



Australian Government
Australian Transport Safety Bureau

Loss of control involving Eurocopter AS350BA, VH-RDU

93 km N of Rockhampton Airport, Queensland | 8 September 2011



Source: Stephen Bottom

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2011-110
Final – 5 September 2013



Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT

Aviation Occurrence Investigation
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**Loss of control involving
Eurocopter AS350BA, VH-RDU
93 km N of Rockhampton Airport, Queensland
8 September 2011**

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Addendum

Page	Change	Date
4	In the section titled <i>Pilot information</i> , the commercial helicopter pilot licence acronyms were deleted for ease of reading and replaced by the full text.	31 January 2014
7	Last paragraph moved from the section titled <i>Wreckage and impact information</i> and inserted at the end of the section titled <i>Helicopter information</i> . Text expanded to provide more detailed information about the hydraulic pump drive belt changes.	31 January 2014
11	Text changes to the last two paragraphs of the section titled <i>Hydraulic system failure</i> , deleting pilots' information and incorporating specific manufacturer's information.	31 January 2014
12	Relating to the immediately preceding general helicopter discussion to the AS350, additional sentence added to the last paragraph of the section titled <i>AS350BA flight characteristics</i> .	31 January 2014
13	For clarification, in the last sentence of the second paragraph of the section titled <i>Servo transparency</i> , text amended to include a quote from the aircraft flight manual.	31 January 2014
14	Last sentence of the first paragraph in the section titled Weight and balance and helicopter performance, textual change to assist understanding.	31 January 2014
17	Diagram indented to conform to quote indentation and original document caption added. Figure 6 caption deleted and subsequent figure captions renumbered.	31 January 2014

Page	Change	Date
19	For consistency, in the last paragraph of the section titled <i>Pinnacle operations</i> , the commercial helicopter pilot licence acronym was replaced by a more generic text.	31 January 2014
22	Last paragraph of the section titled <i>Wreckage and impact information</i> deleted and information moved to the section titled <i>Helicopter information</i> on p7.	31 January 2014
29	For completeness, additional text added to the second sentence of the second paragraph of the section titled <i>Tasking for the occurrence flight</i> .	31 January 2014
34	For clarity, textual changes made to the last paragraph of the section titled <i>Loss of hydraulic assistance</i> and the paragraph divided into two paragraphs.	31 January 2014
35	Minor textual changes made to the last paragraph of the section titled <i>Environmental and operational factors</i> for additional understanding and a new sub-section added titled <i>Summary of accident development</i> .	31 January 2014

SAFETY SUMMARY

What happened

On 8 September 2011, a chartered Eurocopter AS350BA registered VH-RDU, with a pilot and two passengers on board, collided with terrain on approach to a helicopter landing site (HLS). The HLS was located on a peak of Double Mountain South in the Shoalwater Bay military training area, 93 km north of Rockhampton Airport, Queensland. The pilot and front seat passenger were fatally injured and the rear seat passenger received serious injuries. The helicopter was substantially damaged and there was no fire.

What the ATSB found

The ATSB found that the pilot lost control of the helicopter at low speed or while hovering. The reason for that loss of control could not be positively established.

The investigation was unable to determine whether authorisation of pilot tasking in this case had complied with the operator's procedures. The assignment of the pilot to the task did not directly contribute to the accident. However, had a formalised and documented risk assessment of the task been prepared and considered as part of the authorisation process, as prescribed by the operator's Safety Management System, it is likely there would have been a greater awareness of the suitability or otherwise of the pilot for the tasking.

The physical characteristics of the HLS were not a contributing factor to the accident. However, the HLS was found to be potentially hazardous for a pilot who was unfamiliar with its characteristics and not current with the difficulties likely to be encountered with pinnacle and confined helicopter landing sites.

Safety message

This accident highlights the need for helicopter operators to be aware of the potential safety risks associated with tasking pilots, especially those with little experience on the helicopter type, into an operating environment for which their competency has not been established or regularly checked. While pinnacle and confined area operations are part of the normal competencies of a licenced helicopter pilot, they are degradable skills that should be confirmed current prior to the assignment of flights that may involve such locations.

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Acknowledgements

Figure 1: Airservices Australia
Figure 2: GoogleEarth
Figure 3: Eurocopter
Figure 4: Transportation Safety Board of Canada
Figure 7: Queensland Police
Figure 9 (right): Transportation Safety Board of Canada

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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

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

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

Purpose of safety investigations

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

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

Developing safety action

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

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

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting

part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

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

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

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

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

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

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

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

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

FACTUAL INFORMATION

History of the flight

At 0947 Eastern Standard Time¹ on 8 September 2011, a Eurocopter AS350BA helicopter, registered VH-RDU, departed from an airfield in the Shoalwater Bay military training area, Queensland (Qld) with a pilot and two passengers on board. The aircraft was under charter from a Cairns operator and was being flown under the Visual Flight Rules to assist in helicopter landing site (HLS) maintenance in the area. Initially the crew flew to an HLS associated with a communication tower in the eastern sector of the training area. The tower was on a low hill at an elevation about 700 ft. After an hour of maintenance work at that HLS, they departed for another HLS that was located on the western peak of Double Mountain South at an elevation of about 2,421 ft (Figure 1).

Figure 1: Locality map



Source: Airlines Australia - World Aeronautical Chart

¹ Eastern Standard Time (EST) was Coordinated Universal Time (UTC) + 10 hours.

At about 1140, while the helicopter was nearing the hover at the HLS, it started to rotate left. The pilot was unable to control the rotation and the helicopter descended into the trees before colliding in an inverted attitude with the ground.

The pilot and front seat passenger were fatally injured and the rear seat passenger received serious injuries. The helicopter was substantially damaged. There was no fire.

Surviving passenger's recall of events

The flight was part of a series in the Shoalwater bay training area over a number of days. These flights carried the same crew members as involved in the accident.

The surviving passenger, who occupied the rear left seat in the accident, reported that on the previous day low cloud prevented the crew from flying to the more elevated HLSs in the training area and instead they inspected the lower HLSs in the eastern sector of the area. On the day of the accident they flew to one of the HLS that was inspected the previous day before flying to Double Mountain South. He recalled that the Double Mountain South HLS was the most difficult site where they had attempted to land.

The passenger reported that the pilot made four passes of the helipad during which the pilot commented about the HLS being 'particularly tight' and expressed concern about a tree that he thought was within the proposed landing area. The passenger recalled experiencing some turbulence during those passes, which in his experience was usual for a mountain top HLS. The passenger stated that the pilot approached the HLS from the south-west, after having slowly circled the HLS twice in a clockwise direction at slow speed. At an estimated distance of 'about 80 ft' from the HLS, the helicopter commenced a climb, and turned left in what the passenger believed was a controlled manoeuvre by the pilot.

The passenger stated that the helicopter then went from a controlled climb to a rapid climb, as if it encountered an updraft, and started to rotate to the left, completing two full rotations. He did not recall hearing any change in engine or rotor noise, nor did he recall hearing any warning horn. The helicopter's nose then dropped in what the passenger thought may have been an attempt by the pilot to regain control. The helicopter then began to 'oscillate', a manoeuvre that the passenger described as a steep nose-down attitude, and yawing² from side to side.

The helicopter struck the tree canopy and collided with the ground, upside down.

Global Navigation Satellite System data

A portable Garmin GPSMap495, Global Navigation Satellite System receiver, belonging to the pilot, was found in the wreckage. Its data was downloaded and found to contain the activities, including tracking and altitude information, for flights over the previous 4 days.

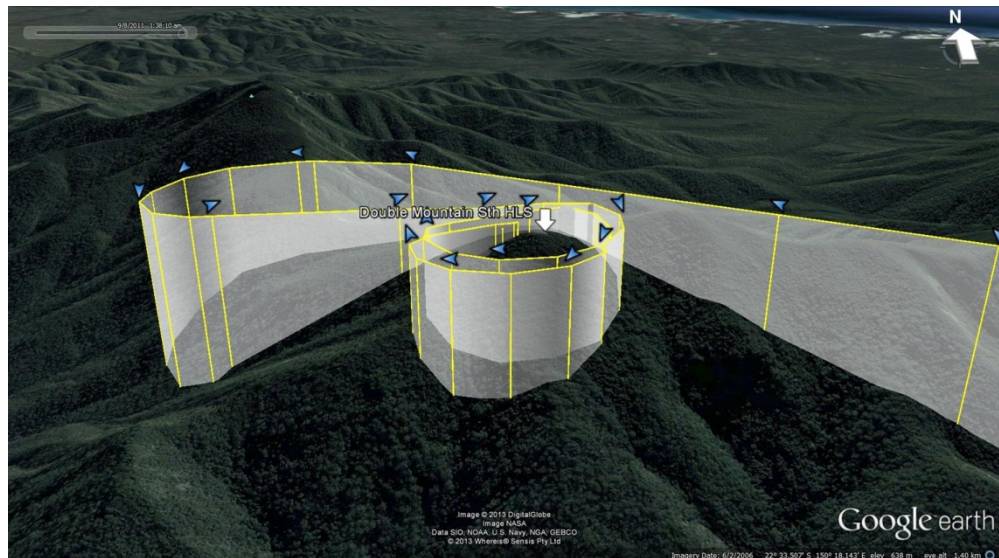
² Term used to describe motion of an aircraft about its vertical or normal axis.

A brief synopsis of the recorded activities on those days follows:

- 5 September 2011: The coordinates of the waypoints to be used in the Shoalwater Bay training area task were entered into the GPS receiver.
- 6 September 2011: The helicopter departed from Cairns International Airport at 1259 and flew to the crew's motel accommodation at Yeppoon via stops at Townsville and Mackay. The helicopter arrived at Yeppoon at 1738.
- 7 September 2011: The helicopter departed from the motel at Yeppoon and flew to an airfield in the Shoalwater Bay training area, 45 km north of Yeppoon. It departed the airfield at 0939 and flew to two other HLS in the Shoalwater Bay training area (elevations of 1,300 and 700 ft) before returning to the airfield at 1654. The GPS recorded a total of 1.8 hours of flight that day.
- 8 September 2011: The helicopter departed the airfield at 0947 and flew to another HLS about 19 km to north-east, arriving at 1004.

At 1117, the helicopter departed for Double Mountain South HLS, about 60 km to the north-west, arriving overhead the HLS at 1135. It passed just to the north of the HLS, tracking north-west before turning left to track back to the landing site (Figure 2).

Figure 2: Helicopter's GPS tracks around the Double Mountain South HLS



Source: ATSB using Google Earth topographic information

The GPS data indicated that the helicopter passed north abeam the HLS on an easterly track, with a groundspeed of 34 kt and at an altitude of about 2,500 ft, about 100 ft above the HLS. It then climbed away and commenced a right circling approach back towards the HLS. On a north-easterly track towards the HLS, the helicopter slowed to a groundspeed of 33 kt and descended to about 2,510 ft, before it climbed away for a second circling approach back towards the HLS.

At 1138, the helicopter approached overhead the HLS on a north-easterly track, slowing to 31 kt groundspeed and descending to about 2,450 ft. Another five track points were recorded. The first two track points indicated that the helicopter maintained a north-easterly track, as its groundspeed reduced to 4 kt and it descended to an altitude of about 2,420 ft. The next two track points indicated a westerly and south-westerly track respectively, as its groundspeed increased to

21 kt and it descended to an altitude of about 2,400 ft.³ The last track point recorded indicated a west-south-westerly track and groundspeed reducing to 9 kt at an altitude of about 2,360 ft.

Pilot information

Qualifications and experience

The pilot held a Commercial Pilot (Helicopter) Licence, a helicopter class endorsement on the AS350, and a valid Class 1 Aviation Medical Certificate. The pilot commenced helicopter training in 2002, and had a total helicopter experience of 957 hours, including 32.8 hours in the AS350. The pilot's logbook showed that he had satisfactorily completed a helicopter flight review on 25 September 2009 in a Bell Helicopter Company (Bell) 206 JetRanger.

Since gaining a commercial helicopter licence, the pilot had worked as a casual pilot for the operator. The majority of the pilot's flying experience was in Robinson Helicopter Company R22 and R44 helicopters. That experience was gained mostly in private flying although, subsequent to commencing work with the operator, included tourist flights around the Cairns area and flights out to the Great Barrier Reef.

Training and checking

On 3 October 2007, the pilot was endorsed to fly Bell 206 JetRanger and LongRanger helicopters and later that month he completed 4.6 hours training, including sling and long-line work in the AS350 for his type and sling load endorsements. The operator's pilot training record did not contain any documentation relating to that endorsement training and the extent of his hydraulic failure training was not known. The next time the pilot flew an AS350 was in September 2010 when, under instruction, he flew from Cairns to Brisbane and return; about 18 hours of cross-country flight.

In March 2011, the pilot accepted an opportunity to ferry a Bell 206 LongRanger from Cairns to Mount Hagen, Papua New Guinea (PNG) and to provide logistical air support for construction company personnel in that country. The pilot had no previous experience of flying in PNG and, in preparation for the flying, undertook some training in the Cairns area. To familiarize the pilot with conditions in PNG, a PNG national pilot with extensive military and commercial flying experience in both aeroplanes and helicopters in PNG, accompanied him on the ferry flight.

The PNG national reported that prior to departing Cairns for PNG, he flew with the pilot and recalled that the pilot had practised approaches to pinnacles and ridge lines during those flights (but not actually landed) as preparation for the PNG flying. Although not assigned as a Training and Check pilot on these flights, the PNG national found that the pilot 'handled the aircraft without problems'.

A training record sheet in the operator's pilot training file showed that on 13 March 2011 the pilot completed a check flight with an instructor. The instructor recorded on the operator's training record form that the pilot had flown an approach

³ The GPS altitude can be different to the barometric altitude and the elevation.

to pinnacle HLS and demonstrated the technique for crossing ridgelines during the flight. That was the only recorded assessment of the pilot's competency for pinnacle approaches, which was recorded as being 'satisfactory'. The pilot had a total flying time of 794 hours and about 35 hours on Bell 206 JetRanger and LongRanger helicopters when he departed for PNG.

After arrival in PNG, the PNG national spent the next 7 days accompanying the pilot on his initial flights to familiarise him with the routes and flying conditions in and around Mount Hagen. That flying included operations from a helipad at Ambua Lodge HLS, where the elevation was about 7,000 ft. Ambua Lodge was a one-way HLS with only one approach/departure direction. The PNG national recalled specifically warning the pilot that the weather conditions most afternoons at Ambua resulted in tailwinds on approach. He advised the pilot that when landing under those conditions there was no margin for any hesitancy or indecision.

After completing the series of flights with the pilot, the PNG national assessed that the pilot lacked the flying experience necessary for the demands and judgement required for high altitude helicopter operations in PNG, and advised the helicopter operator to find a replacement pilot with PNG flying experience as soon as possible. He reported that the flying carried out with the pilot, which appeared in the pilot's log book as in-command time, was not dual training.

On 28 March 2011, the pilot was involved in an accident while approaching to land at Ambua Lodge HLS. The pilot and three passengers were uninjured but the helicopter was substantially damaged. The PNG national was familiar with the circumstances of the accident and described the event as being consistent with a loss of tail rotor effectiveness while approaching to land at slow speed, high power and with a tailwind.

On 29 May 2011, following his return to Australia, the pilot satisfactorily completed a flight check in a Bell 206 with the operator's then chief pilot, before recommencing flying duties. The former chief pilot reported that the check flight included normal and emergency procedures associated with the pilot's usual tourist flying duties. It did not include any confined area take-offs and landings or mountain flying.

Recent history

In the 12 months before being rostered to fly to Shoalwater Bay, the pilot flew the AS350BA twice, and had expressed a preference to flying the operator's other helicopters with which he was more familiar. On 18 August 2011, the pilot completed a check flight in the AS350BA with the operator's lead helicopter pilot (see *Company structure and fleet* section of this report). The lead pilot reported that the reason for that check flight in the AS350BA was to regain the pilot's currency on that helicopter type so that he would be available for scenic flights around Cairns and the Great Barrier Reef. The pilot recorded the flight as an in command under supervision (ICUS) flight of 0.9 hour. The flight standards form completed by the lead pilot indicated that the flight was of 1.7 hours duration and showed that the pilot satisfactorily demonstrated confined area and emergency procedures. This included a simulated loss of hydraulic flight control assistance.

The lead pilot described the confined area used for the check as a nearby HLS with surrounding buildings and fences and an aluminium decking. He reported that although this check was satisfactory, it did not constitute an authorisation for the

pilot to operate from confined areas like the HLSs in the Shoalwater Bay training area. He also indicated that the simulated loss of hydraulic flight control assistance was made according to the manufacturer's procedure in the aircraft flight manual (AFM), but did not include a landing due to the potential for damage, especially with a pilot lacking experience on the AS350BA.

The lead pilot reported that the pilot had used checklists for all his pre-flight checks and did not mute the in-cockpit warning horn during the check of the hydraulic system as the activation of the horn in the case of reduced hydraulic pressure was part of the system check (see the *Hydraulic flight control system* section of this report). The lead pilot thought that, if instead a pilot had muted the warning horn during those system checks, it was unlikely such a pilot would allow a warning horn to remain muted, as there was a caution lamp on the warning-caution-advisory panel to indicate that the horn was muted.

In the 2 days preceding the accident, the pilot flew 5.9 hours in the helicopter from Cairns to Yeppoon, Qld, in preparation for the landing site maintenance task in the Shoalwater Bay training area. This task commenced on the day prior to the accident, and was the pilot's first task in the training area, exposing him to two of the associated HLSs for the first time. The pilot recorded 1.8 hours flying that day with the same passengers as involved in the accident. He was on duty for a total of about 8.5 hours.

The occurrence flight was the pilot's first to the HLS at Double Mountain South.

The pilot was described as fit and healthy and not experiencing any problems with his work or home life. The surviving passenger reported that the pilot dined with him and the other passenger the previous evening and that they retired to their respective accommodation by 2130. The pilot was reported to be well rested and to have performed his duties on the day of the accident in the normal manner.

Helicopter information

The helicopter, serial number 2495, was a six seat, single-engine helicopter that was manufactured in France in 1991. In 1992, it was converted to an AS350BA⁴. In August 2003 it was placed on the Australian register.

In August 2007, the helicopter's Turbomeca model Arriel turbine engine was replaced by a Honeywell model LTS101 600 A3A turbine engine. That modification was carried out in accordance with Soloy Aviation Solutions kit supplementary type certificate number SR00805SE and LTS 101 conversion kit AS350SD1.

In June 2009, after a hard landing and tail rotor strike, the helicopter's tail rotor blades, control rods and drive system components were replaced. Additionally, damaged components of the skid-type landing gear were replaced. The main rotor blades were removed, inspected, repaired and reinstalled and an engine inspection carried out.

At the time of the accident, the helicopter had a total time in service (TTIS) of 19,679.2 hours. The maintenance release was valid until 20 July 2012 or until

⁴ The modification incorporated the fitting of wider chord main and tail rotor blades that were common to the twin-engine AS355 helicopter and a number of other changes.

19,745.3 hours TTIS. It showed that the last scheduled maintenance was a 25-hourly inspection carried out on 22 August 2011. There were no recorded defects at that time.

The helicopter was refuelled the previous day from new drum stock and had flown 2.4 hours since that time.

The helicopter was fitted with an original design flat, coated-fabric hydraulic pump drive belt that had a service life limit of 600 hours. The hydraulic pump drive belt and an adjacent compressor drive belt were not found at the accident site or during the subsequent wreckage examination. Although the belts were most likely liberated during the impact sequence due to displacement of the drive pulleys, the alternative possibility of an in-flight failure of the hydraulic pump drive belt could not be eliminated.

Examination of the helicopter's maintenance documentation showed that replacement hydraulic pump drive belts were generally installed in the helicopter coincident with major maintenance in the engine and drive shaft area. During such maintenance, the pulleys were more readily accessible. This provided for considerable savings in time and labour and increased helicopter availability, rather than separately disassembling and reassembling the surrounding structures and drive mechanism again at the scheduled time of the belt change.

Since February 2008, successive hydraulic drive belts were changed by the operator after the following periods in service:

- 391.9 hours, coincident with the replacement of the adjacent air conditioning belt
- 366.3 hours, when the still-serviceable belt was affixed to the airframe near the pulley as a spare (permitting a more efficient in-field belt change if and when required)
- most recently, at 596.4 hours. This belt was replaced by the belt that was installed in the helicopter at the time of the accident.

At the time of the accident the fitted drive belt, which was manufactured in October 2008, had been in service for 405.5 hours.

Hydraulic flight control system⁵

System description

The flight controls in the AS350BA are assisted by a single hydraulic system that reduces pilot workload during flight by absorbing the flight control loads resulting mainly from aerodynamic forces. This allows the pilot to fly the helicopter with greater precision and reduced effort. In the event of a loss of hydraulic pressure, the flight control loads revert to the unpowered condition. Following a loss of hydraulic

⁵ The descriptions of the hydraulic flight control system and warning system sections of this report were extracted from Transportation Safety Board of Canada AVIATION INVESTIGATION REPORT A05F0025 and reproduced with changes to make the references applicable to the AS350BA. The original report can be viewed at <http://www.tsb.gc.ca/eng/rappports-reports/aviation/2005/a05f0025/a05f0025.pdf>

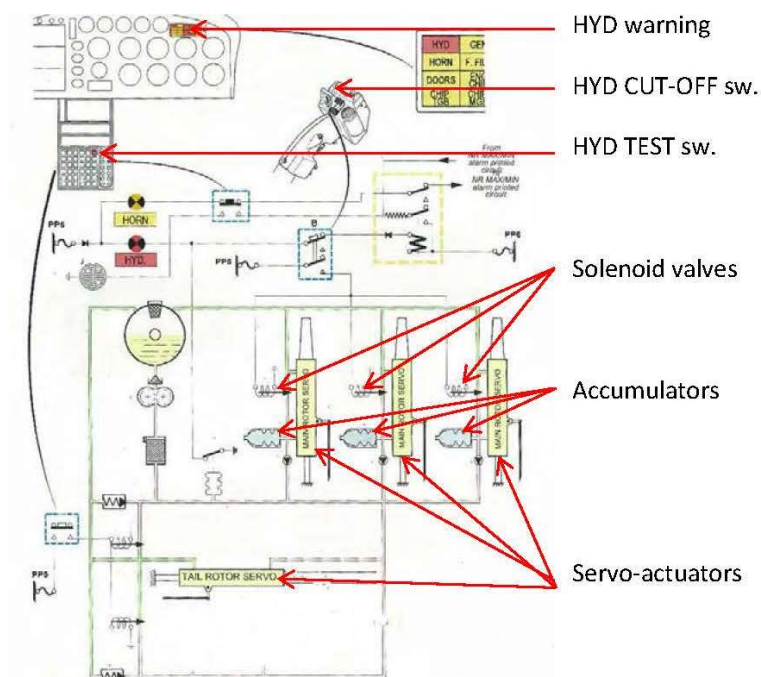
pressure, the tail and main rotor flight controls exhibit force feedback, described in the aircraft flight manual (AFM) for the AS350BA as:

- left and forward cyclic
- collective lever, zero force if the collective is at a neutral point but high if a different collective position is required (for example, the collective lever will need to be raised if it was previously in a low power situation, requiring force to move the lever up).

Following a loss of hydraulic pressure, the AFM advises pilots to ‘LAND AS SOON AS POSSIBLE’.

The hydraulic flight control system consists of an engine-driven pump (via a flexible drive belt from the engine-to-main rotor gearbox power drive shaft), filter, hydraulic fluid reservoir, and three main rotor and one tail rotor hydraulic servo actuators with associated electrically operated warning and emergency systems (Figure 3). Hydraulic accumulators are fitted to each of the three main rotor servo actuators. There is no accumulator on the tail rotor servo actuator.

Figure 3: AS350BA hydraulic system diagram



Source: Eurocopter AS350BA AFM

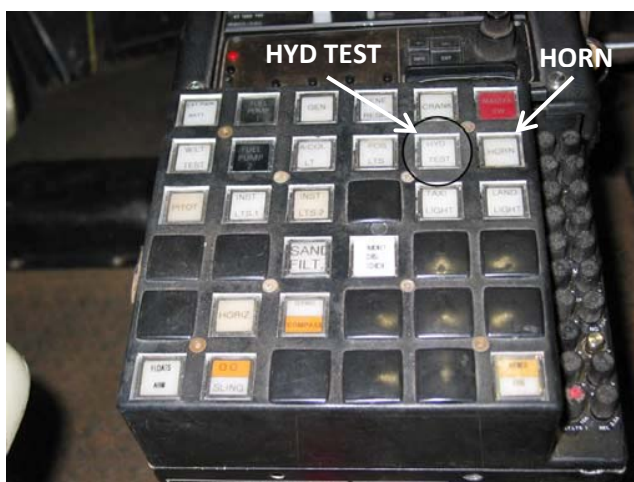
Each accumulator provides its actuator with a small reserve of pressurized hydraulic fluid so that, in the event of loss of system hydraulic pressure, the pilot can establish the helicopter in a safe speed range, where the feedback forces without hydraulic assistance are controllable. The solenoid valves (also called electro-valves) are electrically actuated devices that, when selected by the pilot relieve the hydraulic pressure in the main rotor servos simultaneously.

Given that there is no accumulator associated with the tail rotor servo actuator, the pilot will, following a hydraulic failure, need to apply additional force to that normally expected to move the tail rotor pedals.

Hydraulic system control and monitoring

The hydraulic system is controlled by the pilot using two switches: the hydraulic cut-off (HYD CUT OFF) switch mounted on the collective lever and the hydraulic test (HYD TEST) switch mounted in the centre console switch panel (Figure 4). The HYD CUT OFF switch is a guarded toggle switch with two positions: ON or OFF. The guard protects the switch from unintentional OFF selection that could lead to potential control problems.

Figure 4: Hydraulic test (HYD TEST) and horn mute (HORN) switches on the centre console switch panel



Source: Transportation Safety Board of Canada

The HYD CUT OFF switch is normally set to the ON (forward) position, allowing the servos to be powered when the hydraulic system is functioning correctly. When the pilot selects the HYD CUT OFF switch to the OFF (rear) position, the three main rotor servos are simultaneously depressurized by opening each servo's electrically operated valve (electro-valve): 'dumping' the hydraulic pressure in the respective servo actuators and immediately reconfiguring the helicopter controls from the hydraulically boosted mode to full manual flight control. Selecting the HYD CUT OFF switch to OFF also inhibits the low hydraulic pressure warning function of the warning horn.⁶

If the HYD CUT OFF switch is not used in accordance with the approved procedure in the case of loss of hydraulic pressure, it is possible for the accumulators to deplete asymmetrically. This would result in an imbalance of flight loads experienced by the pilot and the possibility of a loss of controlled flight.

The AFM requires the accumulators to be tested during each pre-flight check by the pilot by selecting the HYD TEST switch to TEST. The cyclic stick is then moved to verify that the accumulators are providing assistance and that the pedal forces are not hydraulically assisted during test.

⁶ The dual function warning horn also alerts the pilot in the case of low rotor RPM.

The HYD TEST switch is an illuminated, pushbutton switch mounted in the centre console switch panel (Figure 4), with two positions: TEST or OFF. Pushing the switch down to TEST opens the solenoid valve on the regulator unit, depressurizing the hydraulic system. The drop in hydraulic system pressure illuminates the red HYD warning lamp on the warning-caution-advisory panel and activates the hydraulic pressure warning function of the dual function warning horn.

When selected, a horn mute switch (HORN) on the centre console switch panel (Figure 4) silences the horn and illuminates the amber HORN caution lamp on the upper left corner of the warning-caution-advisory panel. This informs the pilot of the position of the horn mute switch. In this respect, if the mute switch is inadvertently left engaged during flight, and a loss of hydraulic pressure occurs, the horn would not sound. Despite this lack of an aural alert, the pilot would be alerted to the loss of hydraulic pressure by the red HYD warning lamp and the increased tail rotor pedal forces.

Hydraulic system failure

A reduction in hydraulic pressure below 30 bar⁷ (435 psi) activates a continuous aural warning from a klaxon horn located in the helicopter's cabin. The horn also produces a continuous warning when the main rotor speed reduces below 360 RPM. The normal operating main rotor speed in stabilised flight is 390 RPM.

In response to the activation of the warning horn, Section 3.3, *Warning-Caution-Advisory Panel and Aural Warning*, Subsection 1 *alarm procedure (HORN sounds continuously)* of the AFM, instructs pilots to reduce collective pitch and to reduce speed and to straighten the helicopter if in a turn.

If a red HYD light illuminated on the warning-caution-advisory panel (Figure 4), the pilot is required to complete the following prescribed actions as stated in Subsection 2.1, *Red Lights* of the AFM:

Keep aircraft to a more or less level attitude. Avoid abrupt manoeuvres.

CAUTION: DO NOT ATTEMPT TO CARRY OUT HOVER FLIGHT OR ANY LOW SPEED MANEUVER. THE INTENSITY AND DIRECTION OF THE CONTROL FEEDBACK FORCES WILL CHANGE RAPIDLY. THIS WILL RESULT IN EXCESSIVE PILOT WORKLOAD, POOR AIRCRAFT CONTROL, AND POSSIBLE LOSS OF CONTROL.

NOTE 1: Pressure in accumulators allows enough time to secure the flight and to establish the safety speed.

NOTE 2: Do not silence the horn by using the HORN switch. The HORN will be silenced when the pilot selects the hydraulic cut-off switch to OFF.

⁷ A bar is a metric measurement unit of pressure that equates to 1,000 hPa or 100,000 N/m².

If the helicopter sustains a hydraulics failure while hovering in-ground-effect,⁸ the AFM advises the pilot to land normally, and if hovering out-of ground-effect (OGE)⁹ to:

- In flight: Smoothly.
- Cyclic/collectiveSet IAS within 40 to 60 kt (hydraulic failure safety speed)
- Collective HYD switch OFF

LAND AS SOON AS POSSIBLE

Note: Speed may be increased as necessary but controls loads will increase with speed.

- Approach and landing:
- Over a clear and flat area, make a flat final approach, nose into wind.
- Perform a no-hover/slow run-on landing around 10 knots.
- Do not hover or taxi without hydraulic pressure assistance.

The accumulator charge generally allows the pilot sufficient time to reduce the airspeed to a value at which the manual control forces associated with a loss of hydraulic assistance are more manageable (that is, a safety speed in the range of 40 to 60 kt). Alternately, the pilot is able to accelerate to the safety speed from an OGE hover before choosing a landing area suitable for a running landing.

The manufacturer advised that flight tests for certification of the AS350-series helicopter showed that the control forces following a loss of hydraulic assistance complied with all certification standards. The direction and magnitude of the control forces in the case of a failure were:

- Collective – zero at +7° main rotor blade pitch, equivalent to 50-60 kt in level flight. Any variation from that speed required the application of more collective force but less than the equivalent of 16 kg.
- Cyclic – required left and rearward pilot input below 10 kt and left and forward input above 10 kt. The certification flight testing showed that these forces did not exceed the equivalent of 5 kg in the longitudinal direction and 13 kg in the lateral direction.
- Anti-torque pedals – due to the absence of hydraulic accumulators, control forces would be instantly felt in the pedals. The magnitude of the pedal forces was dependent on the airspeed and engine power setting (torque). From a hover OGE, at the maximum power setting, the required pedal application was just over half of the available right pedal travel and was equivalent to a force of about 37 kg.

⁸ Helicopters require less power to hover in ground effect (IGE) due to a cushioning effect created by the main rotor downwash striking the ground. The performance benefit of being IGE is generally defined as having effect when the helicopter is one main rotor diameter or less above the surface.

⁹ When hovering OGE, the beneficial effect of the cushioning effect in an IGE hover is negated. The height of an OGE hover is usually defined as more than one main rotor diameter above the surface.

The available information about the occurrence helicopter's speed and weight, and the prevailing atmospheric conditions at the time of the accident were provided to the manufacturer. Given this information, the helicopter manufacturer determined that a loss of hydraulic pressure as the helicopter slowed to the hover at the landing site would have required the application of an equivalent of 25 kg of right anti-torque pedal force to prevent the helicopter yawing left.

AS350BA flight characteristics

The main rotor of the AS350BA rotates clockwise (as viewed from above), which is opposite to that of the Bell and Robinson helicopter types with which the pilot was most familiar. Significantly, that resulted in a reversal of the yaw axis control required by the pilot when flying the AS350BA as compared to that experienced in the other helicopters.

The correct use of the tail rotor pedals was the subject of two manufacturer's service letters, one in the case of a clockwise rotating main rotor and the second in the case of an anticlockwise rotating main rotor (refer to appendix A for the complete text of *Lettre-Service 1673-67-04* for helicopters whose main rotor turned clockwise and *Lettre-Service 1692-67-04* for helicopters whose main rotor turned anticlockwise). The letters reminded pilots of the differing yaw axis control in helicopters incorporating clockwise and anticlockwise rotating main rotor blades in a number of flight conditions.

In the case of the AS350-series helicopter, the initiation of a climb by raising the collective would increase the main rotor torque and therefore torque reaction, resulting in the helicopter yawing to the left unless the pilot applied right anti-torque pedal.

Unanticipated yaw

The manufacturer's service letter 1673-67-04 described the conditions conducive to a number of yaw control problems experienced in helicopters with main rotors rotating clockwise, like the AS350BA. These problems were identified as a result of investigations into a number of incidents and accidents. The following observation from that service letter is of potential relevance to this accident:

From hover flight at take-off at very low speed, the Pilot initiates a left turn a few meters above the ground by applying yaw pedals towards the neutral position: the aircraft starts its rotation which increases until the Pilot attempts to stop it by applying the RH yaw pedal.

In the various cases which resulted in the loss of yaw axis control, the action applied to the RH yaw pedal was not enough (amplitude/duration) to stop rotation as quickly as the Pilot wished.

As the aircraft continues its rotation, the Pilot generally suspects a (total or partial) tail rotor failure and decides either to climb to gain speed or to get closer to the ground.

In the first case, increasing the collective pitch results in increasing the main rotor torque and consequently further speeds up leftward rotation. This results in the loss of aircraft control.

The service letter advised pilots encountering this situation to:

... immediate action of significant amplitude applied to the RH yaw [tail rotor] pedal must be initiated and maintained to stop leftward rotation. Never hesitate to go up to the RH stop.

Any delay when applying this correction will result in an increase in rotational speed.

Whether the pilot had seen the service letter or was aware of its contents could not be established. However, the operator's operations manual provided generic guidance to pilots experiencing unanticipated yaw in flight as follows:

Unanticipated Yaw will usually occur in slow or hovering flight and again usually in tail wind or rear quarter tail wind conditions. If sudden unanticipated yaw occurs the recommended recovery technique is:

- apply full opposite pedal,
- apply forward cyclic to gain airspeed if possible reduce collective to unload the effort required at the tail rotor and to ensure that it is operating in a cleaner airflow,
- if altitude permits, reduce power.

If operations require flight at or near the hover the pilot should plan an escape route, preferably into wind to account for unexpected yaw.

Servo transparency

The AS350BA AFM described a characteristic of hydraulically assisted flight controls, known as 'servo transparency'. Servo transparency begins when the aerodynamic forces exceed the hydraulic forces and is then transmitted back to the pilot's cyclic and collective controls. This phenomenon occurs smoothly, and can be managed properly if the pilot anticipates it during an abrupt or high load manoeuvre such as a high positive g-turn or pull-up.

The factors that affect servo transparency are high airspeed, high collective pitch, high gross-weight, high 'g' loads and high-density altitude. On clockwise turning main rotor systems, the right servo receives the highest load when manoeuvring, so servo transparency results in 'an uncommanded right cyclic force and an associated down collective reaction.'

The pilot control force required to counter this aerodynamically induced phenomenon is relatively high and could give a pilot, unaware of the phenomenon, the impression that the controls are jammed. If the pilot does not reduce the manoeuvre, the aircraft will roll right and pitch-up. The amplitude of the induced control feedback loads is proportional to the severity of the manoeuvre. The phenomenon normally lasts less than 2 seconds

However, as the helicopter was not being flown in this manner and its movements immediately preceding the accident were not consistent with those resulting from the onset of servo transparency, it was not considered likely to have contributed to the accident sequence.

Weight and balance and helicopter performance

The weight of the helicopter at the time of the accident could not be accurately determined. However, using information provided by the passenger, including the estimated weights of the occupants, equipment and the remaining fuel, the helicopter's weight was estimated to be about 200 kg below its maximum weight and its centre of gravity was within limits.

Using the estimated weights and the likely atmospheric conditions at time of the occurrence, the helicopter was capable of hovering OGE.

Meteorological information

The passenger reported that the weather at the time was fine. He recalled some turbulence as the helicopter approached the HLS and that the vanes on the wind turbines at the site were spinning in the wind but he was unsure of the wind direction.

Recorded data from the Bureau of Meteorology (BoM) weather station at the airfield from which the helicopter departed that morning showed a moderate east to east-south-easterly wind of up to 15 kt. That airfield was located on the coastal plain 25 km east of Double Mountain,

An aerological diagram, derived by BoM from data obtained by a weather balloon from Rockhampton Airport, Qld at 0900 that morning, showed that the wind at 2,500 ft in the vicinity of Rockhampton was 15 kt from the east-north-east and that the temperature at that altitude was 16 °C.

The wind information from the two BoM sources was consistent with the tendency of wind in coastal areas to increase in strength and back¹⁰ in direction with increasing altitude. Recorded GPS data showed that the pilot took off toward the south-east on the two previous take-offs that morning at the lower elevation HLSs, consistent with taking off into wind. It was most likely that the approaches to the Double Mountain South HLS were also made into wind, in a north-easterly direction.

Communications

The range officer for the Shoalwater Bay military training area reported that communication between the helicopter crew and the range office, was required while operating in the training area. Frequency modulated very high frequency (VHF FM) handheld radios were issued to the crew for that purpose. Radio communications in the area were not recorded, nor were they required to be.

¹⁰ Change in direction of prevailing wind in an anticlockwise direction when viewed from above.

Helicopter landing site information

Double Mountain South HLS

The Double Mountain South HLS is situated atop the south-eastern peak of Double Mountain in Department of Defence (DoD) controlled land. It is located at an elevation of 2,421 ft and was surrounded by trees on three sides and a mast and antenna array on the other (Figure 5). A number of trees impinged the approaches to the HLS and the sloped landing surface was uneven and covered by long grass with numerous tree stumps and rocks that protruded above ground level.

Figure 5: View of the Double Mountain South HLS, looking south-east



Source: ATSB

Civil Aviation Advisory Publication (CAAP) 92-2 (1) *Guidelines for the establishment and use of helicopter landing sites* provided guidance for the establishment of a basic HLS, like Double Mountain South, which are only used for day VFR operations, but did not prescribe minimum HLS dimensions. The CAAP did provide suggested dimensions for an HLS that is intended to be used for both day and night VFR operation. The Double Mountain South HLS did not conform to those dimensions, nor was it required to.

The HLS was established to enable access to radio communication equipment associated with the military training area. Helicopters were the only means by which maintenance crews could access that equipment, as there were no roads or tracks to the site.

The passenger reported that he and the other passenger had intended to carry out maintenance of the HLS. That entailed spraying herbicide and clearing vegetation from around the helipad as they had done at previous sites. He stated that, although there were environmental concerns about clearing vegetation, they took guidance from the pilots as to the extent of the clearing necessary to ensure safe approaches and departures from each HLS. The clearing of vegetation occurred annually as no permanent herbicides were used in support of that task.

The contracted organisation which had chartered the helicopter for the planned maintenance work used a work schedule that was designed to meet the published criteria for safe helicopter operation in a DoD document. This document, the *Shoalwater Bay Training Area Safety and Control Systems -Remote Site Vegetation Management Plan* stated that:

All the sites at Shoal Water Bay Training Area (SWBTA) are located on mountain/hilltops where wind updraught poses a flight safety issue; further, many of the landing pads are small and tight in size. Therefore, it is important that vegetation on the landing pad is cleared and in some cases the landing approach and take-off path be cleared of obstructions; especially where there is a risk of a main rotor or tail rotor blade striking vegetation.

In determining the vegetation clearance requirements for the helicopter landing pads, interviews were conducted with helicopter operators, flight instructors and Civil Aviation Safety Authority Australia (CASA) regulations were reviewed; in particular:

- a. CASA CAAP 92-2 (1) – Guidelines for the establishment and use of helicopter landing sites (HLS);
- b. Australian Defence Force Publication 602^[11], Part 3, Chap 4 –Helipad Obstruction Clearance Surfaces; and
- c. Convention on International Civil Aviation (ICAO) - International Standards and Recommended Practices, Annex 14, Vol II, Chap 1 to 4; Aerodromes^[12].

Using the guidelines above and after talking with pilots and flight instructors that have landed at the SWBTA landing pads on several occasions; we have determined that the minimum clearance for a Final Approach and Take-Off Area (FATO) and the pad is to be 13 metres in diameter.^[13] It is recognised that at a few sites this is not possible because the landing pad is on a peak that does not have that area (13 m) available.

For vegetation clearance purposes, we have divided the FATO into an inner and outer zone. Figure 9 [not reproduced in this report] shows the FATO dimensions and vegetation clearance minimum heights. The heights ensure that no damage is sustained to the underside of the aircraft, or pose a threat to a tail rotor blade strike.

In addition, the document included a description and diagram of the Double Mountain South HLS as follows:

The Double Mountain sites are part of the Normanby Range on the southern border of the Huttonvale Sector with Rowes Lagoon Sector The hills are high with steep sides and covered in thick medium to tall Eucalypt trees and minor low scrub. The surface is firm and consists of Metamorphic sub crop and strewn with rubble and small boulders. The ... [Double Mountain North] was a disturbed site prior to ... [VHF radio communication network] installation, consisting of a QLD Police Communications site and helicopter landing pad.

¹¹ Superseded by the Defence Aerodrome Design Manual.

¹² Reference is to ICAO Annex 14 Aerodromes, Volume II Heliports- Chapters 1-4

¹³ Most likely selected using the dimensions of a Bell 206 helicopter that appeared in the associated diagrams in the document.

The Double Mountain sites consist of two separate communication sites within 1 Nautical Mile (Nm) of each other. Each location has its own landing pad. The vegetation at both Double Mountain sites requires some slashing with the brush cutter before treatment. Dominant vegetation species identified within the treatment areas include Rats Tail Grass, Parramatta Grass and Grass Trees. Trees surrounding the two sites may require coppicing to ensure maximum solar collection...

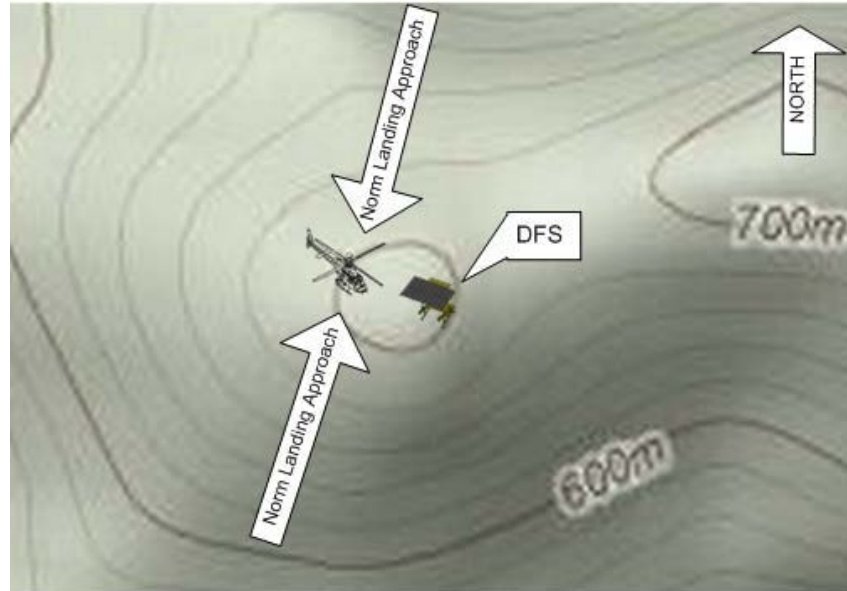


Figure 20 – Double Mountain DFS site

The contour map [Figure 20 in the original document] shows the normal landing and takeoff direction. For a helicopter, the most dangerous portion of the flights to/from the remote sites is during landing and take-off; it is during this period that the main and tail rotor is at risk of striking flora.

Double Mountain South site footprint is 15m x 22m and the Helicopter Landing Pad is 16m diameter.

Based on the CASA guidelines, Figure 11 [Note: diagram from the CAAP not shown in this report] shows the transitional, inner horizontal and conical obstacle limitation surfaces.^[14] It is vital that any obstacle that could hinder a safe landing or take-off is either removed or trimmed to a safe level. Vegetation clearance personnel are to consult with the pilot at the time of conduct of vegetation clearance to gain advice on which trees/shrubs or other flora, present a hazard.

A copy of the document was provided to the helicopter operator at the time arrangements were made for the charter. Additionally, the passenger reported that a copy of the document was available during the briefing with the pilot the previous night. The helicopter operator described operations into the HLS as not being the most difficult of those in the Shoalwater Bay military training area but, as with most of them, ongoing clearing of the surrounding vegetation improved helicopter access. The helicopter operator reported that generally the HLS could be affected by wind 'funneling' up the slope creating turbulence, but that generally a steady wind assisted helicopter operations at the site.

¹⁴ Not relevant for an HLS like Double Mountain South.

Safety audit of Shoalwater Bay training area HLSs

Following the accident, a safety audit of all HLSs in the Shoalwater Bay training area was commissioned by the contractor who had chartered the helicopter. This audit was undertaken in November 2011 by experienced aviation safety auditors and a report was provided to the DoD and the contracted organisation responsible for maintaining the HLSs the following month. That audit reported on the condition of the HLSs, made recommendations relating to the physical improvement of those sites and suggested operational requirements to reduce the risks associated with their use.

The audit report stated that operations into the existing HLS sites were considered to be very hazardous and that they be considered as high risk, confined area operations. It found that the Shoalwater Bay training area HLSs, including the one at Double Mountain South, did not conform to the recommended specifications in CAAP 92-2(1) and identified a number of hazards specific to that site, including:

- the presence of vegetation that restricted the obstacle clearance required to allow for normal approach and take-off gradients
- sloping and irregular helipad surfaces, with rocks and tree stumps creating a risk of 'dynamic rollover'
- the size of the helipads was inadequate
- there were no reliable wind indicators (the wind turbines did not provide an accurate indication)
- the proximity of unmarked guy wires.

The report made a number of recommendations to address those hazards, including the construction of elevated platforms as a means of providing a safe landing area. It also recommended that clearly defined operational restrictions should be imposed. For example, where it was not possible to implement the CAAP 92-2(1) minimum requirements for an HLS, only experienced pilots be used. These pilots should be familiar with, and competent to operate in confined area and mountainous area operations.

Pinnacle operations

The US Federal Aviation Administration (FAA) *Rotorcraft Flying Handbook (2000)* FAA-H-8083-21A¹⁵, provided general guidance to pilots about operating to and from pinnacles. This included a description of the difficulties encountered during pinnacle operations as follows:

... The absence of obstacles does not necessarily lessen the difficulty of pinnacle or ridgeline operations. Updrafts, downdrafts, and turbulence, together with unsuitable terrain in which to make a forced landing, may still present extreme hazards.

... Groundspeed during the approach is more difficult to judge because visual references are farther away than during approaches over trees or flat terrain.

¹⁵ This handbook was replaced in 2012 by the *Helicopter Flying Handbook* with the identifier FAA-H-8083-21A.

In addition, the FAA handbook listed a number of common errors when approaching confined and pinnacle HLS. These common errors included 'failure to consider how wind and turbulence could affect the approach' and 'Flying the approach angle at too steep or too shallow an approach for the existing conditions'.

The FAA handbook indicated a number of factors that determine the appropriate approach angle during the final part of a pinnacle approach. These include the load carried by the helicopter, the elevation of the pinnacle, the surrounding terrain and the wind. In respect of the wind conditions affecting a pinnacle, the handbook stated that 'as a general rule, the greater the winds, the steeper the approach needs to be to avoid turbulent air and downdrafts.' The delineation between the up- and down-drafting air is termed the demarcation line, with the air downwind of this 'line' generally associated with turbulence.

Pinnacle and confined area operations are part of the normal competencies for the award of a helicopter licence. However, CASA advised that they are degradable skills that should be made current prior to the assignment of flights which may involve operations to such locations.

Flight recorders

The helicopter was not equipped with flight data or cockpit voice recorders, nor was it required to be. A health and usage monitoring system (HUMS) unit was installed in the helicopter and automatically captured a range of flight and performance data during the operation of the helicopter. The unit was removed from the wreckage and taken to the ATSB's facilities for download. That data contained recorded information of previous flights but no information relevant to the accident flight.

Wreckage and impact information

The wreckage of the helicopter was located on a steep slope about 50 m west of the HLS, in dense forest about 50 ft below the elevation of the landing site. Damage to the vegetation indicated that the helicopter descended through the trees at a very steep angle, breaking a number of substantial tree branches before impacting the ground. The helicopter was lying inverted on a heading of 250(M) (Figure 6).

Two examinations of the wreckage were made. The first was made on-site with the helicopter inverted and was limited to the examination of major components (Figure 7). During this examination, blade cuts were identified on the tree branches that were consistent with marks on the leading edges of the main rotor blades and of the tail rotor blade that remained attached to the tail rotor gearbox. The first blade strikes were to branches at a height of about 23 m on a tree that was about 9 m back along the swath through the trees from the point where the fuselage of the helicopter came to rest.

All of the helicopter's major rotor and dynamic components were accounted for at the accident site, except for one of the tail rotor blades that was liberated during the impact sequence. Continuity of the flight control system was established.

Figure 6: Aerial view of the wreckage



Source: ATSB

Figure 7: View of the wreckage



Source: Queensland Police

A second examination of the wreckage was made after the helicopter was airlifted from the accident site to a nearby location that permitted a more detailed inspection of the helicopter and its systems. To facilitate that examination, the helicopter was rolled upright and placed on its skid-landing gear. This allowed access to areas that were inaccessible at the accident site (Figure 8).

Figure 8: Recovered wreckage



Source: ATSB

Damage to the rotors and rotor drive systems displayed evidence of the helicopter being powered at the time it contacted the trees but the amount of power could not be determined. The plastic fuel tank that was situated in the area behind the cabin

and underneath the main rotor gearbox remained intact and contained a substantial quantity of aviation turbine fuel, estimated to be at least one third of the tank's 540L capacity.

The mechanical flight control system was examined and no defects were found that would have prevented normal flight control function. A number of components from the helicopter's engine, hydraulic flight control system, and warning system were recovered for later test or examination.

Components of the hydraulic system were later removed from the helicopter for testing by the ATSB (see *Tests and research* section of this report).

Medical and pathological information

A post-mortem examination of the pilot by state authorities found that his injuries were consistent with the accident and that he did not exhibit any physiological condition that would have affected the performance of his duties. Toxicological examinations identified that the pilot was not affected by drugs or alcohol.

Survival aspects

The helicopter collided with terrain in an inverted attitude that crushed the forward section of the cabin. The rear section of the cabin was not crushed to the same extent and the rear seat occupant, unlike the two front seat occupants, was afforded a survivable space.

The rear seat passenger was restrained by a single lap-type seat belt. Due to his injuries, the restricted space in which to move, and being upside down with the weight of his body supported by the belt, he was unable to release the seat belt buckle. The passenger freed himself by cutting the webbing of the belt using the knife on a Leatherman tool carried by the other passenger.

Search and rescue

The helicopter was equipped with an ARTEX ME406 emergency locator transmitter (ELT).¹⁶ When armed, the ELT was designed to activate on impact and transmit a distress signal on frequency 406 MHz.

The COSPAS-SARSAT international satellite-aided tracking system detects distress signals from activated ELTs and relays those signals to the Rescue Coordination Centre (RCC) of the Australian Maritime Safety Authority (AMSA), through a number of ground receiver stations. AMSA is the government agency responsible for search and rescue following accidents to aircraft and marine vessels in Australian-administered territory.

Although the helicopter's ELT activated, its antenna, which was mounted on top of the helicopter's tail boom, separated from the antenna cable on impact and its distress signal was attenuated. Consequently, the RCC did not receive an ELT alert.

¹⁶ Crash-activated radio beacon that transmits an emergency signal that may include the position of a crashed aircraft. Also able to be manually activated.

The operator of the helicopter had also installed a flight monitoring system that used satellite and web-based communication systems to allow the operator to receive accurate information on the location of company aircraft every 10 minutes while they were in flight. An alert, and the last transmitted location of the helicopter, was made if no subsequent updates were received.

The operations manager reported that he was maintaining a SAR time¹⁷ for the pilot of 1200. When he had not heard from the pilot by 1202, he attempted to make contact by mobile phone. When that call was diverted to message bank, the manager contacted the passenger's mobile phone and spoke to the surviving passenger, who advised that the helicopter had crashed. The operations manager then contacted AMSA, who had already been alerted by emergency services as a result of a phone call made earlier by the surviving passenger.

Tests and research

Examination of hydraulic system components

The helicopter's hydraulic pump and lines, main and tail rotor hydraulic servo actuators, and the distribution block were incorporated into a bench test rig. Testing of each component was carried out at an approved facility under ATSB supervision.

Hydraulic pump

The hydraulic pump was intact and in good condition. When examined, the hydraulic pump's drive splines were found to be in good condition and, when driven by an electric motor for the test, the pump performed normally.

Hydraulic servo actuators, valves and accumulators

The Dunlop main and tail rotor hydraulic servo actuators installed on the helicopter had a service life of 1,800 hours before requiring overhaul. The time remaining before overhaul on these particular servos varied from 113 to 1,084 hours.

Each servo actuator was individually subjected to multiple cycles of extension and retraction. All but one of the main rotor servo actuators operated normally. This actuator was damaged during the impact sequence and, when operated at test, jammed at a point along the shaft where it had been bent. When freed by hand, it operated normally to the same point along the shaft each time.

The electrically operated servo valves (electro-valve) associated with each of the three main rotor servo actuators were individually powered up via a 28 volt DC aircraft battery. At test, each solenoid functioned normally.

The engineer who removed the main rotor servo actuators from the helicopter reported partially releasing the pressure of the respective accumulators using the installed valves prior to their transport for examination. When received for testing, the nitrogen pressure in each of the accumulators was found to be 4.8, 6.2 and 6.9 bars (70, 90 and 100 psi) respectively.

¹⁷ A time nominated by the pilot for the initiation of Search and Rescue action if a report from the pilot was not received by the operator.

Prior to their test, the three main rotor servo accumulators were recharged with nitrogen to a pressure of about 15 bar (217 psi). The accumulators remained at about 13.8 bar (200 psi) throughout the testing process, confirming their serviceability.

Hydraulic cut-off switch

The HYD CUT OFF switch was a toggle switch attached to the end of the collective lever (Figure 9). It had a plastic guard to avoid inadvertent selection. The HYD CUT OFF switch was found in the ON (forward) position. However, the plastic guard was broken off, which probably occurred during the impact sequence and could have resulted in the switch being moved to that position. Therefore, the position of the HYD CUT OFF switch prior to impact could not be confirmed.

Figure 9: Hydraulic cut-off switch – VH-RDU (left) and a typical installation (right)



Source: ATSB



Source: Transportation Safety Board of Canada

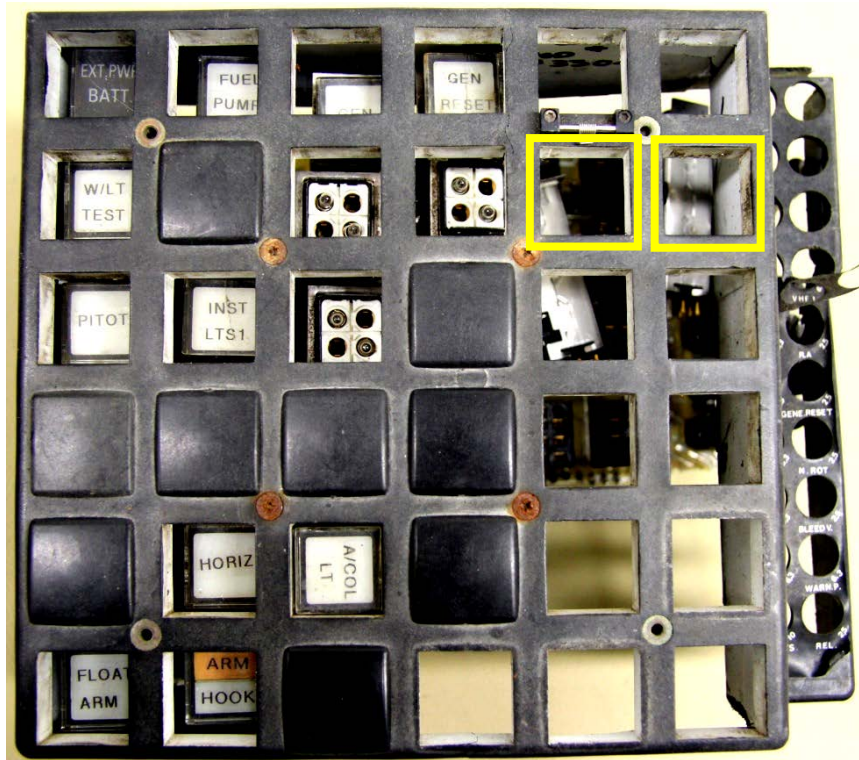
Earlier design of the hydraulic system had caused unequal depletion of the hydraulic accumulators after selection of the HYD CUT OFF switch to OFF. As a result of an investigation involving an AS350B2 in 1999, the hydraulic control system was modified to ensure that the three main rotor servo actuators all dumped pressure simultaneously when the HYD CUT OFF switch was activated.

Examination of the maintenance records found that the modification had been incorporated in the helicopter.

Hydraulic test switch and warning system

Due to the disruption and damage to the cabin and the associated electrical wiring it was not possible to test the function of the low hydraulic pressure component of the dual function warning horn. In addition, the HYD TEST switch and the warning horn mute switch on the centre pedestal selector panel were dislodged and their selection prior to impact could not be determined (Figure 10).

Figure 10: Hydraulic test (HYD TEST) and Horn mute (HORN) switches – dislodged and missing



Source: ATSB

Warning-cautionary-advisory panel

The warning panel (Figure 11) was recovered and the lamps examined to determine if any warning lights had been illuminated at impact. Although none exhibited stretched elements that might indicate their illumination at impact, the angle and magnitude of the impact may not have been sufficient to produce that characteristic. Consequently, it could not be determined if either the HYD (low hydraulic pressure) warning or the HORN (mute) lamps were on at the time of impact.

Figure 11: Warning-caution-advisory panel



Source: ATSB

Electrical fuses and circuit breakers

No electrical circuit fuses were found blown or circuit breakers tripped during the examination of the circuit breaker panel carried out by the ATSB.

Examination of engine components

An on-site examination of the engine found no evidence of catastrophic engine failure. However, a loss of power, although unlikely given the indications of power on the main rotor blades and still-attached tail rotor, could not be totally excluded as a factor.

The power turbine governor, engine driven fuel pump, fuel filter and fuel control unit were subsequently removed from the helicopter for testing. Examination and testing of these components found nothing that would have adversely affected engine operation at the time of the accident.

Organisational and management information

Company structure and fleet

The helicopter operator used both helicopters and aeroplanes in charter operations from its main base in Cairns and from a number of secondary bases in far north Queensland. The helicopter fleet consisted of a number of piston- and turbine-powered, single-engine helicopters, of which the AS350BA was the only one of its type in the fleet.

The operator's head of flying operations (chief pilot) did not hold helicopter licences. As a consequence, the appointment of a helicopter 'lead' pilot with appropriate helicopter licences and endorsements was required by CASA, for oversight of the helicopter operations. The appointed lead pilot was also the chief flying instructor of the operator's helicopter flying school and had been appointed earlier that year following the resignation of the operator's former chief pilot, who had held the appropriate helicopter qualifications.

The Cairns base normally had two full-time helicopter pilots, being the lead pilot and the managing director, who was an experienced helicopter pilot. Additionally, a number of casual pilots, one of whom was the accident pilot, were used on occasions when the full-time pilots were unavailable for tasks.

The operator also employed an operations manager whose duties included taking bookings and quoting on flights and logistical support for those tasks - such as arranging fuel stocks and pilot accommodation. It was an administrative role that did not require any previous flying experience or aviation qualifications. The operations manager had been employed by the operator for most of the previous 6 or 7 years and reported that his role developed as the company had expanded.

Client requirements

The operator's customers included clients from the resource sector¹⁸ who typically specified minimum aircraft equipment, aircrew experience, maintenance requirements and facilities, as well as management and quality assurance to a higher standard than that determined by CASA for the issue of an Air Operator's Certificate (AOC). As a consequence, and to meet a resource sector client requirement, the operator was audited by an independent aviation quality assurance auditor in May 2011. That audit reported:

The company has been in operation for a number of years and in the last 5 years has had one helicopter accident, no injuries resulted. This has been due to a good standard of operational control and commitment to quality and safety which applies equally to both flight operations and maintenance.

Part A2.7 of the operator's Operations Manual – *BARS Minimum Experience Requirements* listed the additional minimum experience for pilots engaged in activities associated with the resource sector as set out by Flight Safety Foundation *Basic Aviation Risk Standard (BARS) – Resource*. In the case of single-engine helicopters, in addition to the minimum CASA requirements for a pilot to conduct commercial operations of a type endorsement, including 5 hours in command for flight under the visual flight rules, the completion of a helicopter flight review and recency requirements, the requirements included:

- 2,000 hours total flight time
- 1,500 hours pilot in command
- 100 hours pilot in command on type
- valid Helicopter Underwater Emergency Training course (Helicopter)
- valid Crew Resource Management course, and
- valid First Aid course.

Although it was not incorporated into the operations manual, the Flight Safety Foundation BARS called for other control measures, in addition to minimum pilot qualifications, including:

Before commencing operations for any new or existing aviation activity a documented assessment of operational risks and their respective mitigation shall be conducted by the aircraft operator.

The operator met the additional requirements for their respective clients through their contractual obligations. The organisation that chartered the helicopter for the Shoalwater Bay training area HLS maintenance, although considered by the safety manager to be a resource sector client, did not have a policy that required application of the BARS minimum experience standards. That organisation relied on the operator's standard operating procedures, which were accepted by CASA when issuing an AOC to the operator.

¹⁸ Broadly defined as mining, exploration, survey and similar activity, often requiring specialist airwork in addition to the transport of passengers.

Flight authorisation

The operator was responsible for ensuring that all flights were duly authorised. The operations manual stated that:

The Chief Pilot or delegated person shall be responsible for authorising all flights with due regard to the following:

- Maintenance status of the helicopter;
- Category or type of flight involved; and
- Pilot qualification requirements.

There was no formal procedure for the lead or chief pilot to confirm the tasking and assignment of pilots to those tasks. The operator's authorisation for flights was implied by the entries on the weekly roster that showed which aircraft and pilots had been assigned to each task.

Rostering and tasking

One of a chief pilot's responsibilities¹⁹ was arranging flight crew rosters. However, in exercising that responsibility, a chief pilot could delegate duties to other members of an operator's staff, with the exception of training and checking, which required written approval from CASA. The chief pilot reported that the lead pilot was delegated responsibility for administering all the operator's helicopter operations, including rostering. The operations manual did not specify that delegation.

The chief pilot reported that tasking was displayed on a whiteboard located in the operations manager's office in another part of the hangar to the chief and lead pilots' office. It displayed the daily tasking for 1 week against the allocated aircraft and the assigned pilot. The chief pilot, the lead pilot and a previous helicopter chief pilot reported that the tasking was often assigned by the operations manager and/or the managing director. Helicopter tasks were accepted and pilots assigned, often without the knowledge of either the chief or lead pilots.

The operations manager advised that the whiteboard in his office was used as a 7-day quick reference guide, mainly for the managing director's purposes and that it frequently changed due to the ad hoc nature of charter work. The main operational planning calendar was computerised and available to senior staff and pilots. The lead pilot reported that he was unaware of the existence of the operator's computerised operational planning calendar at the time of the occurrence.

The chief pilot reported that he preferred to use the whiteboard because he could see all the tasking at a glance and that numerous requests by him to the operations manager for more detailed tasking information to be displayed on the whiteboard went mostly unheeded. Similar requests to the managing director were reported to have resulted in the additional details appearing temporarily. The lead pilot reported that on one occasion, when the operations manager had advised him of tasking, he discovered that information about the relevant HLS for the operation was misleading, and that the assigned pilot lacked the necessary experience for the task. The chief pilot, the lead pilot and the former chief pilot all reported that not being

¹⁹ Civil Aviation Order 82.0, Appendix 1. Sub-section 2.2 (b)

advised of pilot tasking was an on-going issue and a constant cause of dissatisfaction with the operator's practices.

On 11 May 2010, Safety Advisory 03/10 was issued by the safety manager and reported that the (then) chief pilot had sent a letter in February that year raising several safety concerns. That advisory alerted staff to a number of issues that had been addressed by the operator, two of which were:

Pre-Flight preparations: The Operations Manager will e-mail information regarding flights to the crew concerned.

Flight Authorizations: The Chief Pilot is to be kept advised of all flight requirements by the Operations Manager and General Manager (managing director).

However, in an Annual Safety Review in 2010, which was prepared by the safety manager for the managing director, it was reported that:

Company communications still require some fine tuning especially in the area of client information for charters. An external audit finding has recommended a check list be introduced - this may go some way to alleviating this problem.

On 20 September 2011, Safety Advisory 15/011 was issued by the safety manager. This advisory reported on points raised during discussions following the accident at Double Mountain on how to improve the operator's safety processes. Among the issues for consideration were:

Communication between the Operations Manager and Lead Pilot R/W should involve company risk assessments for all designated tasks.

The Managing Director and Operations Manager should consult with the Chief and Lead Pilots on all crewing matters for operations the company has committed to.

Tasking for the occurrence flight

The operations manager recalled that the Shoalwater Bay training area task was an annual event and had been advised several weeks prior to the tasking. In addition, he recalled that the managing director had suggested that the pilot be assigned to the task.

The operations manager was unsure of the exact chronology of events, but reported approaching the lead pilot in the weeks before the accident about assigning the pilot for AS350BA flights. He indicated that the response from the lead pilot at that time had led him to believe that the pilot was approved for operations in the AS350BA and that the lead pilot was aware of the Shoalwater Bay tasking. The operations manager reported that he had also checked with the pilot who, after initially rejecting then considering the request for a while, advised him that he was able to conduct the flying required for the Shoalwater Bay task.

The managing director reported that the pilot had about 1,000 hours of helicopter experience, over 30 hours on type, had satisfactorily demonstrated operations into pinnacle and confined HLSs, and met all of the requirements for the task. He stated that the lead pilot was briefed by himself and the operations manager prior to the pilot's departure to the Shoalwater Bay training area, and that the lead pilot had not expressed any reservations about the pilot's ability to carry out the task. The managing director recalled arranging for the pilot to fly the helicopter to Yeppoon

and complete the first few days' flying duties before he, the managing director, would travel to Yeppoon to fly those flights that involved external load operations.

The chief pilot did not recall seeing the pilot's name against the planned Shoalwater Bay task on the whiteboard in the operations manager's office. He reported having spoken to the pilot in the hangar a few days before his departure to Yeppoon. From that discussion he believed that the pilot was to ferry the helicopter to Yeppoon in preparation for the Shoalwater Bay training area task, where he would be met by the managing director who was to fly the task.

The lead pilot reported that he was unaware of the tasking for the Shoalwater Bay training area and that the managing director, the operations manager and the pilot had not consulted him about the planned flight. He thought that the managing director would be flying the Shoalwater Bay task as he had done previously. The lead pilot stated that had he been informed, he would not have considered assigning the pilot to that task because of the pilot's low time on the helicopter type and his inexperience with that type of flying. He estimated that about 100 hours on type would be an appropriate level of experience before assigning a pilot to that task.

The safety manager reported speaking to the pilot on the morning of his departure from Cairns for Yeppoon. He was unaware of the intended flying task, and later reported that had he known that the pilot had been assigned to that task, he would have insisted on a risk assessment for the planned flying. That assessment would have included consideration of the necessary level of pilot experience for the task.

The ATSB was unable to reconcile the contradictory accounts of the pilot's assignment to the Shoalwater Bay training area tasking.

Safety Management System

Although CASA had promoted the adoption of Safety Management Systems (SMS) by all aviation operators, the regulatory requirement was only mandatory for operators providing scheduled services.²⁰ As the operator's Air Operator's Certificate (AOC) was limited to charter operations, there was no regulatory obligation to develop or implement and use an SMS at the time of the occurrence.

Despite this lack of a regulatory requirement, in 2009 the operator proactively undertook to develop a regulatory compliant SMS for its operations in order to attain industry best practice. Training was provided to key personnel by an external safety management training provider in 2009, with the SMS being implemented in 2010. A part-time (1 day per week) safety manager was also appointed to this task.

The operator's SMS was designed to comply with guidance provided by the International Civil Aviation Organization and CASA. The SMS was developed around the following four components, as listed in the operator's SMS manual:

- Safety Policy, Objectives and Planning
- Risk Management
- Safety Assurance

²⁰ Civil Aviation Order (CAO) 82.3 *Conditions on Air Operator's Certificates authorising regular public transport operations in other than high capacity aircraft* and CAO 82.5 *Conditions on Air Operator's Certificates authorising regular public transport operations in high capacity aircraft*.

- Safety Promotion.

However, the safety manager reported that the organisation was slow in adopting the new SMS, and was characterised by a lower number of hazard reports than had been anticipated. Indeed, many of the hazard reports in the log were generated by the safety manager following verbal consultation or emails sent to him by company personnel, rather than being submitted by the personnel themselves.

Meeting minutes showed that regular safety meetings were attended by key personnel and safety concerns were discussed. However, personnel later reported that although a number of changes in procedures to address identified issues were agreed to, very few operational changes were effectively implemented. This contrasts to a mature SMS which utilises a cycle of continuous improvement whereby hazards are identified, associated risks are mitigated, and a system of assurance is implemented to confirm that mitigations are effective.

The issue of communication difficulties between the operations manager and the chief and lead pilots was identified in the meeting minutes on several occasions. In addition, the lack of tasking information and incidence of the details of charter flights not always being made known to the chief and lead pilots for proper authorisation, as reported in the case of this accident, was an issue that remained unresolved. Attempts by the safety manager to rectify this issue went unheeded, and these issues remained, even after the accident. Consequently, the SMS was mostly reactive, that is, responding to previous occurrences and had not matured to a point where hazards were being proactively identified.

In the chapter *Safety Risk Management*, the operator's SMS manual stated:

Due to the diverse mission profiles undertaken by ... [operator] aircraft, ... [operator] management has chosen to use a mission specific format for flight operations risk analysis. ... [Operator] management feels that a specific hazard can have vastly different risks in different scenarios. Analysing these hazards on a mission specific basis allows for different mitigations, or levels of mitigation of the same hazard, under different circumstances; which overall enhances the flexibility and functionality of the SMS.

Although the operator's SMS contained a section dealing with the need to perform risk assessments and the creation of *Safety Risk Management Worksheets*, no documented risk assessment was found for the Shoalwater Bay training area tasking or any other missions. Such a document would, if completed, have provided a broader information base upon which to determine the suitability or otherwise of the pilot, for that tasking.

In May 2011, an independent audit of the operator by an aviation safety organisation found that the operator's SMS and the quality assurance measures that it introduced '... provide a satisfactory standard of oversight'. In a comment regarding the safety committee, the audit report stated that '... a sample of these reports were reviewed and found overall to be managed satisfactory with closeout of safety items.' It also found the hazard reports contained within the hazard register '... to be of good standard.'

In September 2012, a CASA surveillance visit included a review of the operator's SMS. That review resulted in five Observations that were critical of the SMS. One Observation reported that hazards were not being captured effectively; some hazards appeared on the forms, others appeared in the Safety Committee minutes and some were not captured at all. In addition, CASA found that a consolidated

hazards register was not being maintained by the operator. Although 2 years after its implementation (and 1 year after the accident), the CASA review concluded:

The SMS appears to be in a rudimentary state and cannot demonstrate where causal factors, system faults and human factors issues are explored to sufficient depth to drive the necessary changes to operating systems and third party interfaces to improve safety outcomes.

Helicopter landing site register

The holder of an AOC authorising charter and aerial work operations was required to maintain a catalogue of Helicopter Landing Sites,²¹ commonly referred to as an HLS register. The following documentation was to be provided in an operator's HLS register:

... a catalogue of heliports and helicopter landing sites in the area of operations showing, in diagrammatic form, location by co-ordinates or in reference to prominent geographic features or nearest navigation aid, direction of approach and departure paths, dimensions of approach and take-off areas, ground-effect area(s), nature and slope (if any) of the surfaces, elevation above sea level, hazards in the area, any restrictions or specific conditions relating to the use of the particular site and the name, and method of contacting the owner or controlling authority.

The operations manager reported that the Shoalwater Bay HLSs were contained in the operator's HLS register and that the managing director had briefed the pilot on those HLSs. A copy of the operator's HLS register entry for Double Mountain South HLS could not be found. However, a comprehensive briefing document was provided to the operator by the contractor who chartered the helicopter for the Shoalwater Bay training area task. This document included detailed information about the Shoalwater Bay HLSs and incorporated all of the information required by CASA for inclusion in the operator's HLS register. The operations manager reported that the pilot was provided with a copy of the contractor's briefing document before leaving Cairns.

A scheduled CASA surveillance visit that was conducted just before the accident identified a deficiency with the operator's HLS register. CASA found that the operator's HLS register was '... not adequately controlled or updated by any formal process.' and as a result issued a Request for Corrective Action.

²¹ CAO 82.1 *Conditions on Air Operators' Certificates authorising charter operations and aerial work operations* Appendix 1 sub-section 2.5 (f).

ANALYSIS

While approaching a pinnacle helicopter landing site (HLS) within the Shoalwater Bay military training area, the pilot lost control of the helicopter and it impacted terrain. This analysis will examine the possible mechanical, environmental or operational factors that may have contributed to the accident. Organisational aspects that had the potential to adversely affect the safety of the operation will also be considered.

Development of the accident

The passenger reported that while climbing at slow speed a short distance from the HLS, the helicopter turned left in what the passenger believed was a controlled manoeuvre by the pilot. The passenger recalled that the helicopter then climbed abruptly, as if it had encountered an updraft and started to rotate to the left. The helicopter completed two full rotations before descending and colliding with trees and terrain. Neither the passenger's description of events nor the recorded satellite navigation data explained the behaviour of the helicopter.

Consideration of potential mechanical factors

Power loss

Examination of the wreckage and subsequent technical examination of the engine and associated components found no evidence of engine failure. Damage to the engine-to-main rotor drive shaft indicated that the rotor system was being driven when the helicopter collided with the trees, although the amount of power could not be determined. The passenger's description of the helicopter's motion, prior to control being lost, was not consistent with the pilot experiencing a loss of power or low main rotor RPM. The ATSB assessed that power loss was unlikely to have been a factor in this occurrence.

Loss of hydraulic assistance

Testing of the hydraulic and flight control system components did not find any pre-existing fault. However, the hydraulic pump drive belt was not found and the ATSB could not determine with any certainty if it had failed in flight, resulting in a loss of hydraulic pressure, or if it failed during the impact sequence.

In the event of a loss of hydraulic pressure, the pilot would normally have been alerted by an aural warning in the cabin and an illuminated red warning light on the warning-caution-advisory panel. The passenger did not report hearing the warning horn. Although it was possible to mute the horn, the reported use of checklists by the pilot, which required the warning horn to be selected for flight, suggested that the horn would have been selected. In combination with the presence of a horn mute caution lamp on the panel that would alert the pilot of the need to select the horn, the ATSB considered that it was unlikely that the pilot would have flown with the warning horn inoperative or inadvertently muted. Damage to components, including the electrical wiring, prevented functional testing of the hydraulic pressure warning system.

Following a loss of hydraulic pressure, the accumulators may deplete at different rates depending on the number and range of cyclic and collective control inputs by the pilot, potentially leading to variable flight control feedback forces. Normally, this would be prevented by the pilot operating the hydraulic pressure cut-off switch on the collective once established in the helicopter's safety speed range for flight without hydraulic assistance. Damage to the hydraulic cut-off switch meant that its selection prior to the impact sequence could not be determined. In addition, damage to the associated electrical wiring meant that the serviceability of the hydraulic cut-off switch and associated system components could not be confirmed.

A pilot having low familiarity with the helicopter might not recognise, or react promptly to the symptoms of a loss of hydraulic pressure, especially if the warning horn had not sounded. If in forward flight, this could result in an unfamiliar pilot continuing to fly outside of the safety speed range without selecting the hydraulic cut-off switch. If in hover flight or in any low speed manoeuvre, any inaction or delayed response could lead to excessive pilot workload and possible loss of control. The aircraft flight manual warned of this risk.

The pilot had satisfactorily demonstrated manual control of the helicopter following a simulated hydraulic failure during a check flight about 1 month before the accident. However, that simulated hydraulic failure was in forward flight and did not involve a landing without hydraulic assistance. Control of the helicopter following a loss of hydraulic assistance at low speed, particularly in turbulent conditions, would have been more difficult than the simulated conditions previously encountered by the pilot.

During operation with normal hydraulic system pressure, a pilot-initiated climb would result in a tendency for the helicopter to yaw left due to the increased engine torque applied to the rotor system. The magnitude of that yaw would be proportional to the rate of application of the collective and could be countered entirely by appropriate anti-torque pedal input. Following a loss of hydraulic pressure, there would also be a pronounced increase in the pilot anti-torque pedal input forces normally experienced to counter that left yaw tendency. This is a consequence of there being no hydraulic accumulator on the anti-torque pedal controls, meaning that the anti-torque pedals would immediately lose hydraulic assistance.

In contrast, the collective and cyclic controls would not initially be affected because of the stored energy in their respective hydraulic accumulators. Accordingly, there would not be any immediate tendency for the helicopter to climb or descend following a loss of hydraulic pressure unless there was a deliberate pilot input or an environmental influence such as turbulence.

Environmental and operational factors

The pilot approached the Double Mountain South HLS from a direction that conformed with the approach directions shown in the HLS diagram in the Department of Defence *Shoalwater Bay Training Area Safety and Control Systems - Remote Site Vegetation Management Plan*, and was probably into wind. During the inspection of the HLS, the pilot was reported to have expressed concern about trees obstructing the landing area and was making a third close inspection of the site when control was lost. Such caution was consistent with the pilot attempting to identify relevant hazards in an unfamiliar situation. Despite the positive aspects

of this action by the pilot, any turbulence experienced during a vulnerable phase of flight may have been in excess of that anticipated by the pilot.

The orientation of the helicopter in relation to the wind was not conducive to unanticipated yaw. However, the reported turbulence at the HLS increased the potential that varying control inputs would be required to maintain control, including in yaw. As described in the manufacturer's service letter, any hesitation by a pilot to counter a left yaw by applying up to and including full right (opposite) anti-torque pedal, in particular if coinciding with a need to raise collective to maintain the approach or increase altitude, would have allowed the rotation to continue, or possibly increase its rate. The contribution of the reported turbulence on the loss of control by the relatively unfamiliar pilot with low time in the AS350BA helicopter could not be quantified.

Summary of accident development

The witness description of the helicopter climbing and turning during the final approach to the landing site was consistent with the pilot discontinuing the approach either:

- for operational reasons, including following the loss of hydraulic pressure
- as a result of encountering an updraft or turbulence.

The reason for the loss of control, following the climb and turn, could not be determined.

Pilot tasking

Although the pilot was appropriately licenced and endorsed on the helicopter type, his relative inexperience, low time on type and unfamiliarity with the Shoalwater Bay training area meant that his assignment to the HLS maintenance task was, in the circumstances, probably inappropriate. There was only one recorded assessment of the pilot's competency to satisfactorily perform pinnacle operations, similar to the Double Mountain South HLS. That assessment was recorded prior to the pilot's PNG accident and nearly 6-months before the accident at Double Mountain South.

The pilot's acceptance of the rostered flying indicated that he was satisfied with his ability to safely undertake the flight in the AS350BA. Although his assignment to the Shoalwater Bay training area task without the lead pilot's knowledge or approval could not be confirmed, such actions were reported by the chief pilot, the lead pilot and the former chief pilot to have frequently occurred.

Weekly tasking, shown on the whiteboard in the operations manager's office, could be assigned or changed without the knowledge of either the chief or lead pilots. The operational planning calendar electronically stored on the operator's computer, was not routinely viewed by the chief pilot and the lead pilot was unaware of its existence at the time of the accident. That practice circumvented the safety intent of the requirement by the Civil Aviation Safety Authority (CASA) for the appointment of a chief or lead pilot to supervise the operator's helicopter operations. Without formal procedures for the chief or the lead pilot to verify tasking, flights could not be presumed to have been duly approved.

Safety management

At the time of the accident, the operator's safety management system (SMS), although not required by regulation, had been in place for almost 2 years. Throughout that time the SMS appeared to have evolved slowly, if at all, and was mostly reactive. In this context, the SMS was unable to reliably deliver positive outcomes and improve the operator's safety management of its activities.

The intent of the risk management section of an SMS is to introduce hazard identification and risk management processes for application to operational activities. This includes operational aspects related to pilot tasking. Although the operator's SMS contained a requirement to perform hazard identification and risk assessments, no documented risk assessment was found for the Shoalwater Bay training area tasking. Had a formalised and documented risk assessment, as prescribed by the SMS, been prepared, and integrated as part of the chief or lead pilots' authorisation processes, a greater awareness of the suitability or otherwise of the pilot for the tasking was likely to have occurred.

Helicopter landing site

The ability of helicopters to operate from confined areas and pinnacles allows for a wide range of tasks that would not be possible otherwise. A Civil Aviation Advisory Publications (CAAP) was published by CASA in support of these operations that provided guidance on the establishment of different types of helicopter landing sites. This included general guidance for the establishment of a basic HLS, which did not recommend minimum dimensions and obstacle clearances for safe operation. More specific guidance, including minimum dimensions and obstacle clearances, were available for a standard HLS.

A licenced helicopter pilot might reasonably be expected to safely operate from a standard HLS that conformed to the CAAP. In this context, it is unrealistic to expect the same pilot to necessarily operate safely from basic HLSs that do not have the protection of defined dimensions and obstacle clearances applicable at standard HLSs. This increased risk can be exacerbated in the case of confined area or pinnacle landing sites due to piloting skills associated with operations at these sites being degradable and pilots, therefore, needing to be current prior to the assignment to flights that involve such operations. The responsibility to ensure that a pilot is competent for those operations rests with the operator.

In this case, the HLS was situated on a pinnacle, increasing the likelihood of the approach being affected by environmental conditions and limited visual references. The size of the HLS, the proximity of obstacles, and wind conditions combined with the pilot's limited experience of pinnacle operations compounded the level of difficulty for a pilot who was attempting to land there for the first time.

FINDINGS

Context

While inspecting the pinnacle helicopter landing site (HLS) in preparation for landing at Double Mountain South, the pilot of an AS350BA helicopter, registered VH-RDU, lost control of the helicopter and collided with terrain. The reasons for the loss of control could not be positively established. However, the investigation identified safety factors that, while they did not directly contribute to the development of the accident, had increased risk.

From the evidence available, the following findings are made with respect to the loss of control and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- For reasons that were unable to be determined, the pilot was unable to prevent the loss of control of the helicopter while attempting to land at a pinnacle helicopter landing site.

Other safety factors

- The pilot was assigned to a task for which he most likely lacked experience on both the helicopter type and the nature of the flying. *[Safety issue]*
- The operator's safety management system was ineffective in assessing the underlying risk associated with the task and allowed the pilot to be assigned to the flight.
- The minimal clearance from obstructions, unfavourable surface conditions and a lack of appropriate wind indication at the helicopter landing site (HLS) increased the risk associated with operations to the HLS, particularly for a pilot unfamiliar with the site. *[Safety issue]*

SAFETY ACTION

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

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

Helicopter operator

Assignment of the pilot to the task

Safety issue

The pilot was assigned to a task for which he most likely lacked experience on both the helicopter type and the nature of the flying.

Action taken by the helicopter operator

In relation to pilot rostering and authorisation, the operator advised that the operations manual, Section 1.4 was specific in regard to the duties and responsibilities of the lead pilot. In addition, the operator indicated that, although operations into helicopter landing sites (HLS) within the Shoalwater Bay training area can carry a medium risk factor, it was satisfied that a full briefing mitigated that factor.

However, the safety manager reported later that the operator had subsequently applied its resource sector pilot minimum experience requirements to all tasking other than scenic flights. On 31 May 2013, the company changed ownership and this requirement, if not already incorporated into the operator's operations manual, was superseded by the new operator's procedures and documentation.

ATSB assessment of action

The ATSB is satisfied that reported application by the operator of the resource sector experiential standards to all tasking other than scenic flights, will, when formalised in the operator's operations manual, adequately address this safety issue and therefore makes no recommendation.

Helicopter landing site owner

Landing site hazards

Safety issue

The minimal clearance from obstructions, unfavourable surface conditions and a lack of appropriate wind indication at the helicopter landing site (HLS) increased the risk associated with operations to the HLS, particularly for a pilot unfamiliar with the site.

Action taken by helicopter landing site owner

An independent safety audit of all Shoalwater Bay training area HLSs was carried out following the accident. In response to recommendations made in that report, vegetation was cleared at the Double Mountain South HLS to provide obstruction-free approach and departure paths into the prevailing wind, a wind indicator in the form of windsock was installed and a steel deck was constructed to provide a level landing surface that was clear of rocks and tree stumps. Similar work was carried out at other HLSs and one HLS was relocated to a more favourable location.

ATSB assessment of action

The ATSB is satisfied that the action by the owner of the Shoalwater Bay training area HLSs adequately addresses this safety issue and therefore makes no recommendation.

APPENDIX A: EUROCOPTER SERVICE LETTERS

The following service letter examines a number of yaw control occurrences in helicopters having, like RDU, main rotors that rotate in a clockwise direction when viewed from above. Observations are made and technical comments provided in terms of the control inputs by the affected pilots and the helicopter systems and aerodynamic considerations in the development of the occurrences.



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Lettre-Service
No. 1673-67-04

Marignane, 04.02.05

**To all Pilots,
for all types of helicopters fitted with a tail rotor.**

Main rotor rotating clockwise

SUBJECT: Reminder concerning the YAW axis control for all helicopters in some flight conditions

The technical comments in this Service-Letter apply to main rotors rotating clockwise when seen from above. For rotors rotating anticlockwise, see Service-Letter No. 1692-67-04.

Ref.: First reminder = S.L. No. 1518-67 dated 26.04.2001



Dear Customer,

The analysis of the causes of severe helicopter incidents or accidents leads EUROCOPTER to issue a few reminders as regards YAW axis control in some flight situations.

1 - BACKGROUND:

Various events which occurred during flight near the ground and at very low speed in light wind conditions on aircraft fitted either with conventional tail rotors or with Fenestrans, took place as follows:

From hover flight at take-off at very low speed, the Pilot initiates a left turn a few meters above the ground by applying yaw pedals towards the neutral position: the aircraft starts its rotation which increases until the Pilot attempts to stop it by applying the RH yaw pedal.

In the various cases which resulted in the loss of yaw axis control, the action applied to the RH yaw pedal was not enough (amplitude/duration) to stop rotation as quickly as the Pilot wished.

As the aircraft continues its rotation, the Pilot generally suspects a (total or partial) tail rotor failure and decides either to climb to gain speed or to get closer to the ground.

In the first case, increasing the collective pitch results in increasing the main rotor torque and consequently further speeds up leftward rotation. This results in the loss of aircraft control.

In the second case, sharp decrease in collective pitch can make the aircraft tilt to the side whilst rotating and cause it to touch the ground.

The investigations carried out following such events have never revealed any defect as regards flight controls and tail rotor assembly.

Furthermore, given their altitude and weight conditions the tail rotors were far from their maximum performance limits.

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2 – IMPORTANT REMINDERS

AIRCRAFT SEEN FROM ABOVE

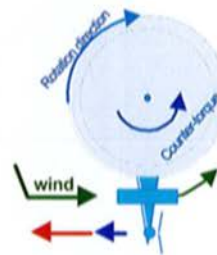


In hover flight or in very low speed flight:

The Pilot counteracts the leftward aircraft rotation by applying RH yaw pedal.

When adding a light unfavourable wind.

never forget that a leftward rotation departure can result in the aircraft's initiating a high rotation rate, if no adequate and **additional** action is immediately applied to the yaw pedals.



Remember that a **tail wind** component upon departure would worsen the problem.



In a quick leftward rotation, if the Pilot attempts to counteract this rotation by applying the RH yaw pedal up to a position corresponding to that of hover flight, the aircraft will not decelerate significantly!

In this situation, **immediate action of significant amplitude** applied to the RH yaw pedal must be initiated and **maintained** to stop leftward rotation. **Never hesitate to go up to the RH stop.**

Any delay when applying this correction will result in an increase in rotation speed.

Intentional or accidental initiation of this **rotation phenomenon** can therefore be **physically explained** and is in no way connected to the tail rotor performance; **in all cases, when adequate correction is applied, rotation will stop!**

Finally, it **should also be remembered** that any intentional manoeuvre to **initiate leftward rotation** in hover flight conditions or at very low speed, must be performed through a **moderate action** on the LH yaw pedal!

3 – ADDITIONAL TECHNICAL INFORMATION relative to various tail rotor types

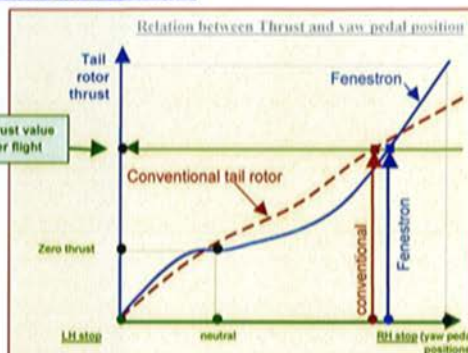
Yaw pedal positions around the hover flight

The « yaw pedal position / tail rotor thrust » law curve shape is not the same for a « conventional » rotor and a « Fenestron ».

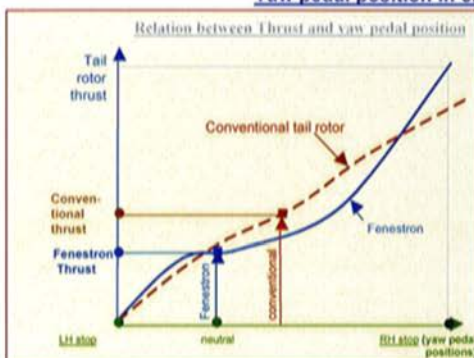
Consequently:

For the same thrust value needed for hover flight, the Fenestron requires a little more action to be applied to the RH yaw pedal.

But in hover flight, the same variation of yaw pedal position will result in **more significant effect** with the Fenestron than with the conventional rotor.



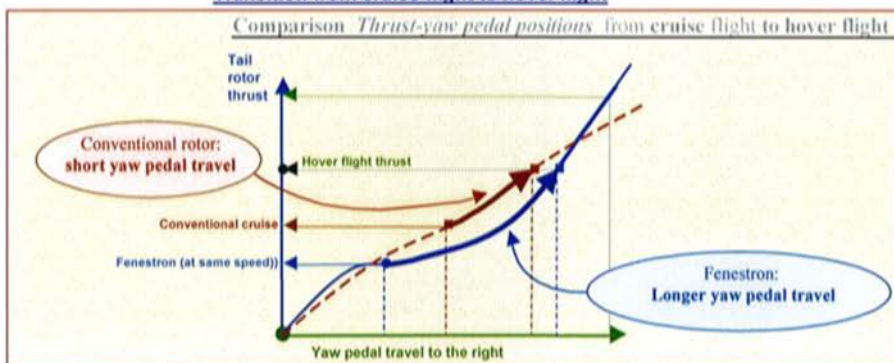
Yaw pedal position in cruise flight



In cruise flight, the **conventional rotor** delivers a thrust which comes in addition to its vertical stabilizer profile effect, so as to maintain zero sideslip.

As regards the **Fenestron**, since the fairing effect is higher due to its large surface, the thrust to be applied by the tail rotor is lower.

Transition from cruise flight to hover flight



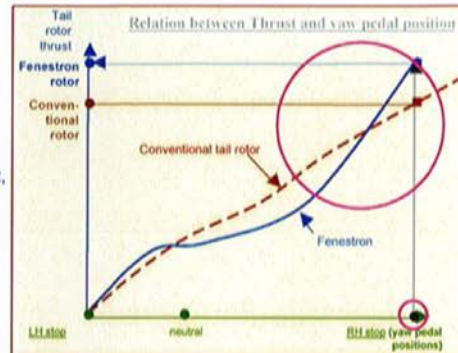
With a Fenestron, when changing from cruise flight to hover flight, be prepared for a **significant movement of the foot to the right**.

Insufficient application of pedal would result in a leftward rotation of the aircraft during the transition to hover.

Using maximum thrust

To stop rotation to the left, whether it is intentional or not, never hesitate to go up to the yaw pedal RH stop!

It can be noticed that near the RH stop, the Fenestron efficiency is very high (curve slope).



Conclusion

- 1 – In hover flight or at very low forward flight speed, stopping a quick rotation to the left must be performed by **immediately applying** the RH yaw pedal with a significant and maintained amplitude, regardless of the tail rotor type.
- 2 – In hover flight or at very low speed, intentional initiation of a turn to the left shall always be made by moderate action on the yaw pedals.
- 3 – Wind coming from the left or tail wind increases the aircraft rotation speed.

Yours sincerely,

Technical Support Operations Department
Customer Service

M. SOULHIARD

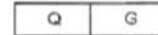
The following service letter examines a number of yaw control occurrences in helicopters having main rotors that rotate in an anticlockwise direction when viewed from above. Observations are made and technical comments provided in terms of the control inputs by the affected pilots and the helicopter systems and aerodynamic considerations in the development of the occurrences.



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DIFFUSION / ISSUE
AUSGABE / PUBLICATION



Lettre-Service
No. 1692-67-04

Marignane, 04.02.05

To all Pilots,
for all types of helicopters fitted with a tail rotor.

Main rotor rotating anticlockwise

SUBJECT: **Reminder concerning the YAW axis control for all helicopters**
in some flight conditions

The technical comments in this Service-Letter apply to **main rotors rotating anticlockwise when seen from above**. For rotors rotating clockwise, see Service-Letter No. 1673-67-04.

Ref.: First reminder = S.L. No. 1518-67 dated 26.04.2001



Dear Customer,

The analysis of the causes of severe helicopter incidents or accidents leads EUROCOPTER to issue a few reminders as regards YAW axis control in some flight situations.

1 - BACKGROUND:

Various events which occurred during flight near the ground and at very low speed in light wind conditions on aircraft fitted either with conventional tail rotors or with Fenestrons, took place as follows:

From hover flight at take-off at very low speed, the Pilot initiates a right turn a few meters above the ground by applying yaw pedals towards the neutral position; the aircraft starts its rotation which increases until the Pilot attempts to stop it by applying the LEFT yaw pedal.

In the various cases which resulted in the loss of yaw axis control, the action applied to the LEFT yaw pedal was not enough (amplitude/duration) to stop rotation as quickly as the Pilot wished.

As the aircraft continues its rotation, the Pilot generally suspects a (total or partial) tail rotor failure and decides either to climb to gain speed or to get closer to the ground.

In the first case, increasing the collective pitch results in increasing the main rotor torque and consequently further speeds up rightward rotation. This results in the loss of aircraft control.

In the second case, sharp decrease in collective pitch can make the aircraft tilt to the side whilst rotating and cause it to touch the ground.

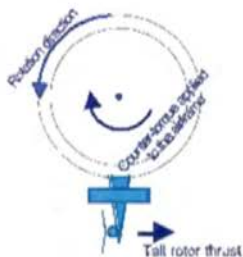
The investigations carried out following such events have never revealed any defect as regards flight controls and tail rotor assembly.

Furthermore, given their altitude and weight conditions the tail rotors were far from their maximum performance limits.

EUROCOPTER, S.A. 31 av. capital de 551 962 907,10 Euros, immatriculée au R.C.S. d'Aix-en-Provence sous le n° B 352 383 713
dont le Siège social est situé Aéroport International Marseille-Provence - 13725 Marignane Cedex - France

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2 – IMPORTANT REMINDERS AIRCRAFT SEEN FROM ABOVE

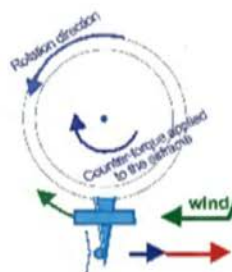


In hover flight or in very low speed flight:

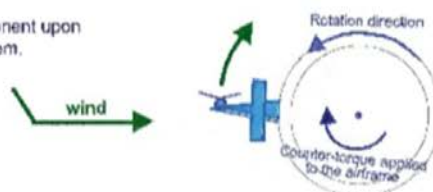
The Pilot counteracts the rightward aircraft rotation by applying LEFT yaw pedal.

When adding a light unfavourable wind,

never forget that a rightward rotation departure can result in the aircraft's initiating a high rotation rate, if no adequate and **additional** action is immediately applied to the yaw pedals.



Remember that a **tail wind** component upon departure would worsen the problem.



In a quick rightward rotation, if the Pilot attempts to counteract this rotation by applying the LEFT yaw pedal up to a position corresponding to that of hover flight, the aircraft will not decelerate significantly!

In this situation, **immediate action of significant amplitude** applied to the LEFT yaw pedal must be initiated and **maintained to stop** rightward rotation. **Never hesitate to go up to the LEFT stop.**

Any delay when applying this correction will result in an increase in rotation speed.

Intentional or accidental initiation of this rotation phenomenon can therefore be **physically explained** and is in no way connected to the tail rotor performance; in all cases, when **adequate correction is applied, rotation will stop!**

Finally, it **should also be remembered** that any intentional manoeuvre to **initiate rightward rotation** in hover flight conditions or at very low speed, must be performed through a **moderate action** on the RIGHT yaw pedal !

3 – **ADDITIONAL TECHNICAL INFORMATION** relative to various tail rotor types

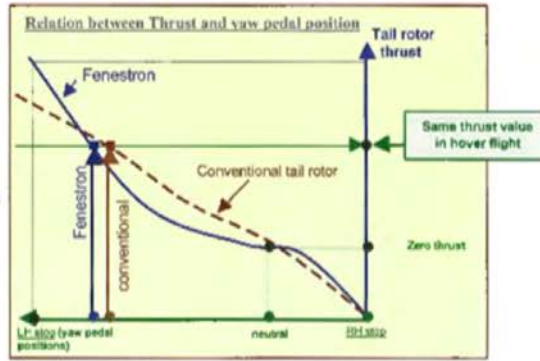
Yaw pedal positions around the hover flight

The « *yaw pedal position / tail rotor thrust* » law curve shape is not the same for a « conventional » rotor and a « Fenestron ».

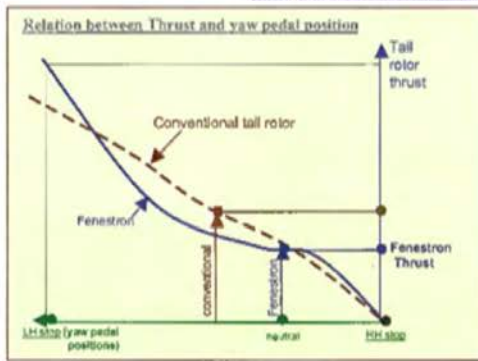
Consequently:

For the same thrust value needed for hover flight, the Fenestron requires a little more action to be applied to the LEFT yaw pedal.

But in hover flight, the same variation of yaw pedal position will result in more significant effect with the Fenestron than with the conventional rotor.



Yaw pedal position in cruise flight

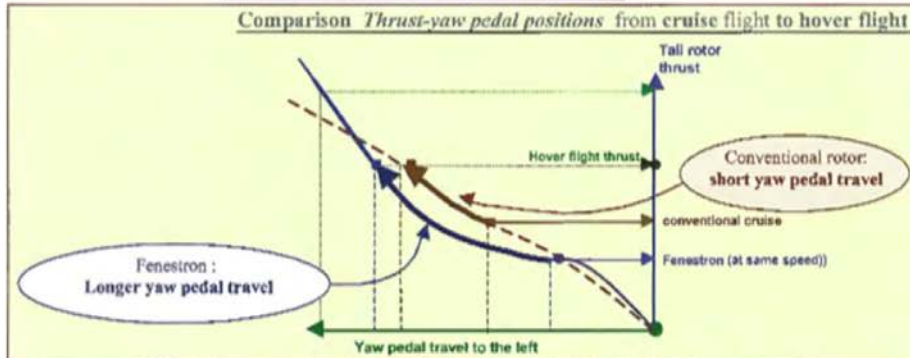


In cruise flight, the conventional rotor delivers a thrust which comes in addition to its vertical stabilizer profile effect, so as to maintain zero sideslip.

As regards the Fenestron, since the fairing effect is higher due to its large surface, the thrust to be applied by the tail rotor is lower.

Transition from cruise flight to hover flight

Comparison Thrust-yaw pedal positions from cruise flight to hover flight



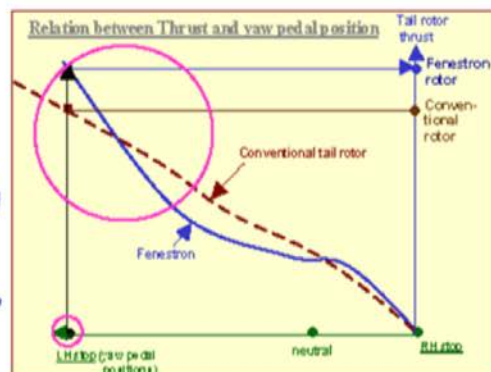
With a Fenestron, when changing from cruise flight to hover flight, be prepared for a significant movement of the foot to the left.

Insufficient application of pedal would result in a rightward rotation of the aircraft during the transition to hover.

Using maximum thrust

To stop rotation to the right, whether it is intentional or not, never hesitate to go up to the yaw pedal LEFT stop!

It can be noticed that near the LEFT stop, the Fenestron efficiency is very high (curve slope).



Conclusion

- 1 – In hover flight or at very low forward flight speed, stopping a quick rotation to the right must be performed by **immediately applying** the LEFT yaw pedal with a significant and maintained amplitude, regardless of the tail rotor type.
- 2 – In hover flight or at very low speed, intentional initiation of a turn to the right shall always be made by moderate action on the yaw pedals.
- 3 – Wind coming from the right or tail wind increases the aircraft rotation speed.

Yours sincerely,

Technical Support Operations Department
Customer Service

M. SOULHIARD

APPENDIX B: SOURCES AND SUBMISSIONS

Sources of information

The sources of information during the investigation included the:

- passenger
- owner and current and former staff of the operator
- a number of pilots who had previously flown with the pilot
- helicopter manufacturer
- hydraulic system manufacturer
- charterer of the helicopter
- Civil Aviation Safety Authority (CASA)
- Australian Maritime Safety Authority
- Bureau of Meteorology
- Queensland Police Service and Coroner.

References

Transportation Safety Board of Canada Aviation Investigation Report A05F0025 2006, Gatineau Q C, pp. 5-11 and pp. 45-49.

Aircraft Flight Manual AS350BA, Eurocopter France, Etablissement de Marignane, France.

Rotorcraft Flying Handbook (2000), US Federal Aviation Administration - FAA-H-8083-21A. Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, DC 20402-9325.

Basic Aviation Risk Standard - Resource Sector. Flight Safety Foundation Headquarters, 601 Madison Street, Suite 300 Alexandria, Virginia US 22314-1756

Submissions

A draft of this report was provided to CASA, the operator, the passenger, the charterer of the helicopter, a number of pilots who had previously flown with the pilot, the helicopter manufacturer and the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'Aviation Civile (BEA).

Submissions were received from CASA, the operator, a number of the pilots who had previously flown with the pilot, the passenger and the helicopter manufacturer. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report

Aviation Occurrence Investigation

Loss of control involving Eurocopter AS350BA, VH-RDU
93 km N of Rockhampton Airport, Queensland , 8 September 2011

AO-2011-110

Final – 5 September 2013