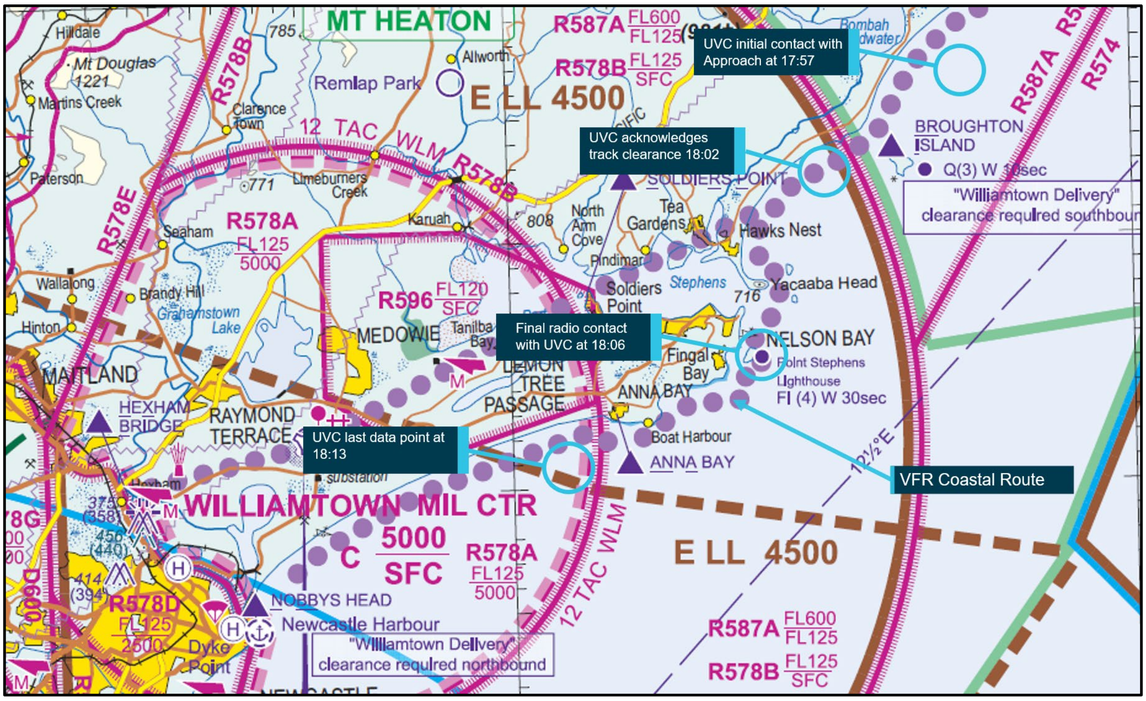
2 Eastern Standard Time (EST): Coordinated Universal Time (UTC) +10 hours

3 Visual flight rules (VFR) are a set of regulations which allow a pilot to only operate an aircraft in weather conditions generally clear enough to allow the pilot to see where the aircraft is going.

4 The lowest altitude that could be assigned for night operations due to terrain clearance requirements.

side of the R578A Williamtown restricted area. The controller clarified this request and in response, the pilot advised that if the track was not available, they would continue on the VFR coastal route. The pilot was then cleared to track as required for Bankstown Airport. The track clearance was acknowledged by the pilot at 1802.

Figure 1: Williamtown airspace map with VH-UVC's position at various times



Source: Airservices Australia, annotated by the ATSB

A final text message from the passenger was received by the Bankstown operator at 1804 advising that UVC was approaching Williamtown.

At 1805, the Approach controller contacted the pilot to confirm that operations were normal, having observed that UVC's altitude had dropped to 2,700 ft. The pilot acknowledged the loss of altitude, commenting on a wind gust affecting the helicopter. The controller responded by providing clearance for the pilot to operate between 2,400 and 3,500 ft. This was acknowledged by the pilot who also commented on the turbulent conditions that were being experienced. The controller acknowledged the conditions and made a further offer of assistance should it be required.

UVC was then observed on Williamtown ATC radar to make a left turn to the south, depart the VFR coastal route and head offshore. Automatic Dependent Surveillance - Broadcast (ADS-B)[5] data supplied by Aireon, indicated that the helicopter's position at the beginning of the turn, at 1811:23, was 2.3 km west-south-west of Anna Bay[6] (Figure 2).

The turn offshore was witnessed by two recreational fishers who were located on Stockton Beach, about 2 km to the west of Birubi Point, Anna Bay. They described seeing a helicopter track overhead in a westerly direction, then turn out to sea, heading in a south-westerly direction. They

5 ADS-B is a system in which equipment on board an aircraft automatically broadcasts the precise location of the aircraft. The data can be used by other aircraft and air traffic control to identify the aircraft's position and altitude without the need for radar.

6 All distances with respect to Anna Bay are referenced from the intersection of Morna Point and Gan Roads, Anna Bay New South Wales.

reported that the helicopter sounded loud, and its lights were observed until it disappeared from sight, following a turn to the east.

The helicopter continued to track offshore to the south-west for about 90 seconds, maintaining an altitude of between 2,568 and 3,168 ft, before commencing a rapidly descending left turn. ADS-B data showed that the aircraft commenced this descent from 2,968 ft at 1812:55 which was about 12 minutes after published last light. At 1813:12, a short, loud but indistinct transmission, that may have originated from UVC was recorded by Williamtown ATC. The last Aireon ADS-B data point identified the aircraft passing an altitude of 93 ft at 1813:18. UVC disappeared from the Williamtown ATC radar display at 1813:26.

Figure 2: Flight path of VH-UVC following the VFR coastal route passing Anna Bay and the turn offshore

Source: Google and ADS-B data (Aireon), annotated by the ATSB

Two attempts by the Approach controller to contact the pilot at 1813:17 and 1813:27 were unsuccessful. The controller then broadcast advice to the pilot that surveillance identification had been lost and to immediately check altitude. Further advice of the area's QNH[7], the lowest safe altitude in the area, and an instruction to climb immediately, were broadcast. The controller followed that transmission with several more unsuccessful attempts to contact the pilot. There was no response and at 1815 the Approach controller contacted the Australian Maritime Safety Authority's, Joint Rescue Coordination Centre and notified them of the missing helicopter.

The initial search for UVC, using a fixed wing aircraft and several rotary wing aircraft, was hampered by poor weather and sea conditions. The search was concentrated in the vicinity of reported oil slicks and floating wreckage several kilometres to the south west of Birubi Point. The search was suspended after several days when the likelihood of locating survivors had passed.

An extended sea and aerial search for the helicopter was continued by the NSW police and later, with assistance from the Royal Australian Navy. Wreckage from the destroyed helicopter was located on 25 September 2019, 5.3 km to the south west of Anna Bay, in about 30 m of water.

7 QNH: altimeter barometric pressure subscale setting used to indicate an aircraft's height above mean sea level.

Two of the five persons on board the helicopter were confirmed to have received fatal injuries. The bodies of the pilot and two of the occupants were not found but they were presumed to have similarly not survived the accident.

Context

Pilot information

The pilot held Private and Commercial Pilot licences (Helicopter) and was qualified to fly by day under the Visual Flight Rules (VFR). The pilot also held a single-engine helicopter class rating and a gas turbine engine design feature endorsement. The pilot last conducted a single-engine helicopter flight review on 25 October 2018 that was valid until 31 October 2020. A Class 1 Aviation Medical Certificate issued by the Civil Aviation Safety Authority (CASA), valid until 26 April 2020, was also held.

The pilot's logbook indicated a total of 1,440.5 hours total flying experience, of this about 103 hours were on the UH-1H. In the previous 90 days, 9 hours were accrued with 1.8 hours on the UH-1H. A review of flying-related documents showed that the pilot:

- commenced flying on 9 September 2011
- completed his Private Pilot Licence (Helicopter) on 10 April 2013
- completed his low level (Helicopter) flying training on 13 June 2013
- completed his Commercial Pilot Licence (Helicopter) on 26 June 2015.

The pilot completed their endorsement on the UH-1H on 26 October 2018 and was appropriately qualified to operate VH-UVC (UVC). The pilot was not qualified or trained to fly at night. At the time of gaining their Private and Commercial Pilot Licences (Helicopter) there was no requirement for night or instrument flight training. An examination of the pilot's logbook found no evidence of night flying or instrument flying experience.

Pilot's medical history

The pilot was being treated for significant health issues and sought regular medical support from a non-aviation medical specialist from January-March 2019. Following a break in treatment, the pilot again visited the specialist on 3 September 2019. While being treated, the following medications were prescribed:

- valdoxan
- olanzapine
- naltrexone
- diazepam

Valdoxan and olanzapine have the potential for producing a sedating side-effect, requiring management of the dosage amount. During medical reviews with their specialist, the pilot did not report feelings of sedation in the morning or during the day. The diazepam was prescribed three days before the accident, with a planned review at a subsequent appointment.

A witness reported that in the week of the accident the pilot disclosed that they had slept for a full day, waking briefly in the evening, then slept through to the following morning. No explanation was offered as to what prompted this. The pilot's treating specialist last saw the pilot on 3 September 2019 and was unaware of the reported sleep episode. The specialist's opinion was sought on possible reasons, and the ATSB's assessment of their comments was that it was unlikely to have been the result of any of the prescribed medicines taken at their specified dosages.

As the pilot's body was not recovered following the accident, the ATSB was unable to gain any further medical information from a post-mortem examination or toxicological assessment.

72-hour history

The ATSB was unable to gather sufficient information to complete a 72-hour history, primarily due to the pilot living alone. However, in the 24-hour period prior to the accident, the pilot:

- exchanged text messages with a family member around midnight
- accessed the National Aeronautical Information Processing System to gain location briefings that included weather related information at 0200
- briefly met up with a family member around 0745 on the morning of the accident.

With the limited information available, it was not possible to determine, whether at the time of the accident, the pilot was operating with a level of fatigue known to affect performance. However, from the available history, the pilot had about five hours of sleep opportunity the night before the accident.

Aviation medical certificates

A current medical certificate is required to exercise the privileges of a pilot licence. A Class 1 medical certificate is required to exercise the privileges of a commercial pilot licence and a Class 2 medical certificate is required for a private pilot licence.

When applying to renew a medical certificate, pilots are required to update their medical history by providing details of medications they have taken or have been prescribed. Additionally, pilots are required to provide information relating to any medical procedures, medical issues or symptoms that required the input of a medical specialist.

On completion of an examination by a Designated Aviation Medical Examiner (DAME) a report is submitted to the CASA to assess whether a medical certificate can be issued or whether further information or tests are required.

In the course of renewing their medical certificates, the accident pilot did not disclose medical conditions under treatment, or the medications that had been prescribed.

For the awareness of flight crews, CASA publicises a limited list of approved medications,[8] along with a list of medications that are considered hazardous to aviation. Medications that assist sleep are considered as hazardous. Medications that are considered as hazardous can only be used with the express clearance of the CASA or a DAME.

The ATSB sought advice regarding the medications that had been prescribed to the pilot of UVC from a subject matter expert (SME) in aviation medicine. The SME advised the ATSB that diazepam, olanzapine and naltrexone:

> Were absolutely incompatible with flying with respect to CASA guidelines, as were the conditions for which they had been prescribed.

and for valdoxan:

> (restrictions) would be imposed for conditions requiring valdoxan, but only after 1-3 months grounding and then with a written clearance from a [treating specialist], DAME and treating GP. CASA would require on-going medical audit and only a restricted medical certificate would be issued.

The SME further advised that, based on the pilot’s medical history and occurrence information, medical incapacitation from a heart attack, seizure, other underlying condition or known medications were unlikely to have contributed to the accident.

Aircraft information

General information

UVC was a Bell Helicopter Company UH-1H, S/No 5144, manufactured in the United States of America in 1966. The UH-1H is a medium size, single engine utility helicopter with a two-bladed main rotor system. Standard configuration included dual controls, seating capacity for 13 persons,

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[8] Available at www.casa.gov.au – aviation medicine - medication

including two crew members, and skid type undercarriage. UVC was placed on the Australian Civil Aircraft Register on 2 October 2018 and was issued with Special Certificate of Airworthiness No. 13L1817 in the Limited[9] category on 17 October 2018.

The Special Certificate of Airworthiness specified that the aircraft was to be operated:

- in accordance with the operating limitations contained within the approved Army Model UH-1H Helicopter Operator's Manual
- by day under the Visual Flight Rules unless the aircraft was appropriately equipped for night or instrument flight.

Aircraft records

UVC's Log Book Statement[10] specified that maintenance releases were to be issued for periods of 150 hours time-in-service or 12 months, whichever occurred earlier. Maintenance reference data for UVC was the UH-1 series, military services Inspection Planning Guide from the Interagency Committee for Aviation Policy (ICAP[11]).

The maintenance release, current at the time of the accident, was issued on 16 October 2018 for day VFR operations at an aircraft time in service of 6,693.0 hours.

The current maintenance release with flight hour information for UVC was not recovered from the helicopter following the accident. An estimate of the aircraft time in service was derived from the pilot's logbook to determine UVC's operating time since the issue of the maintenance release. It was estimated that prior to departure from Archerfield, UVC's total time in service was about 6790.0 hours.

At 6,743.0 airframe hours a 50-hour inspection was required, involving:

- visual inspections
- mounting hardware torque checks
- rotor drive train oil system maintenance.

Additionally, a voltage regulator inspection was required to be performed by 16 April 2019.

Maintenance history

Following arrival in Australia, the helicopter was assembled and refurbished. The refurbishment included maintenance actions for the initial issue of the certificate of airworthiness, systems checks and post-maintenance testing. Maintenance records indicated that on completion of the refurbishment, flight testing that included dynamic balancing of the main rotor system and confirmation of correct flight control stick forces was conducted. Additional and on-going maintenance requirements were annotated on the maintenance release.

Prior to departure from Archerfield, a 10-hour/14-day inspection was performed, and a clearing endorsement was entered on part 1 of the maintenance release. An image of the maintenance release showing the clearing endorsement was provided to the ATSB.

The image also showed that the 50-hour inspection due at 6,743.0 hours, and the voltage regulator inspection due on 16 April 2019, had not been endorsed on the maintenance release as having been completed. An image of part 2 of the maintenance release, where maintenance can

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9 Operational category assigned to ex-military (warbird), historical or replica aircraft under Part 132 of the Australian Civil Aviation Safety Regulations

10 Log Book Statement - a document contained within an aircraft's permanent records that identifies relevant aircraft details and documents the aircraft's maintenance program and maintenance release inspection information

11 ICAP: Interagency Committee for Aviation Policy established by the General Services Agency, United States of America, for the effective acquisition, management and disposal of federally owned aircraft

be certified, was not provided. The aircraft logbook did not contain details of maintenance activity beyond UVC's refurbishment and maintenance release issue on 16 October 2018.

The ATSB was unable to verify if the required maintenance had been performed as the aircraft's maintenance release was not recovered from the wreckage.

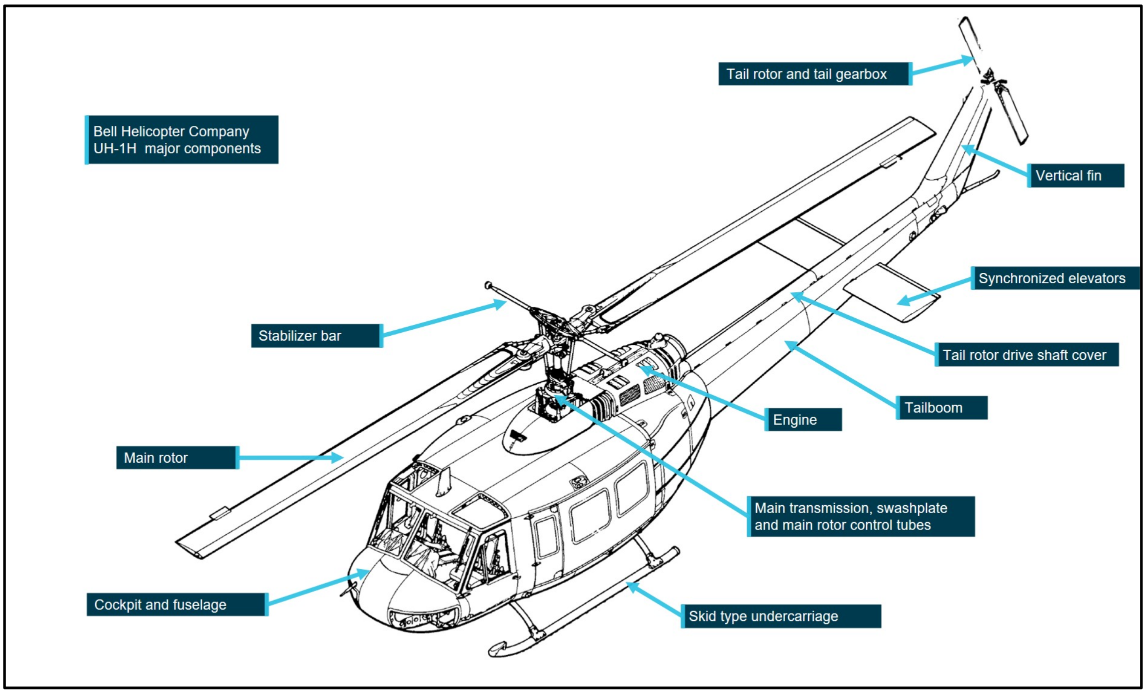
Aircraft systems

Flight control system

UVC was equipped with a hydraulically-assisted flight control system which could be operated by either the pilot or co-pilot. The system included the cyclic and collective control systems, allowing operator inputs to the main rotor system, and tail rotor pedals for control of the tail rotor.

With hydraulic assistance power removed, the pilot would experience higher than normal forces to move the cockpit controls, and moderate feedback would be felt when the controls were moved. However, full main and tail rotor system control would still be available and control movements would result in a normal helicopter response.

Figure 3: Layout of Bell Helicopter Company UH-1H with major components labelled



Source: Bell Helicopter Company, annotated by the ATSB

Hydraulic system

The hydraulic system consists of a single hydraulic pump supplying pressure to the hydraulic servo cylinders connected to mechanical linkages in the helicopter's flight control system. When the cockpit controls are moved, pressurised hydraulic fluid enters the cylinders reducing the force for control movement.

In the event of a hydraulic system malfunction, feedback forces from the main rotor are prevented by irreversible (check) valves in the hydraulic servo cylinders. This allows the pilot to continue making the required control system inputs. In the event of a hydraulic power failure, the pilot should land a soon as practicable in an area that will permit a run-on landing.[12]

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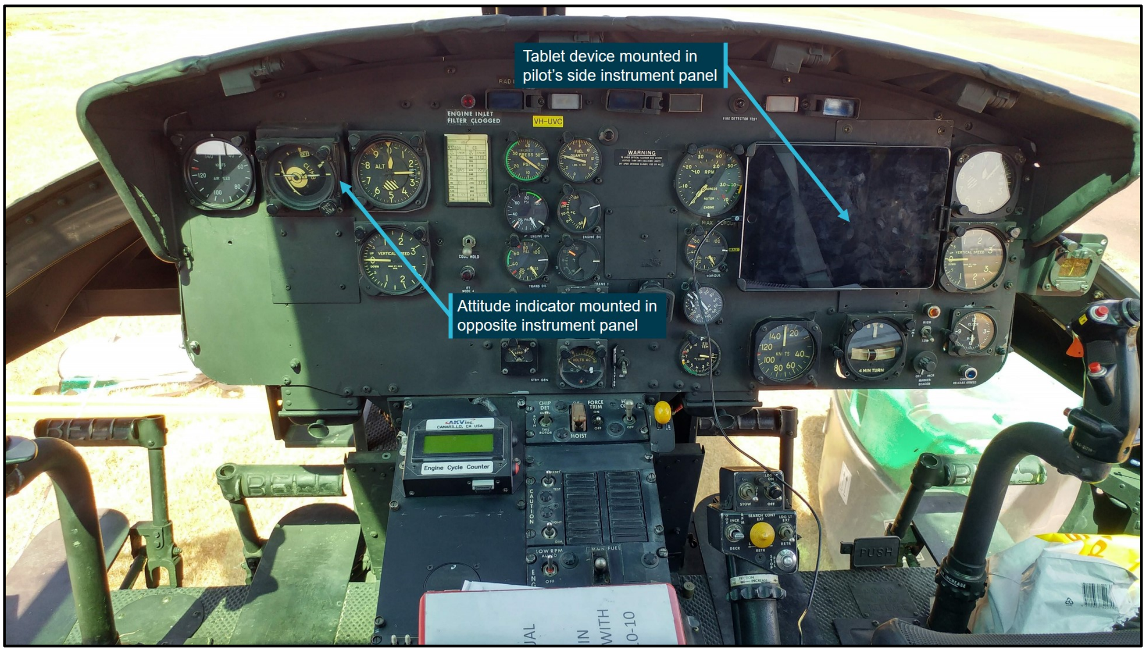
12 A manoeuvre that is used to transition from forward flight to a landing on the surface where a hover landing is not possible or appropriate.

Aircraft modifications

UVC was a standard UH-1H helicopter with no recorded airframe modifications, however a tablet device (Figure 4) was mounted on the pilot's side instrument panel. From reference to an image of UVC's cockpit and the UH-1H Operator's Manual it was determined that the pilot's side, attitude indicator and directional gyro may have been removed to accommodate the device or were obscured once the device was installed. A second attitude indicator was mounted in the left side instrument panel.

To accommodate the tablet installation, the pilot's airspeed and turn and slip indicators were relocated to new positions below the tablet device. While the UH-1H Operator's Manual did not specify the instruments that were required for VFR flight, relocation of instruments was permitted.

Figure 4: VH-UVC instrument panel



Source: Niza Villanueva, annotated by the ATSB

UH-1H helicopter limitations

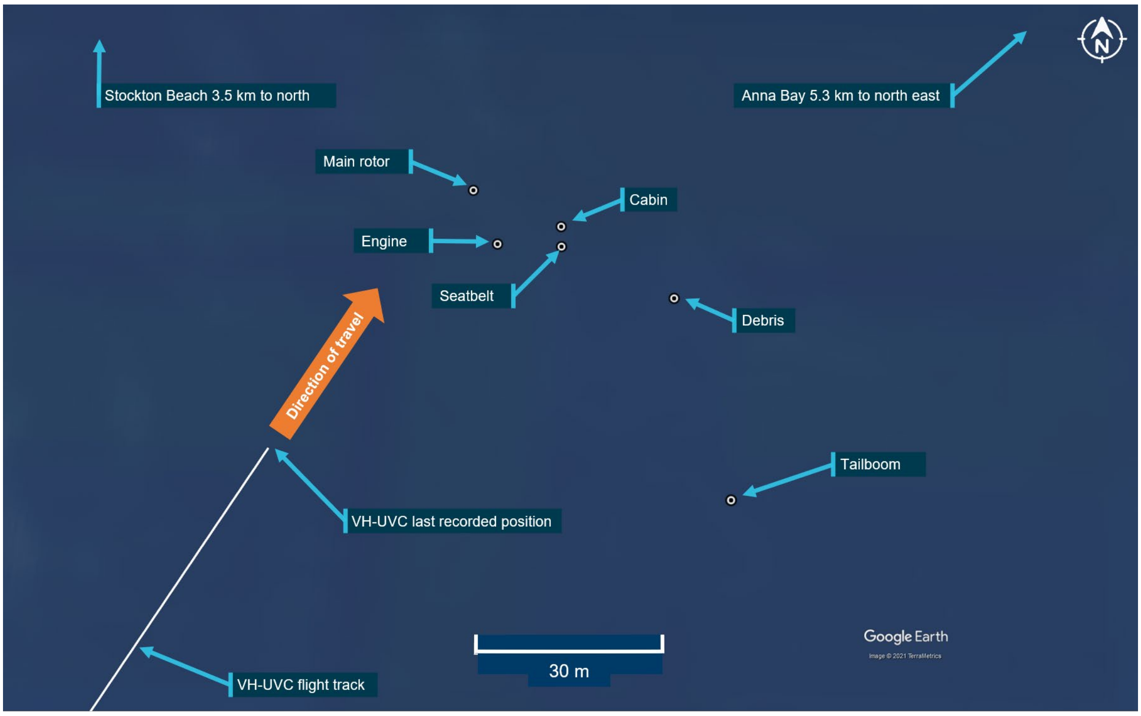
The Operator's Manual for Army Model UH-1H helicopters, specified that intentional flight into severe or extreme turbulence or into thunderstorms was prohibited. Other limitations for UVC were a gross weight limitation of 4,309 kg, and a never exceed limit of 112 kt indicated airspeed. This limiting airspeed varied slightly with aircraft gross weight and atmospheric conditions.

Wreckage information

Search for helicopter and wreckage field

A Royal Australian Navy vessel tasked to assist the search, located the helicopter wreckage field about 3.5 km offshore, in about 30 metres of water. NSW police divers located parts from the helicopter and provided the ATSB with a series of location coordinates from a GPS-enabled dive camera. The positions of the helicopter parts were mapped to show their relative positions on the ocean floor (Figure 5).

Figure 5: Map showing relative positions of helicopter wreckage on the ocean floor relative to UVC's flight path



Source: Google using Aireon data for UVC flight path and NSW police supplied positions of wreckage items, annotated by the ATSB.

The heaviest items, including the main rotor system and the engine, were located within 10 metres of each other. Other debris and parts of the cabin were also nearby. The tailboom was located about 51 metres to the south-east of the engine's position.

Helicopter wreckage

The engine, main rotor system and tailboom were identified in underwater imagery recorded by the Royal Australian Navy during the search for the helicopter. The imagery showed that the tailboom was missing the vertical fin, tail rotor gearbox, tail rotor, and the synchronised elevators (Figure 3).

Imagery of the main rotor system showed both main rotor blades attached to the rotor head and the transmission mast connected to the upper reduction gearbox section of the transmission assembly. The lower section of the transmission assembly that included the mount casing and tail rotor drive section was not identified.

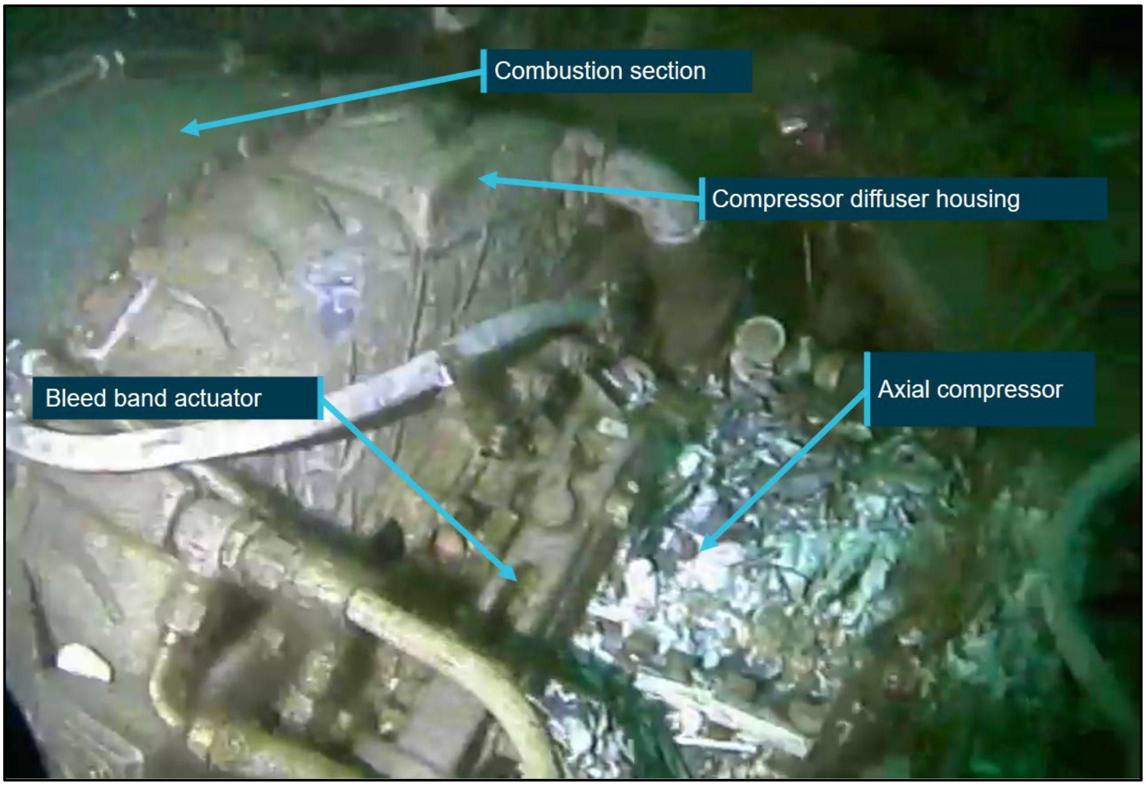
One of the main rotor blades appeared to be largely straight with damage to the outboard section. In contrast, the opposite blade was significantly damaged. The blade tip section was missing and there was evidence of blade deformation in bending. The 'D' section leading edge main spar, was visible and portions of the blade aerofoil section between the blade leading and trailing edges were missing. It is likely that both blades were rotating when they struck the water.

The swashplate, main rotor system (Figure 3) and pitch control mechanism were also present. Additionally:

- the transmission and main rotor blade system had detached from the fuselage during the accident sequence
- there was no evidence of a flight control system fault
- significant disruption of other sections of the helicopter was evident
- the damage was consistent with a high-speed impact with water.

The engine was located on the ocean floor in the vicinity of the main rotor system and the cockpit and cabin remains (Figure 5). The engine was intact, with the exception of the exhaust pipe. It was not possible to determine the integrity of the engine, or its serviceability from available imagery, however no obvious defects were identified.

Figure 6: Engine from VH-UVC located within the wreckage field



Source: NSW police, annotated by the ATSB.

Other helicopter parts that were identified included:

- remains of the cockpit area
- both cockpit seats
- fragments of cabin structure
- sections of the undercarriage
- items of portable refuelling equipment.

Other pieces of the helicopter were present however identification was limited by the clarity of the water and some items had become partially buried by sand. On Monday 16 September 2019 a member of the public provided NSW police with a small honeycomb panel. It had washed ashore between Kingsley Beach and Little Kingsley Beach, located about 2 km to the south-east of Anna Bay.

Two other pieces were found and reported to NSW police on 18 September 2019. They were also of honeycomb construction (Figure 7) and were found at separate locations on Stockton Beach, NSW. The construction and paint colour of the panels were similar to structural panels used in UVC, however no features specifically linking the items to UVC were identified.

A portion of helicopter main rotor blade washed ashore at Blinky Beach on Lord Howe Island, NSW and was reported to police on Friday 17 January 2020. The blade was constructed from an aluminium composite material, measured 800 mm by 340 mm and was painted matt black. It bore a sticker that read 'bh Fort Worth Texas', which identified the section as belonging to a Bell Helicopter.

Figure 7: Items of honeycomb construction found on Stockton Beach, probably from UVC

Source: NSW police

Tailboom assessment

UVC's tailboom was retrieved by NSW police divers and made available to the ATSB for examination. The tailboom (Figure 8), without the vertical fin, synchronised elevators, tail rotor gearbox and tail rotor assembly (Figure 3), had separated at the fuselage rear bulkhead due to overstress failure of the rear fuselage structure.

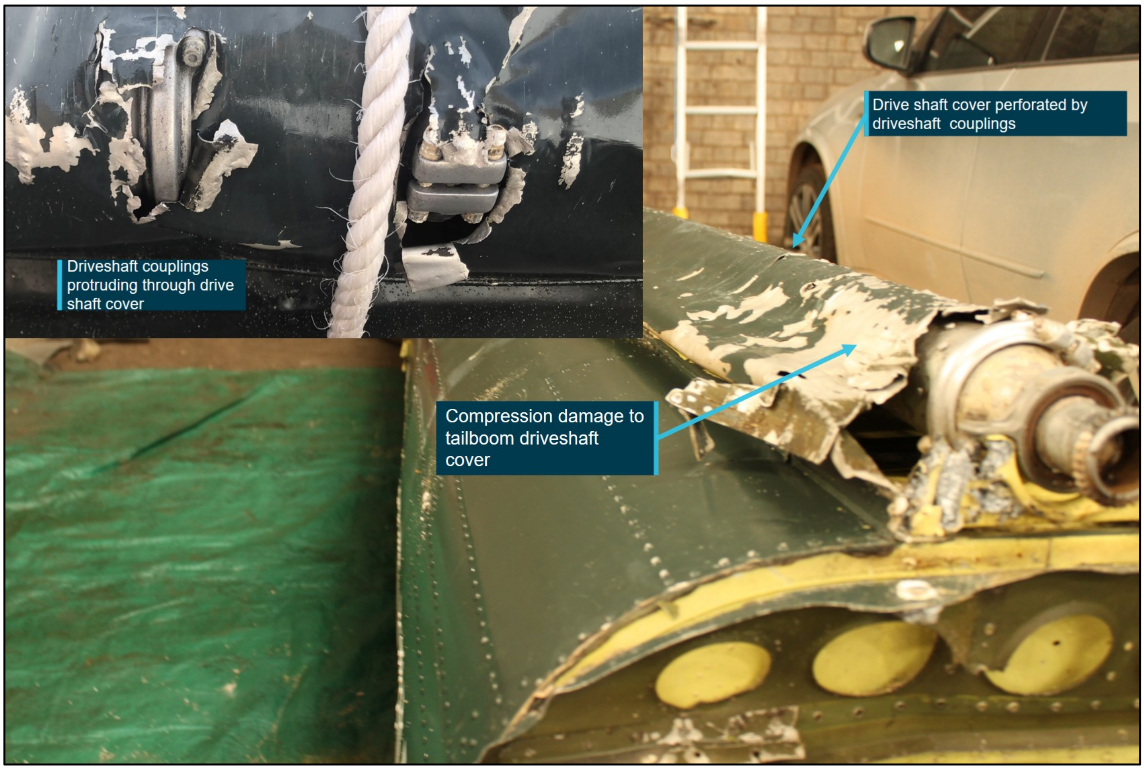
Figure 8: VH-UVC tailboom following recovery from the ocean floor

Source: NSW police, annotated by the ATSB

Internally, the remains of the synchronised elevator control system and the tail rotor pitch control systems were present. Failures of the control tubes and cables were attributed to overstress. Examination of the tailboom did not identify any pre-existing defects likely to have influenced the accident sequence.

The tail rotor drive train from the rear fuselage tailboom junction to the 42° gearbox was also present. Compression damage to the tailboom driveshaft cover was consistent with water impact. Drive shaft coupling imprints were noted on the cover (Figure 9). The imprints were consistent with the driveshaft not rotating at the time of impact. However, rotational damage signatures were also present at either end of the recovered tail rotor drive train. Additionally, multiple contact marks were evident on the side of the boom in the vicinity of the synchronised elevator attachment points. Those marks were consistent with repeated movements of the elevators.

Figure 9: Tailboom driveshaft cover with inset showing driveshaft coupling imprints



Source: ATSB

Recorded data

Overview

The aircraft was fitted with a Mode S transponder that broadcast ADS-B data. This information included the position and altitude of the aircraft and was received by Airservices Australia as well as other third-party ADS-B receivers (Aireon and Flightradar24).

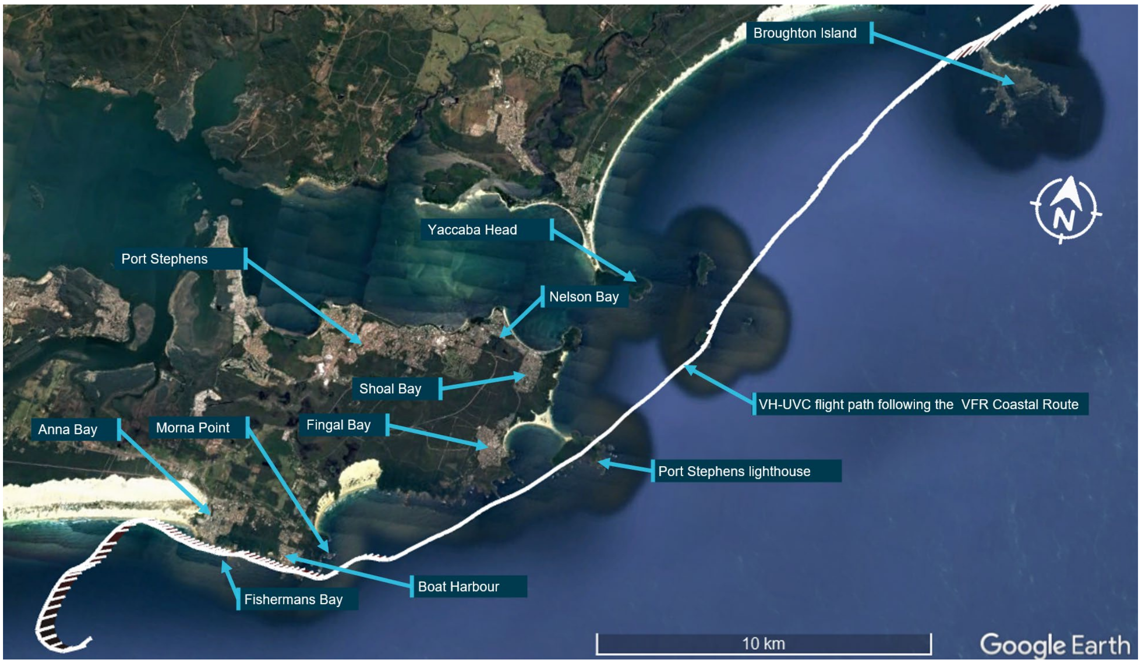
Two mobile devices with the OzRunways electronic flight bag application installed were on board. The application provided the option for live flight tracking by transmitting the device's position and altitude. ADS-B and OzRunways data was obtained and analysed by the ATSB.

Both the Aireon and OzRunways data was compared and found to be consistent, however the Aireon data has been used in this report as it provided higher fidelity for altitude information over the final flight segment. The data was transmitted at five second intervals and a track line was produced by joining each data point with a straight line. Variations between these data points were not captured.

VH-UVC flight path

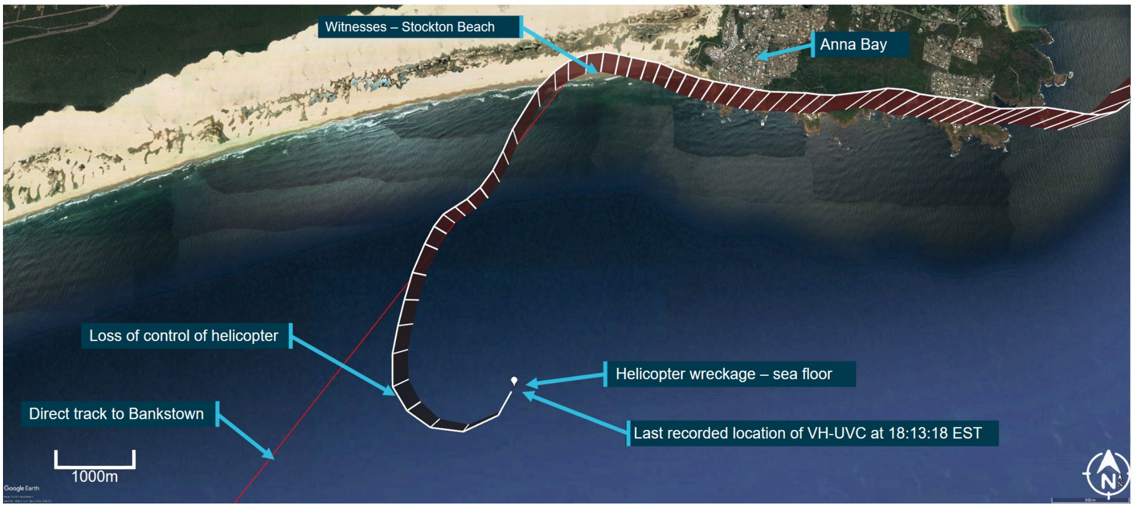
From Broughton Island UVC tracked past Yacaaba Head, Fingal Bay then Morna Point (Figure 10). Once past Anna Bay, the pilot commenced a left turn away from the coast, aligning with a direct track to Bankstown (Figure 11 and 12). The turn and subsequent track were inside the Williamtown military control zone area boundary. The helicopter tracked offshore to the south-west for about 90 seconds before commencing a rapidly-descending, left turn followed by a collision with the ocean surface.

Figure 10: Townships along the VFR coastal route once UVC passed Broughton Island



Source: Google using ADS-B data (Aireon), annotated by the ATSB

Figure 11: Overhead view of UVC flight path showing turn to seaward and spiral descent



Source: Google and ADS-B data (Aireon), annotated by the ATSB

Figure 12: Side view of UVC flight path showing turn to seaward and spiral descent

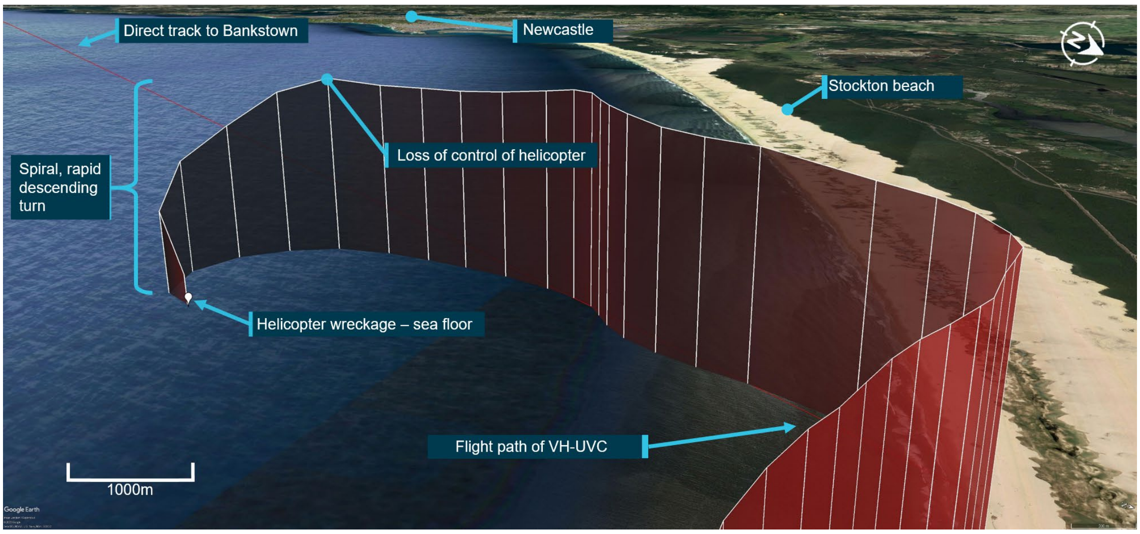
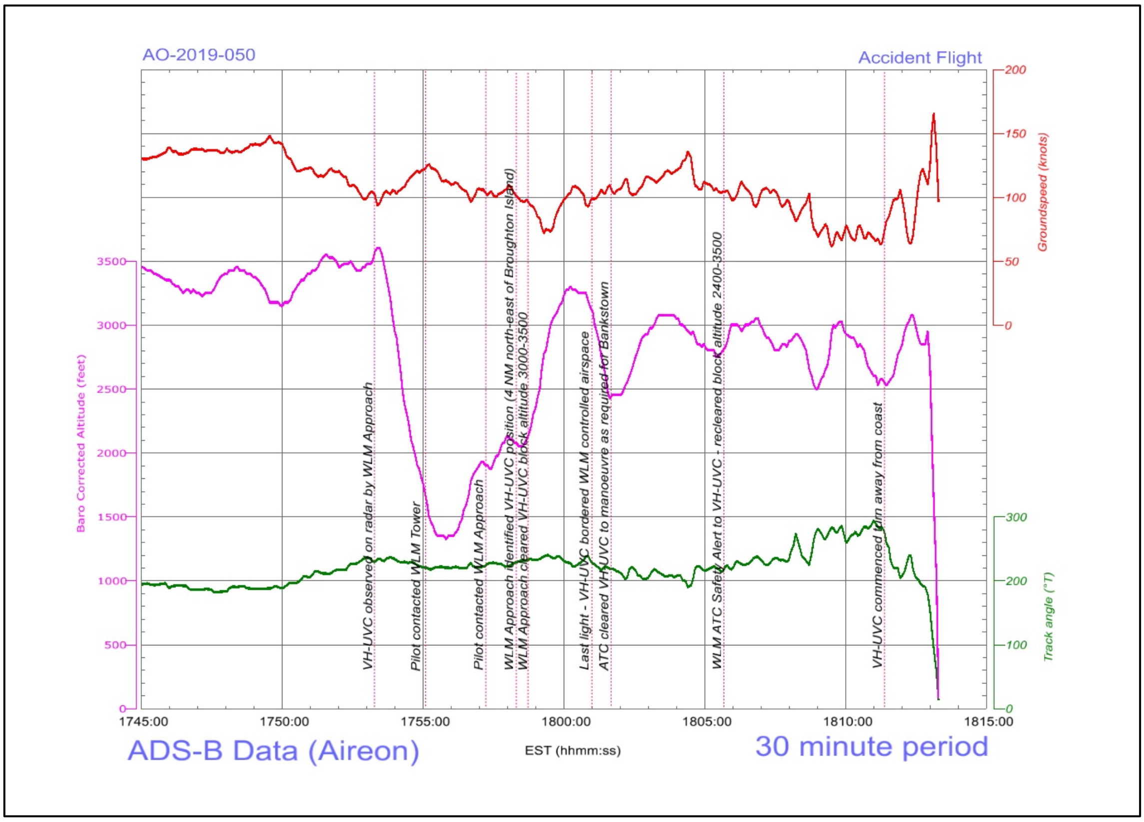


Image description: The flight path is provided for illustrative purposes. The altitudes as presented originate from raw data and have not been corrected for atmospheric conditions.
Source: Google and ADS-B data (Aireon), annotated by the ATSB

The variation in UVC's flight parameters over the final 30 minute period is presented in a graphical format (Figure 13) with key events presented in an overhead view (Figure 14). The rate of change of altitude and track, before and after last light, where the pilot appeared to be attempting to maintaining a constant altitude, were averaged and compared. For the period after last light and prior to the turn away from the coast:

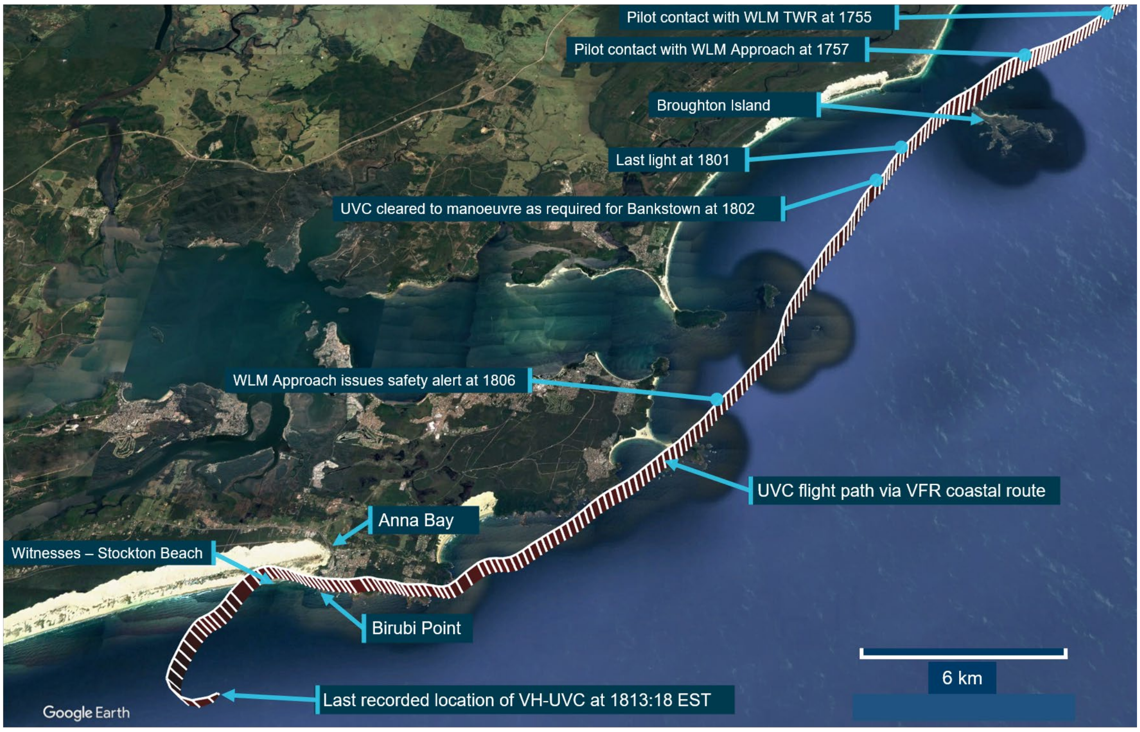
- the average variations in altitude increased by a factor of 2 compared to daylight operation.
- excluding what appeared to be a deliberate turn by the pilot at about 1809, the average variations in track increased by a factor of 3 compared to daylight operation.

Figure 13: UVC flight parameter variation over the final 30 minutes



Source: ADS-B data (Aireon) with ATSB analysis

Figure 14: UVC flight path from Broughton Island

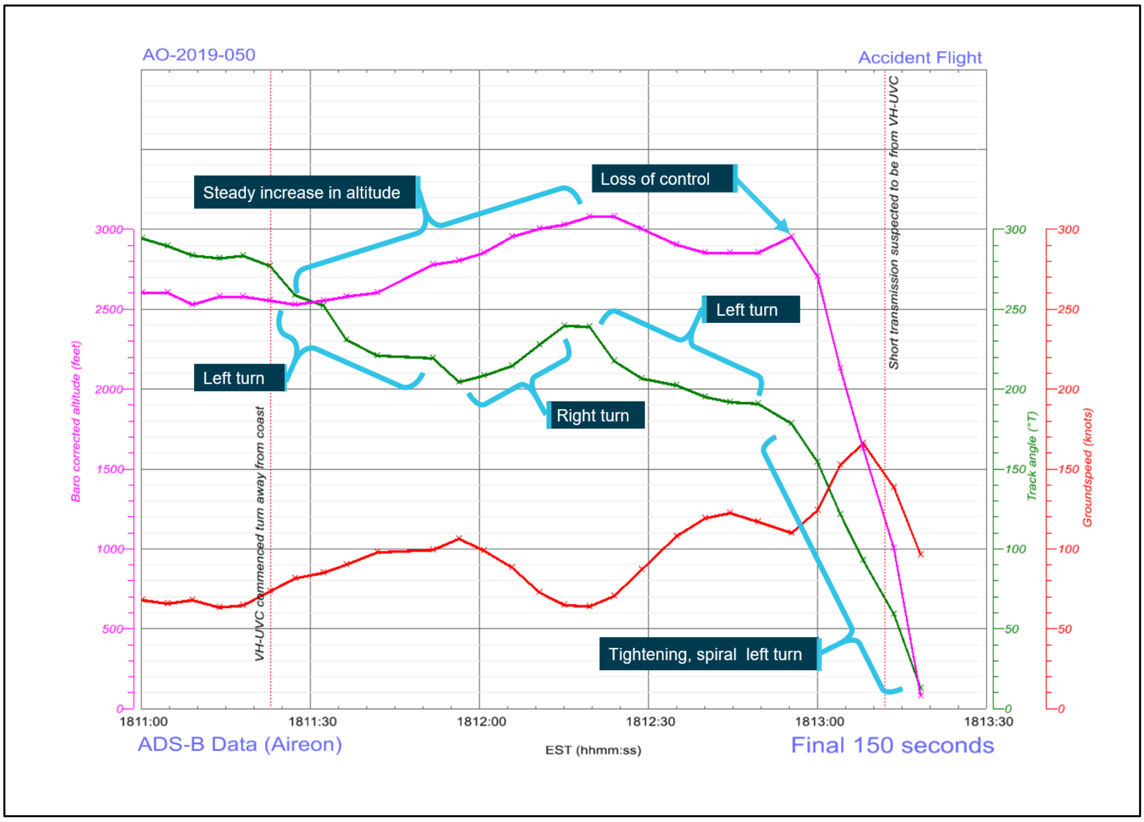


Source: Google and ADS-B data (Aireon), annotated by the ATSB

Once past Anna Bay, UVC's flight path from the turn to seaward to the spiral descending turn was further examined. The flight path is presented in a graphical format in (Figure 15) with key aspects noted below:

- at 1811:23, UVC commenced a left turn which continued until 1811:56, aligning with the direct track to Bankstown Airport
- from 1811:27 to about 1812:24, the altitude increased by about 550 ft
- a right turn commenced at 1811:56, continuing until 1812:15. Ground speed decreased during this time period
- a turn to the left commenced between 1812:15 and 1812:20
- from 1812:20 to 1812:24 the track changed to the left by about 21º
- from 1812:24 to 1812:50 there were ground speed and altitude changes, with a continuing left turn
- from 1812:50 to 1812:55 the turn rate and altitude increased
- from 1812:55 there was a rapid loss of altitude and rapid changes in track and ground speed, consistent with a loss of control. The average rate of descent after the loss of control was calculated to be about 7,500 feet per minute, peaking at 11,636 feet per minute at 1813:18
- Based on wind speeds recorded at WLM it is estimated that in the last 14 seconds of the descent, UVC's V_{NE}[13] limit was exceeded by up to 45 kt.

Figure 15: UVC flight parameter variation over the final 150 seconds of flight



Source: ADS-B data (Aireon) with ATSB analysis

13 V_{NE}: Never-exceed speed.

Air traffic services

The pilot submitted a flight plan for the Archerfield to Coffs Harbour leg. A flight plan was not submitted for the Coffs Harbour to Bankstown leg, however, there was also no requirement for one.

The pilot's first contact with Williamtown Air Traffic Control (WLM ATC) was a request for an airways clearance at 1755. When issuing the requested clearance, the controller asked whether UVC had a CAR174B exemption[14], which would allow UVC to operate at a lower minimum altitude at night. On receiving no acknowledgement, the Approach (APP) controller advised the pilot that 2,400 ft was the lowest altitude that could be offered. There was no indication provided to the controller in the radio exchange that the pilot was not qualified to continue the flight after last light.

At 1800:27 and 1800:56 WLM ATC offered the pilot of UVC alternate tracking and at 1801:41 cleared the pilot to manoeuvre as required for tracking to Bankstown. At 1805:41, the APP controller issued a safety alert advising the pilot to 'check altitude' when UVC dropped to 2,700 ft, which was below the clearance altitude of 3,000 ft. The pilot reported turbulent conditions and in response the controller re-cleared the pilot to operate from the lowest safe altitude of 2,400 ft to 3,500 ft. At 1806:09 the controller requested the pilot to advise if anything further was needed.

The turn offshore at 1811:23 was observed on WLM radar. An indistinct transmission, which was assumed by ATC to be from UVC, was heard at 1813:12, about 17 seconds after the loss of control had likely occurred (Figure 15). UVC was observed on radar in a rapid descent from about 2,900 ft, disappearing from WLM radar coverage at 1813:26. By 1813:27, the APP controller had alerted the Tower controller of the unfolding situation, and made two standard radio calls seeking a response from UVC.

A detailed alert to UVC specifying that identification had been lost, and a low altitude warning to check altitude, was made at 1813:32 by the APP controller. The alert also included the area barometric pressure, the lowest safe altitude, and an instruction to initiate an immediate climb. There was no response from UVC and a further five radio calls were made to contact the pilot by WLM ATC controllers.

At 1824:13, in response to a request from the APP controller, the pilot from one of the WLM departing aircraft called UVC on the 121.5 emergency frequency and reported that no response was received.

The ATSB engaged the services of an ATC subject matter expert (SME) to review the controller's interaction with the pilot of UVC. The SME concluded that:

> The actions of WLM ATC throughout the flight of UVC were in accordance with the published rules and procedures for an aircraft operating Night VFR. In addition, WLM ATC offered alternative and flexible clearances to meet the needs of the pilot in command.

Operational information

Flight endurance

CASA regulatory requirements specify that pilots of helicopters conducting private flights under the VFR are to carry a fixed fuel reserve of 20 minutes flight time. The pilot in command is required to ensure that this fuel reserve remains unused on landing unless an emergency is declared. Pilots are also required to refer to operational information such as current weather reports and forecasts for the route to be flown and to plan the flight using that information.

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[14] An exemption to Civil Aviation Regulation CAR174B that places minimum safe altitude restrictions upon an aircraft operating under the night VFR.

The witness at Coffs Harbour noted that prior to departure, the helicopter's fuel tank had been filled to overflowing and a quantity of fuel remained in the 205 litre drum. The UH-1H operations manual stated that the useable fuel quantity was 781.6 litres or 1,362 lbs of fuel. UVC's fixed fuel reserve requirement was calculated to be 195 lbs of fuel.

The distance from Coffs Harbour to Bankstown via a coastal route to Anna Bay and then direct track to Bankstown, was calculated to be about 250 nautical miles. A flight in nil wind conditions, allowing for climb and descent, at an indicated airspeed of 95 kt would have required about 1,570 lbs of fuel. The fuel quantity required for UVC to transit from Coffs Harbour to Bankstown using forecast winds was calculated to be about 1,265 lbs.

Provided the forecast conditions had continued, the pilot of UVC would have required an intermediate refuelling stop or to declare a fuel emergency prior to arrival at Bankstown. Any holding or diversion would likely have required a landing before Bankstown to prevent airborne fuel exhaustion.

Pilot access to weather information

The pilot accessed the National Aeronautical Information Processing System (NAIPS) using the OzRunways electronic flight bag application at 0200 and 0202 on 6 September 2019. Requests were made for location briefings and NOTAM[15] information for Archerfield, Coffs Harbour and Sydney.

A forecast for the intended route was not requested, nor were Head Office NOTAMs or SIGMETs.[16] The pilot did not access further weather information through NAIPS. However, it could not be established whether the pilot, or one of the passengers, sourced further updates enroute via other means.

Night VFR (Helicopter) qualification and training

For VFR flights conducted at night, a Night Visual Flight Rules (NVFR) rating and helicopter NVFR endorsement are required. Training for the rating and endorsement covers theory and practise in the areas of basic instrument flight, navigation aid training and procedures in the event of abnormal situations. In addition, human factors and non-technical skills awareness and application, specific to the night flying environment are covered.

A minimum of 10 hours night flying experience is necessary, of which at least five hours are required to be in a helicopter or approved flight simulation training device. These night hours must include dual flight, solo night circuits, and cross-country flights. Three hours of dual instrument time in a helicopter or approved flight simulation training device is also required.

CASA regulatory requirements specify that a pilot who does not hold a NVFR rating, or instrument rating, is not permitted to depart on a flight before first light or after last light, and is also not permitted to depart unless the estimated time of arrival at the destination is at least ten minutes before last light.

Decision making

Flight under the VFR requires minimum conditions of visibility and distance from cloud. Variation from the expected weather conditions enroute may not enable a pilot to reach the planned destination under this ruleset. That, in turn, will require a timely decision to land or divert when

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15 Notice to Airmen (NOTAM): NOTAMs provide information that is of direct, and often immediate, operational significance.

16 Significant meteorological information (SIGMET): a weather advisory service that provides the location, extent, expected movement and change in intensity of potentially hazardous (significant) or extreme meteorological conditions that are dangerous to most aircraft, such as thunderstorms or severe turbulence.

things are not going to plan. However, the human tendency to continue with a course of action is documented in various research studies.

The American Psychological Association defines plan-continuation bias as:

> 'The tendency of people to continue with an original course of action that is no longer viable'. An example would be an airline pilot who unexpectedly encounters bad weather at the scheduled destination but decides to land anyway rather than divert to another location. Plan-continuation bias tends to be particularly strong towards the end of the activity and has been theorized to result from the interaction of such factors as cognitive load, task demands, and social influences.

Errors associated with plan-continuation have been recognised in the analysis of a number of aircraft accidents previously (NTSB, 1994; Batt and O'Hare, 2005; Dismukes, Berman and Loukopoulos, 2007).

In the ATSB research investigation report B2005/0127, addressing general aviation pilot behaviours in the face of adverse weather, Batt and O'Hare (2005) identified that the halfway point of a flight may feel like a psychological 'turning point' for pilots.

> The focus of the pilot's thoughts and attention will shift gradually from the point of departure to the planned destination…as the flight progressed, the chances of a VFR into IMC encounter increased until they reached a maximum of 27.6% during the final 20% of the flight distance. This pattern suggests that an increasing tendency on the part of pilots to 'press on' as they near their goal.

Options available to day VFR pilot's experiencing reduced visual cues include contacting air traffic control for assistance or conducting a precautionary landing. The ATSB's 'Don't push it, LAND It' safety messaging, jointly developed and supported by the Civil Aviation Safety Authority and the Australian Helicopter Industry Association, encourages helicopter pilots to exercise this option.

Weight and Balance

Weight and balance information was derived from maintenance records, witness statements and images provided to the ATSB. Additionally, estimated and known weights of the pilot, passengers, baggage, equipment and fuel on board were used to calculate UVC's weight and centre of gravity. It was estimated that the weight of UVC on departure from Coffs Harbour was 3,808 kg, which was below the Operator's Manual gross weight limit of 4,309 kg.

The occupant seating positions were established from information provided by witness and from on-board images that occupants exchanged with ground-based parties following their departure from Coffs Harbour. UVC's longitudinal and lateral balance was found to be within limits from Coffs Harbour to Anna Bay.

Helicopter – basic operational equipment for flight under the night VFR

In addition to the equipment requirements for day VFR operations, Civil Aviation Order, CAO 20.18 specifies that a helicopter may only be operated under the night VFR, if it is equipped with instruments that include an attitude indicator and a heading indicator (directional gyroscope).

Further, for night VFR flights conducted over land or water where the helicopter's attitude cannot be maintained by the use of external visual surface cues from lights on the ground or celestial illumination, a helicopter is to be:

- equipped with an approved automatic pilot or automatic stabilisation system, or
- operated by a qualified two pilot crew, each with access to the flight controls.

Helicopter emergency procedures

The Operator's Manual for Army Model UH-1H helicopters provides guidance for pilots in the event of system malfunctions or loss of function. In the event of a partial power loss, or if the engine is no longer operating (Figure 16), an auto rotational descent[17] and landing is required.

Likewise, the pilot would initiate an auto rotational descent in response to:

- a drive train or tail rotor failure
- an engine to transmission main drive shaft failure
- a transmission free wheel unit disengagement.

Figure 16: Airflow through the main rotor system during an auto rotational descent

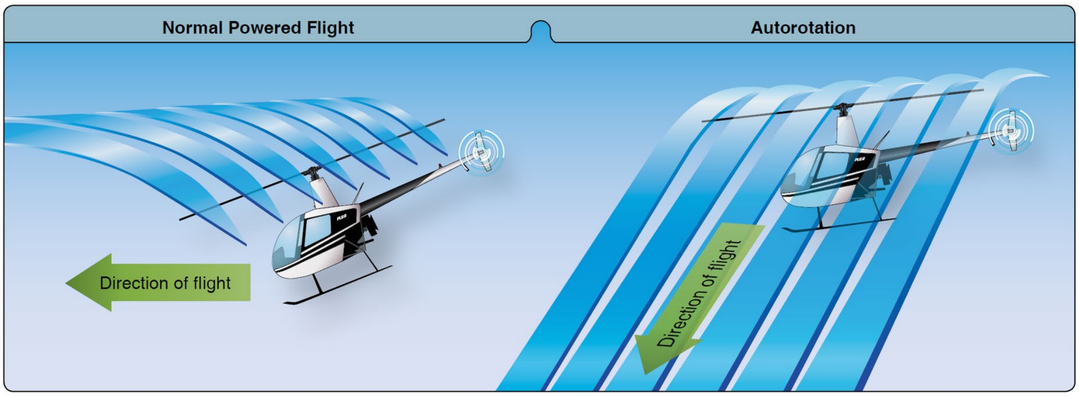

Image description: During an autorotation, the upward flow of relative wind permits the main rotor blades to rotate at their normal speed.
Source: FAA Helicopter Flying Handbook

The descent is typically conducted at a specified forward airspeed for the helicopter type and characterised as a controlled descent. For the UH-1H helicopter a typical auto rotational rate of descent is about:

- 1,600 feet per minute with an indicated airspeed of 52 kt for minimum rate of descent, or
- 2,060 feet per minute with an indicated airspeed of 82 kt for maximum glide distance.

A loss of tail rotor control or drive to the tail rotor, is manageable provided adequate airspeed is maintained, as directional stability will be provided by the helicopter's vertical fin. The UH-1H helicopter requires airspeeds above 30-40 kt to maintain directional control with a loss of tail rotor drive. Other tail rotor malfunctions, including stuck pedals (fixed tail rotor pitch settings), require 40-70 kt airspeed be maintained.

When performing an auto rotational descent to a suitable landing site, a pilot has a choice in the angle of descent, varying from vertical to maximum horizontal range. Pilots are trained to perform auto rotational descents and auto rotational capability is a certification requirement for helicopters.

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[17] An auto-rotational descent is a power off manoeuvre in which the engine is disengaged from the main rotor system and the rotor blades are driven solely by the upward flow of air through the main rotor.

Meteorological information

Forecast weather

Graphical Area Forecast (GAF)

The flight from Coffs Harbour to Bankstown occurred within the Graphical Area Forecast[18] New South Wales – East that was valid from 1500 to 2100. Forecast conditions included:

- average conditions of greater than 10 km visibility with areas of scattered[19] cumulus and stratocumulus cloud at altitudes between 4,000 and 8,000 ft
- widespread blowing dust reducing visibility to 5,000 m
- scattered showers of rain reducing visibility to 4,000 m with associated scattered cumulus and stratocumulus cloud from 3,000 to 5,000 ft and broken cumulus and stratocumulus cloud from 5,000 to above 10,000 ft
- isolated smoke over the land reducing visibility to 4,000 m and isolated heavy smoke over the land north of Taree reducing visibility to 2,000 m
- isolated thunderstorms over the sea reducing visibility to 3,000m with associated isolated cumulonimbus clouds from 3,000 to above 10,000 ft
- moderate mountain wave activity forecast above 4,000 ft
- severe turbulence forecast below 10,000 ft with moderate turbulence north of Taree

The GAF also noted that moderate turbulence[20] is implied in cumulus, stratocumulus and altocumulus cloud and severe turbulence[21] is implied in cumulonimbus cloud.

Significant Meteorological Information Advisory (SIGMET)

The Bureau of Meteorology (BoM) issued a Significant Meteorological Information Advisory at 1436 for severe turbulence below 10,000 ft valid from 1500 to 1900. The area affected by the SIGMET covered the entire flight from Archerfield to Bankstown.

Grid Point Wind and Temperature

The Grid Point Wind and Temperature forecast valid at the time of the flight indicated the average wind south of Coffs Harbour was 25 kt from the north-north-west at 2,000 ft.

Mean Sea Level Pressure chart

The Mean Sea Level Pressure chart showed a trough and frontal system approaching the Williamtown area on the afternoon of the flight. These systems were moving west to east and had an associated tight pressure gradient.[22]

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[18] Graphical Area Forecast (GAF) provides information on weather, cloud, visibility, icing, turbulence and freezing level in a graphical layout with supporting text. These are produced for 10 areas across Australia, broadly State-based.

[19] Scattered cloud is defined as cloud totalling 3 to 4 OKTAS, meaning 3 to 4 eights of the sky obscured by cloud.

[20] Moderate turbulence. There may be moderate changes in aircraft attitude and/or altitude, but the aircraft remains under positive control at all times – usually, small variations in air speed – changes in accelerometer readings of 0.5g to 1.0g at the aircraft's centre of gravity – difficulty in walking – occupants feel a strain against seat belts – loose objects move about.

[21] Severe turbulence. Abrupt changes in aircraft attitude and/or altitude – aircraft may be out of control for short periods – usually, large variations in air speed – changes in accelerometer readings greater than 1.0g at the aircraft's centre of gravity – occupants are forced violently against seat belts – loose objects are tossed about.

[22] The pressure gradient is indicated by the proximity of isobars (lines of constant pressure) on a surface weather map. When the lines are close together a large (tight) pressure gradient exists, which can indicate relatively higher wind speeds.

Williamtown TAF

The BoM provided an aerodrome forecast (TAF)[23] for Williamtown Airfield, located about 21 km to the west of the accident location. Due to the weather front passing through the area, the TAF was amended several times. An updated TAF for Williamtown was issued at 1534 and was valid from 1600 on the 6 September 2019 to 1600 the following day. The forecast conditions were:

- wind 20 kt, gusting 35 kt from 320° with CAVOK[24] conditions
- from 1600, moderate to severe turbulence below 5000 ft until 1800
- from 1800:
  - wind 27 kt, gusting 48 kt from 290°, visibility 9,000 m in blowing dust with light showers of rain, cloud scattered 4,000 ft and broken cloud[25] at 12,000 ft
  - a 40 per cent probability of visibility reducing to 4,000 m in blowing dust until midnight
  - severe turbulence below 5,000 ft.

Williamtown Aerodrome warning

On the afternoon of the flight there were two aerodrome weather warnings in place for Williamtown. The weather warnings were valid from 1800 to 2200. The first warning released at 1306 was for wind gusts in excess of 41 kts. A later warning released at 1345 added visibility reduction in blowing dust to the wind gust warning.

Actual weather

The BoM provided a summary of the conditions in the area at the time of the accident and stated that broad scale severe turbulence was likely to have been present. A tight pressure gradient near the frontal system generated strong and gusty west to north-westerly winds. Generally, significant west to north-westerly wind crossing the mountains to the west of the Newcastle area would have caused mechanical turbulence in the area, particularly downwind of the ranges. Strong north westerly winds were observed following the passage of the trough (ahead of the front).

The Bureau of Meteorology (BoM) provided the ATSB with the SPECI[26] and METAR[27] data from Williamtown at the time of the accident (Table 1).

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[23] Aerodrome Forecast (TAF): a statement of meteorological conditions expected for a specific period of time in the airspace within a radius of 5 NM (9 km) of the aerodrome reference point. The heights referenced in TAFs are heights above the aerodrome reference point (ground).

[24] Ceiling and visibility okay (CAVOK): visibility, cloud and present weather are better than prescribed conditions. For an aerodrome weather report, those conditions are visibility 10 km or more, no significant cloud below 5,000 ft, no cumulonimbus cloud and no other significant weather.

[25] Broken cloud is defined as cloud totalling 5 to 7 OKTAS meaning 5 to 7 eights of the sky obscured by cloud.

[26] SPECI: An aerodrome weather report issued whenever weather conditions fluctuate below specified criteria.

[27] METAR: A routine aerodrome weather report issued routinely on the half-hour.

Table 1: Williamtown observations

Type	Time	Wind	Visibility (m)	Cloud	Temp (°C)	QNH (hPa)
SPECI	1745	310°, 15-26 kt	9,999	SCT070, SCT078	30	997
METAR	1800	310°, 14 kt	9,999	BKN072	30	997
SPECI	1810	300°, 15-29 kt	9,999	BKN070 OVC081	30	997
METAR	1830	290°, 19 kt	9,000	OVC072	29	997

Although SPECI and METAR reports indicated visibility in the area was unlimited, comments between Williamtown Approach and Tower controllers at 1753 made reference to visibility to be about 6-7 km with dust. Also of note are the overcast cloud conditions from 1810.

The BoM also provided the ATSB with one-minute interval data recorded by the Williamtown Automatic Weather Station. The one-minute cloud data from Williamtown showed that the cloud cover started to build from 1728, was likely overcast by 1751 and considered as overcast by 1802.

Visibility at Williamtown reduced markedly from 35.7 km at 1742 to 8.34 km by 1811. SPECI reports are only issued when weather conditions fluctuate about or below specified criteria. Visibility reductions only trigger a SPECI when the visibility is below an aerodrome's highest alternate minimum visibility or 5,000 m, whichever is greater. As such, the one-minute visibility data indicating 8.34 km was not low enough to trigger a SPECI.

Last light

For aviation purposes, night is defined as the period of darkness between the end of evening civil twilight (last light) and the beginning of the following morning civil twilight (first light). At last light, in ideal conditions, there will be enough light from the sun for large objects to be seen, but no detail.

Published last light[28] for the Anna Bay area, on the day of the accident was 1801, however the presence of cloud cover, dust and masking terrain to the west would have resulted in last light occurring earlier.

Additionally, although the moon was high on the horizon, with the lunar disc 52 per cent illuminated, any celestial lighting was likely obscured by the overcast conditions.

Data from a privately-owned weather station located about 4 km to the north-east of the accident site was provided to the ATSB. The data, which included ambient lighting levels, showed that by 1750, the ambient light had degraded to 19 lux[29], reducing to 4 lux by 1800. By 1820, the available light had reduced to zero. By comparison, at 1700 the lux level was 2,055 while in full daylight, the lux levels were about 10,750.

Once UVC passed Broughton Island various townships were present along the VFR coastal route that may have provided sources of lighting for the pilot's reference (Figure 10).

Spatial disorientation

Spatial orientation defines the natural human ability to maintain body orientation and/or posture in relation to the surrounding environment (physical space) at rest and during motion. The FAA's *Medical Facts for Pilots* provides the following:

[28] Last light computations do not include the nature of the terrain surrounding a location, or the presence of other than a cloudless sky and unlimited visibility at that location.

[29] Lux: Unit of illuminance that is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface

> Humans are designed to maintain spatial orientation on the ground. The three-dimensional environment of flight is unfamiliar to the human body, creating sensory conflicts and illusions that make spatial orientation difficult, and sometimes impossible to achieve. Statistics show that between 5 to 10 % of all general aviation accidents can be attributed to spatial disorientation, 90 % of which are fatal.

Spatial disorientation is defined by Benson (1999) as where 'the pilot fails to sense correctly, the position, motion or attitude of the aircraft or of him/herself' with respect to the ground. For pilots flying under the VFR, seeing the horizon is crucial for orientation of both the pilot's sense of pitch and bank of the aircraft (Gibb et al, 2010). In conditions of low visibility where the horizon may not be visible to the pilot, they can become rapidly disorientated.

Spatial disorientation is also often simply described as an inability to determine 'which way is up', although the effects of disorientation can be considerably more subtle. It occurs when the brain receives conflicting or ambiguous information from the sensory systems. It is likely to happen in conditions in which visual cues are poor or absent, such as in adverse weather or at night. Spatial disorientation presents a danger to pilots, as the resulting confusion can often lead to incorrect control inputs and resultant loss of aircraft control.

Pilots obtain information about their orientation from:

- The visual system (eyes), which can obtain information from a range of cues outside the aircraft and relevant flight instruments inside the aircraft
- The vestibular system, which consists of the balance organs located in the inner ears. The semicircular canals provide information about angular or rotational accelerations in the vertical (yaw), horizontal (pitch) and longitudinal (roll) axes, and the otolith organs provide information about linear accelerations
- The somatosensory system, which includes a range of receptors in the muscles, tendons, joints and skin that sense gravity and other pressures on the body. Such perceptions are often known as the 'seat of the pants' aspect of flying.

The visual system generally provides about 80 per cent of a person's raw orientation information, with the remainder provided by the vestibular and somatosensory systems, both of which are prone to misinterpretation and illusions during flight (Newman 2007). Although the visual system can overcome these limitations, the risk of spatial disorientation is significantly increased if the relevant visual cues are absent, ambiguous or not attended to.

Benson (1999) outlined that spatial disorientation would typically occur within 60 seconds of all visual cues being removed, while another United States study showed a loss of control by non-instrument rated pilots would occur, on average, about 180 seconds after the loss of all visual cues (Bryan, Stonecipher, & Aron, 1954).

A range of factors can influence the extent to which a pilot may experience or be able to recover from spatial disorientation. Common factors include limited or ambiguous visual cues outside the cockpit, not directing sufficient attention to the flight instruments due to workload or distraction, and not being proficient in instrument flying skills.

The risk of experiencing spatial disorientation can be managed effectively in the absence of external visual cues by reference to suitable aircraft instrumentation. However, controlled flight by sole reference to cockpit instruments is a separate, and complex, learned skill from those skills associated with flight in visual conditions.

Newman (2007) reported that spatial disorientation is affected by:

- pilot factors such as fatigue, medication and workload
- aircraft factors that include single pilot operations, the presence or otherwise of an autopilot or stability augmentation system, and serviceable cockpit instrumentation

- operational factors, that include pressing on into instrument meteorological conditions[30] without an instrument rating
- environmental factors that are related to time of day (flight after last light) and ambient weather conditions.

A further consideration is the likelihood that the lack of training and qualifications makes the day VFR-rated pilot susceptible to spatial disorientation following the loss of visual cues when flying in dark night conditions.

Newman (2007) also commented on the inherent instability of a helicopter increasing pilot workload and the likelihood for spatial disorientation. The Flight Safety Australia (2015) article, *Workload and Helicopters* includes the following about piloting a helicopter.

> Piloting a helicopter is a complex, continuous, multi-task operation…This means helicopter pilots face a high workload in day-to-day flying…Workload also varies temporarily, according to weather (IMC, wind/turbulence) and environment (terrain, obstacles, wires).

Compared to fixed wing aircraft, helicopters are dynamically unstable and require constant pilot input to maintain controlled flight (Fay, 1976; Prouty, 2004). Depending on design, they can be fitted with stability control systems or an autopilot to assist the pilot and reduce workload.

Vestibular system illusion

A false sensation of rotation is an illusion generated by the vestibular system involving the semicircular canals, that can lead to spatial disorientation and result in loss of control. It is commonly referred to as the 'graveyard spiral'. The FAA's *Medical Facts for Pilots* describes how under conditions of unreliable or unavailable visual references, the false sensation of rotation is:

> …associated with a return to level flight following an intentional or unintentional prolonged bank turn. For example, a pilot who enters a banking turn to the left will initially have a sensation of a turn in the same direction. If the left turn continues (~20 seconds or more), the pilot will experience the sensation that the airplane is no longer turning to the left. At this point, if the pilot attempts to level the wings this action will produce a sensation that the airplane is turning and banking in the opposite direction (to the right).
>
> If the pilot believes the illusion of a right turn (which can be very compelling), he/she will re-enter the original left turn in an attempt to counteract the sensation of a right turn. Unfortunately, while this is happening, the airplane is still turning to the left and losing altitude. Pulling the control yoke/stick and applying power while turning would not be a good idea–because it would only make the left turn tighter. If the pilot fails to recognize the illusion and does not level the wings, the airplane will continue turning left and losing altitude until it impacts the ground.

With appropriate training and experience, pilots who become disorientated when flying in compromised visual conditions are able to recognise illusions and utilise cockpit instruments to restore their orientation.

Related Occurrences

Between 2010 and 2019 the ATSB investigated 11 fatal accidents, involving aircraft flown after last light in dark night conditions, that resulted in a collision with water or terrain. Loss of control was a factor in five of them, with spatial disorientation found to have contributed to three of the five. Of the 11 accidents, five involved pilots who were qualified to fly an aircraft at night. Six of the accidents involved helicopters, two of which were flown by pilots who were qualified to fly at night. The remaining four accidents involved non-night qualified, day VFR-rated pilots. Four related occurrences are presented below.

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30 Instrument meteorological conditions (IMC): weather conditions that require pilots to fly primarily by reference to instruments, and therefore under Instrument Flight Rules (IFR), rather than by outside visual reference. Typically, this means flying in cloud or limited visibility

ATSB investigation AO-2011-087

On the evening of 27 July 2011, the owner-pilot of a Robinson Helicopter Co. R22 helicopter, registered VH-YOL was conducting a local flight from Big Rock Dam to Brooking Springs homestead near Fitzroy Crossing, Western Australia. The pilot was reported missing and the wreckage of the helicopter was located the following day, 14 km north-west of Fitzroy Crossing township. The helicopter was seriously damaged, and the pilot sustained fatal injuries. The ATSB found that the pilot was operating at night without the appropriate training or qualifications in a helicopter that was not suitably equipped.

ATSB investigation AO-2011-100

On 15 August 2011, the pilot of a Piper PA-28-180 Cherokee aircraft, registered VH-POJ, was conducting a private flight transporting two passengers from Essendon to Nhill, Victoria under the VFR. The flight was arranged by the charity Angel Flight to return the passengers to their home location after medical treatment in Melbourne. Global Positioning System data recovered from the aircraft indicated that when about 52 km from Nhill, the aircraft conducted a series of manoeuvres followed by a descending right turn. The aircraft subsequently impacted the ground at 1820 Eastern Standard Time, fatally injuring the pilot and one of the passengers. The second passenger later died in hospital as a result of complications from injuries sustained in the accident.

The ATSB found that the pilot landed at Bendigo and accessed a weather forecast before continuing towards Nhill. After recommencing the flight, the pilot probably encountered reduced visibility conditions approaching Nhill due to low cloud, rain and diminishing daylight, leading to disorientation, loss of control and impact with terrain.

ATSB investigation AO-2011-102

On 18 August 2011, an Aérospatiale AS355F2 (Twin Squirrel) helicopter, registered VH-NTV, was being operated under the VFR in an area east of Lake Eyre, South Australia. At about 1900 Central Standard Time, the pilot departed an island in the Cooper Creek inlet with two film crew on board for a 30-minute flight to a station for a planned overnight stay. It was after last light and, although there was no low cloud or rain, it was a dark night.

The helicopter levelled at 1,500 ft above mean sea level, and shortly after entered a gentle right turn and then began descending. The turn tightened and the descent rate increased until, 38 seconds after the descent began, the helicopter impacted terrain at high speed with a bank angle of about 90°. The pilot and the two passengers were fatally injured, and the helicopter was destroyed.

The ATSB found that the pilot probably selected an incorrect destination on one or both of the helicopter's global positioning system (GPS) units prior to departure. The ATSB concluded that, after initiating the right turn at 1,500 ft, the pilot probably became spatially disoriented. Factors contributing to the disorientation included:

- dark night conditions
- high pilot workload associated with establishing the helicopter in cruise flight and probably attempting to correct the fly-to point in a GPS unit
- the pilot's limited recent night flying and instrument flying experience
- the helicopter not being equipped with an autopilot.

ATSB Investigation AO-2016-031

On 7 April 2016, the pilots of two Robinson R22 helicopters flew from Mossman, Queensland, to various fishing locations to the north with a passenger in each helicopter. Late in the afternoon, on the return flight to Mossman the pilots encountered weather and winds that slowed their progress and required them to refuel at Cooktown. The pilots departed Cooktown at last light and as the flight progressed, the light available from the sun continued to decrease and there was no moon. There were also patches of cloud and rain in the general area.

Shortly after passing Cape Tribulation, in dark night conditions one of the helicopters registered VH-YLY, collided with the sea. The passenger was injured in the accident but was able to reach the shore and notify emergency services. A search was initiated and the missing helicopter was located about 400 m offshore in about 10 m of water. The pilot was not located. The ATSB found that the pilot of VH-YLY, who was only qualified to operate in day VFR conditions, departed on a night flight and continued towards the destination in deteriorating visibility until inadvertently allowing the helicopter to descend into water.

Safety analysis

Introduction

While on a positioning flight to Bankstown, New South Wales, Bell Helicopter Company UH-1H registered VH-UVC entered a descending turn, about 12 minutes after last light, resulting in a collision with water near Anna Bay, New South Wales.

The pilot was not qualified, and the helicopter was not equipped, to operate at night. At the time of the accident, dark night conditions and moderate to severe turbulence were likely present. No evidence was found of a mechanical defect with the helicopter that may have contributed to the accident.

The following analysis will discuss the continuation of the flight after last light, and the reasons for the subsequent loss of control. The analysis also considers the pilot's medical history.

Flight after last light

Due to the departure time from Archerfield Airport, and the need to refuel enroute, there was insufficient time to reach Bankstown before published last light. Considering the prevailing weather conditions, last light probably passed prior to the published end of evening civil twilight, as the helicopter approached Broughton Island.

Recognising that the pilot could have identified prior to departing Coffs Harbour that the flight could not be completed in daylight, given the inherent utility of a helicopter, there were also opportunities to land at a beach, or other suitable areas, prior to reaching Broughton Island. After this point, the pilot would have required suitable ground lighting to avoid obstacles during landing. An option available to the pilot at this point was to contact Williamtown air traffic control for assistance and a possible landing at Williamtown Airfield.

The pilot's decision to continue the flight at night may have been influenced by self-induced pressure to complete the flight for business and personal reasons. It is also possible that plan-continuation bias influenced the pilot's decision. As the flight passed the halfway point and progressed closer to the destination the pilot may have become increasingly committed to continuing with the original plan. Consequently, deciding to turn back or divert may have become increasingly difficult.

Loss of visual cues

As the flight progressed after last light visual cues may have been available to the pilot from ground-based lighting close to the aircraft's track and there may have been a horizon or silhouette of terrain to the west.

However, about 10 minutes after published last light UVC commenced a left turn, departed the coastal route, and tracked offshore. The position of the helicopter at this point was about 2 km to the west of Anna Bay. As the helicopter tracked over a featureless sea with overcast conditions blocking out celestial lighting, the pilot likely lost any remaining visual cues and encountered dark night conditions.

Loss of control

Flight profile

The aircraft's flight path after last light showed increasing variations in track and altitude. Considering that turbulent conditions were likely present for the whole flight from Coffs Harbour it is likely that the reduced visual cues encountered by the pilot affected their ability to control the helicopter.

UVC's track following the turn offshore was aligned with a direct track to Bankstown and was inside the Williamtown military control zone, which shared a lateral boundary with the R578A restricted area. As such, it is likely that the pilot was attempting to track directly to Bankstown, rather than follow the R578A restricted area boundary as previously requested.

From 1812:55 UVC entered a descending and tightening left spiral turn. Information derived from ADS-B data indicated that between UVC's last two recorded positions the helicopter's descent rate was in excess of 11,500 feet per minute and the aircraft's airspeed was in excess of 150 kt. The magnitude of those parameters significantly exceeded the operational limitations published in the Operator's Manual and, together with the characteristic spiralling turn, supported a loss of control of the helicopter at that point.

Helicopter systems assessment

Compression damage to the tailboom driveshaft cover was consistent with the upper surface of the tailboom impacting the ocean surface. Further, witness marks on the driveshaft cover indicated that the tail rotor drive train was stationary at the time of impact. However, there was also physical damage consistent with rotation and continuity of the tail rotor drive train. As such, it was considered likely that the tailboom detached from the helicopter prior to impact, decoupling the tail rotor drive and allowing the boom to rotate to an inverted position prior to impact.

Considering that the loss of control commenced about 1.2 km from the wreckage field and the tailboom was found only about 51 meters away from the main wreckage of the helicopter, it is likely the tailboom separation from the helicopter occurred very close to the helicopter's impact point and did not contribute to the loss of control.

The vertical fin and synchronised elevators detached from the tailboom and were not identified in underwater wreckage imagery provided to the ATSB. From the available information, it was not possible to determine when these components separated from the tailboom. However, as there was no evidence of pre-existing defects, it is considered more likely that they separated in the final moments due to the forces associated with contacting the water or as a result of dynamic loading effects associated with flight in turbulent conditions at very high airspeed.

The ATSB considered whether a system failure or malfunction influenced the development of the accident. Due to the location and condition of the wreckage the ATSB was unable to examine the helicopter's powerplant, rotor and flight control systems. As a result, the helicopter's flight path after 1812:55 was analysed in order to determine if it was consistent with a system fault.

The three possible faults considered were a loss of drive to the main rotor, loss of thrust from the tail rotor or loss of hydraulic power. The Operator's Manual advised that in the event of a loss of drive to the main rotor system an autorotational descent is required. A loss of tail rotor thrust or failure of the hydraulic system requires the pilot to maintain an airspeed above 30-70 kt and to position the aircraft for a run on landing at a suitable flat location.

The left turn initiated at 1812:55 was inconsistent with a track to a suitable landing site due to the proximity of Stockton beach to the right of the helicopter's track and a mayday call was not made, as would be expected in this situation. In addition, the helicopter's airspeed prior to 1812:55 was above that required to counter both a loss of tail rotor drive and hydraulic failure.

The airspeed and descent rate were also inconsistent with an autorotational descent or approach to a suitable landing site. It is therefore considered likely that the aircraft control and propulsion systems were serviceable and did not compromise the operation of the helicopter.

Spatial disorientation

When the pilot turned offshore near Anna Bay it is likely that the absence of celestial lighting and ground references resulted in dark night conditions being encountered. In addition, moderate to severe turbulence was likely present. The lack of external visual cues would have required the pilot to reference the aircraft's flight instruments to maintain control of the helicopter.

The primary instrument for maintaining control, or to recover from an unusual attitude, is the attitude indicator. In UVC the pilot's attitude indicator was not available to the pilot due to the location of a tablet on the instrument panel. The tablet was not located in the wreckage, as a result the screen brightness settings and their potential influence on the pilot's night vision could not be determined.

A second attitude indicator was located on the left side instrument panel however, it would have been difficult for a pilot with no instrument training to effectively use that instrument given its cross-cockpit position.

The pilot was not trained or experienced in maintaining control of the helicopter with sole reference to the flight instruments. Research has shown that pilots not proficient in maintaining control of an aircraft with sole reference to the flight instruments will become spatially disorientated and lose control of the aircraft within 1 to 3 minutes after visual cues are lost.

The helicopter's inherent instability coupled with the turbulence conditions and lack of an auto pilot probably made it more difficult to control UVC and may have increased the pilot's susceptibility to spatial disorientation. In addition, the pilot's reduced sleep opportunity the night before the accident, the elapsed flight time since departure from Archerfield and the workload associated with the turbulent conditions may have increased their level of fatigue, increasing the likelihood of disorientation.

The helicopter's spiralling descent flight profile after 1812:55 was consistent with spatial disorientation influenced by limitations of the vestibular system and absence of visual cues. The absence of external visual references also prevented the pilot from regaining control of UVC before it collided with the water.

Reporting of medication and medical conditions to the Civil Aviation Safety Authority

To assess and manage flight safety risk, the Civil Aviation Safety Authority (CASA) uses Designated Aviation Medical Examiners (DAMEs) as a point of contact for pilots renewing their medical certificates. The renewal process relies on self-reporting by the pilot of any medical conditions or treatments. Specifically, pilots are required to advise their DAME, and ultimately CASA, of any medications, medical procedures, medical conditions or symptoms that required the assessment a medical specialist.

The pilot, who was under the care of a non-aviation medical specialist in the month prior to their most recent medical certificate renewal process, did not disclose to their DAME the medical conditions that were being treated nor details of the medications that were prescribed.

The pilot's treating specialist reported that the sedating characteristics of the prescribed medications were known, and the dosages were carefully monitored, albeit based on pilot self-reports. The specialist further reported that the dosage was appropriate for the pilot and did not impact on the pilot's decision-making ability or physical functioning.

While the specialist's clinical assessment was not in question, the input of CASA aviation medicine specialists was necessary to determine whether the pilot remained eligible to be issued with an aviation medical certificate.

Pathways exist for managing certain medical conditions that do not preclude a pilot from maintaining an aviation medical certificate. However, disclosure of medical information is essential to enable CASA to manage any on-going flight safety risk for both the individual and flight safety overall.

Findings

From the evidence available, the following findings are made with respect to the collision with water involving Bell UH-1H helicopter, VH-UVC, 5 km south-west of Anna Bay, New South Wales, on 6 September 2019. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- The pilot continued to fly after last light without the appropriate training and qualifications, and then into dark night conditions that provided no visual references. That significantly reduced the pilot's ability to maintain control of the helicopter, which was not equipped for night flight.
- The pilot likely became spatially disorientated, resulting in a loss of control and collision with water.

Other factors that increased risk

- The pilot did not disclose on-going treatment for significant health issues to the Civil Aviation Safety Authority. That prevented specialist consideration and management of the on-going flight safety risk the medical conditions and prescribed medications posed.

General details

Occurrence details

Date and time:	6 September 2019 – 1813 EST	
Occurrence category:	Accident	
Primary occurrence type:	Collision with water	
Location:	5 km south-west of Anna Bay, New South Wales	
	Latitude: 32°48.995' S	Longitude: 152° 3.228' E

Aircraft details

Manufacturer and model:	Bell Helicopter Company UH-1H	
Registration:	VH-UVC	
Operator:	Brisbane Helicopters PTY LTD	
Serial number:	5144	
Type of operation:	Private flight	
Activity:	Repositioning	
Departure:	Archerfield Airport, Queensland	
Destination:	Bankstown Airport, New South Wales	
Persons on board:	Crew – 1	Passengers – 4
Injuries:	Crew – 1, fatal	Passengers – 4, fatal
Aircraft damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- Aireon
- Airservices Australia
- Bureau of Meteorology
- Civil Aviation Safety Authority
- FlightRadar24
- maintenance organisation for VH-UVC
- medical and air traffic control specialists
- New South Wales police service
- OzRunways
- a number of witnesses

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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:

- medical specialists
- Bureau of Meteorology
- Civil Aviation Safety Authority
- maintenance organisation for VH-UVC
- Williamtown air traffic controllers
- air traffic control specialist.

Submissions were received from:

- Bureau of Meteorology
- a medical specialist

The submissions were reviewed and, where considered appropriate, the text of the 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.