SERIOUS INCIDENT

Aircraft Type and Registration:	Agusta Westland AW189, G-MCGR
No & Type of Engines:	2 General Electric Co CT7-2E1 turboshaft engines
Year of Manufacture:	2014 (Serial no: 92004)
Date & Time (UTC):	17 February 2018 at 1200 hrs
Location:	Beinn Narnain, Scotland
Type of Flight:	Public Transport with easements
Persons on Board:	Crew - 4 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	43
Commander's Flying Experience:	3,800 hours (of which 350 were on type) Last 90 days - 56 hours Last 28 days - 24 hours
Information Source:	AAIB Field Investigation

Synopsis

The helicopter was tasked to rescue three climbers in the area of the Beinn Narnain mountain. The flight was at night and the crew made several attempts to reach them from different directions but due to low cloud were unable to do so. On the fourth attempt, from another direction, the visual references seen through each pilot's Night Vision Imaging System (NVIS) were lost and a turn back down the re-entrant was attempted. Due to the proximity of the ground, the pilot climbed the helicopter but lost airspeed after which the helicopter yawed to the right. The Pilot Flying (PF) attempted to use the Automatic Flight Control System (AFCS) upper modes to assist him but decoupled them because they caused the collective control lever to lower. The helicopter spot-turned through some 370° before regaining VMC on top. Control was regained and the aircraft subsequently landed. The crew liaised with the Mountain Rescue Team (MRT) who recovered the climbers on foot.

History of the flight

Search and Rescue (SAR) operations in the UK are conducted as Public Transport (PT) flights under the Air Navigation Order (ANO). The CAA, as the national regulator, grants operators 'easements' from specific provisions of the ANO to enable them to operate effectively. In particular, easements are granted with respect to PT weather operating minima, which would otherwise be too restrictive.

G-MCGR, an SAR AW189 helicopter, was based at Prestwick Airport and the crew of two pilots and two crewmen had reported for duty at 1300 hrs. They carried out their normal aircraft and equipment inspections as well as detailed briefings including the weather to be expected during the shift.

At 1919 hrs, the Maritime and Coastguard Agency (MCA) tasked the aircraft to rescue three climbers in difficulties in the area of the Beinn Narnain feature, a 3,050 ft mountain in the Arrochar range some 40 nm north of Prestwick Airport and just to the west of Loch Lomond in Scotland (Figure 1).

The weather conditions were forecast to be poor with thick cloud and snow blizzards passing through the area, rapidly changing the wind direction and strength. The commander in the right seat was the Pilot Flying (PF) with the Pilot Monitoring (PM) in the left seat. Both were equipped with helmet-mounted Night Vision Imaging Systems (NVIS) which they were using to see the ground and weather in the dark. In the cabin, the winch operator was also using his NVIS to look out of the bubble window on the right side of the aircraft whilst the winchman was using the Forward Looking Infra-Red (FLIR) system to monitor the terrain and search for the climbers.

On arrival at the scene the conditions were "around freezing" and NVIS performance was acceptable given the absence of any cultural lighting and the overcast cloud cover. The pilots could still identify enough terrain features to fly and navigate, despite a dusting of snow on the higher ground. The helicopter was being flown by the PF handling the controls in attitude (ATT) mode[1] to control the flightpath, with the conventional white lights selected ON. Their first attempts to locate the climbers were made from the south-west, but during two attempts to enter a re-entrant the cloud was too thick, so a valley turn was made to exit the area on both occasions. The conditions were described as "very challenging", but a third attempt was made from the north-east during which the lights of the climber's torches were seen through the NVIS. Due to the cloud base, the commander decided not to continue to attempt a rescue from that direction as he felt it was unsafe, so another valley turn was carried out.

The crew reviewed their options and decided to attempt to locate the climbers by entering a third re-entrant from the southeast. This had the additional problem that the helicopter would have to cross a saddle feature at the far end of the re-entrant, but if the weather was better, and this could be continuously assessed, then it might have been possible to reach the climbers from that direction. This would have allowed a safe rescue with only a small left turn to come to the hover into the wind.

As they entered the re-entrant, which with the saddle at the end the PF described as a bowl, he elected to keep the high ground on his right. With the wind from his left the helicopter would be in the up-drafting air and, should a valley turn be required to the left, it would be into wind, reducing the ground track in the 180° turn onto the escape track towards the lower ground and re-entrant entrance. The ground tracks of the previous attempts and the entry into the third re-entrant are shown in black at Figure 1.

Footnote

[1] See later sections for a description of flight control modes.

Figure 1

Ground tracks of the rescue attempts

The crew cautiously entered the re-entrant at low speed but with the PF in visual contact with the terrain on the right and the PM able to see the line feature of the stream in the bottom of the re-entrant. The PM engaged the Hover (HOV) speed mode of the Automatic Flight Control System (AFCS) which also engaged the Radio Altimeter Height (RHT) mode. This was subsequently changed to Altitude (ALT) mode and the PF "trickled" the helicopter forward at slow speed. He recalled that he used the collective control lever to adjust the height by depressing the trim release trigger, rather than by operating it against the trim actuators. As they progressed towards the saddle at the re-entrant head, differentiating between cloud, terrain, and snow-covered terrain became increasingly difficult. Realising that they were near high ground ahead which they could not see, the PF asked the PM to clear the area to the left of the helicopter in order to make a valley turn in that direction. Using his NVIS, the PM confirmed the area was clear and the PF disengaged the HOV mode and commenced a low speed moderately banked turn to the left whilst gently increasing the airspeed but also climbing. About half way around the turn, the PM stated that he had lost visual references and the PF looked across the cockpit to the left to try and pick up some visual cues but was unable to see any. The winch operator noted that at about this time the view out of his window went completely white from the helicopter external lights reflecting in the cloud.

The PF stated subsequently that in looking for visual references he became "distracted" from monitoring the helicopter heading and it passed through the intended escape track. He believed they were heading towards the rock face of the eastern side of the re-entrant, the tops of which were above his altitude. He turned the helicopter to the right with a moderate angle of bank using both cyclic and pedal controls, during which the nose pitched up and the airspeed reduced rapidly. Concerned about the high ground, he raised the collective lever to climb and attempted to engage the Go Around (GA) mode of the AFCS, which brought the collective lever under the control of the AFCS. Almost immediately, the AFCS commanded the collective lever to lower, which he did not want, and so he believed he deselected the GA mode. The GA mode had already decoupled, however, as the airspeed dropped below the disengagement threshold of 38 KIAS, and the AFCS reverted to ATT on both longitudinal and lateral axes and RHT on the collective axis. With airspeed at zero and the helicopter yawing rapidly to the right, the PF concentrated on climbing and maintaining the helicopter pitch attitude on the horizon, as indicated on the Attitude Indicator (AI). He then engaged the Transition Up (TU) mode, but again the collective lever lowered, and so he decoupled it. Apart from his concerns about the proximity of the high ground, he was concerned that, with the low airspeed, had a high rate of descent developed, raising the collective lever could have caused the helicopter to enter a vortex ring state[2].

The helicopter climbed vertically whilst continuing to yaw to the right. The winch operator could feel the yawing motion and looked across at the co-pilot's Primary Flight Display (PFD) where he saw from the Synthetic Vision System (SVS) display that the helicopter was yawing rapidly to the right. The PF was trying to maintain wings level and pitch control when the PM called that they were "above the highest terrain", the height of which they had briefed before entering the area. They had previously inhibited the Terrain Alerting and Warning System (TAWS) to prevent nuisance warnings when operating close to terrain, but this had also removed the terrain display from the PFD.

The PF pressed the trim release on his cyclic control to reset the pitch and roll trims and then trimmed the cyclic control forward to increase the airspeed. Having achieved 80 KIAS he engaged GA and the helicopter climbed wings level. At some point during this, they became VMC on top of the cloud, and saw that the helicopter had yawed through some 370°.

With the aircraft back under control, the crew flew to a landing site at Ardgartan close to where the Mountain Rescue Team (MRT) were assembled and briefed them on the conditions that had prevented the rescue. The MRT then walked onto the mountain and recovered the three climbers.

Recorded information

The operator provided the AAIB with a copy of the recorded data for the flight. No CVR recording for the flight was available as the recordings had been overwritten with more recent flights in the time between the incident and when the AAIB were notified of the event.

Footnote

2 Vortex Ring state where the helicopter downwash created by the main rotor, at low airspeed and with a significant rate of descent with power applied, will recirculate the downwash through the main rotor and cause the helicopter to descend rapidly in the downwash. Recovery is difficult and can result in significant height loss.

Figure 2 shows a plot of the salient data for the event and starts with the helicopter already within the re-entrant, which it had entered one minute earlier on a heading of 295°M at about 2,180 ft amsl and with 4 kt groundspeed (11 KIAS) before climbing to about 2,400 ft amsl and accelerating to 14 kt groundspeed. Both autopilots were on with HOV and ALT modes selected on the AFCS.

With reference to Figure 2, the following points in the flight are highlighted:

- UTC 20:08:10 – The helicopter commenced a turn to the left at the head of the re-entrant. Altitude was 2,400 ft amsl, airspeed was 11 KIAS and groundspeed 14 kt. The AFCS HOV and ALT modes were deselected 5 seconds later, and the AFCS reverted to the ATT mode.
- UTC 20:08:30 – During the left turn, the airspeed was just over 50 KIAS. The roll angle peaked at 30°, with the groundspeed reaching 57 kt a few seconds later as the helicopter started to roll out of the turn on a heading of 098°M at a height of 840 ft agl.
- UTC 20:08:38-40 – The helicopter pitched to 18° nose-up with the wings level at 2,750 ft amsl (1,070 ft agl) and on a heading of 123°M. At an airspeed of 47 KIAS the GA mode was selected for two seconds before decoupling due to the drop in airspeed to below 38 KIAS. The AFCS reverted to ATT mode on the longitudinal and lateral axes and RHT on the collective axis. With the RHT mode engaged the collective lever lowered to maintain the radio height. The airspeed had reduced rapidly to 11 KIAS.
- UTC 20:08:50 – After 10 seconds the RHT mode dropped out with the airspeed still at 11 KIAS. The helicopter was at 2,880 ft amsl rotating through the vertical axis to the right through a heading of 140°M.
- UTC 20:09:00 – The TU mode and its associated RHT mode were engaged as the helicopter climbed through 2,975 ft amsl with a climb rate of about 1,000 fpm. Airspeed was still 11 KIAS and the helicopter was yawing through a heading of 250°M as it continued to rotate.
- UTC 20:09:10 – The helicopter climbed above the height of highest ground (Beinn Narnain at 3,050 ft amsl). Radio altitude was 1,100 ft agl, airspeed 11 KIAS and the heading was 345°M. TU and RHT modes were decoupled with the AFCS defaulting to the ATT mode.
- UTC 20:09:23 – The maximum altitude of 3,250 ft amsl was reached and the helicopter then descended and accelerated on a heading of 130°M.

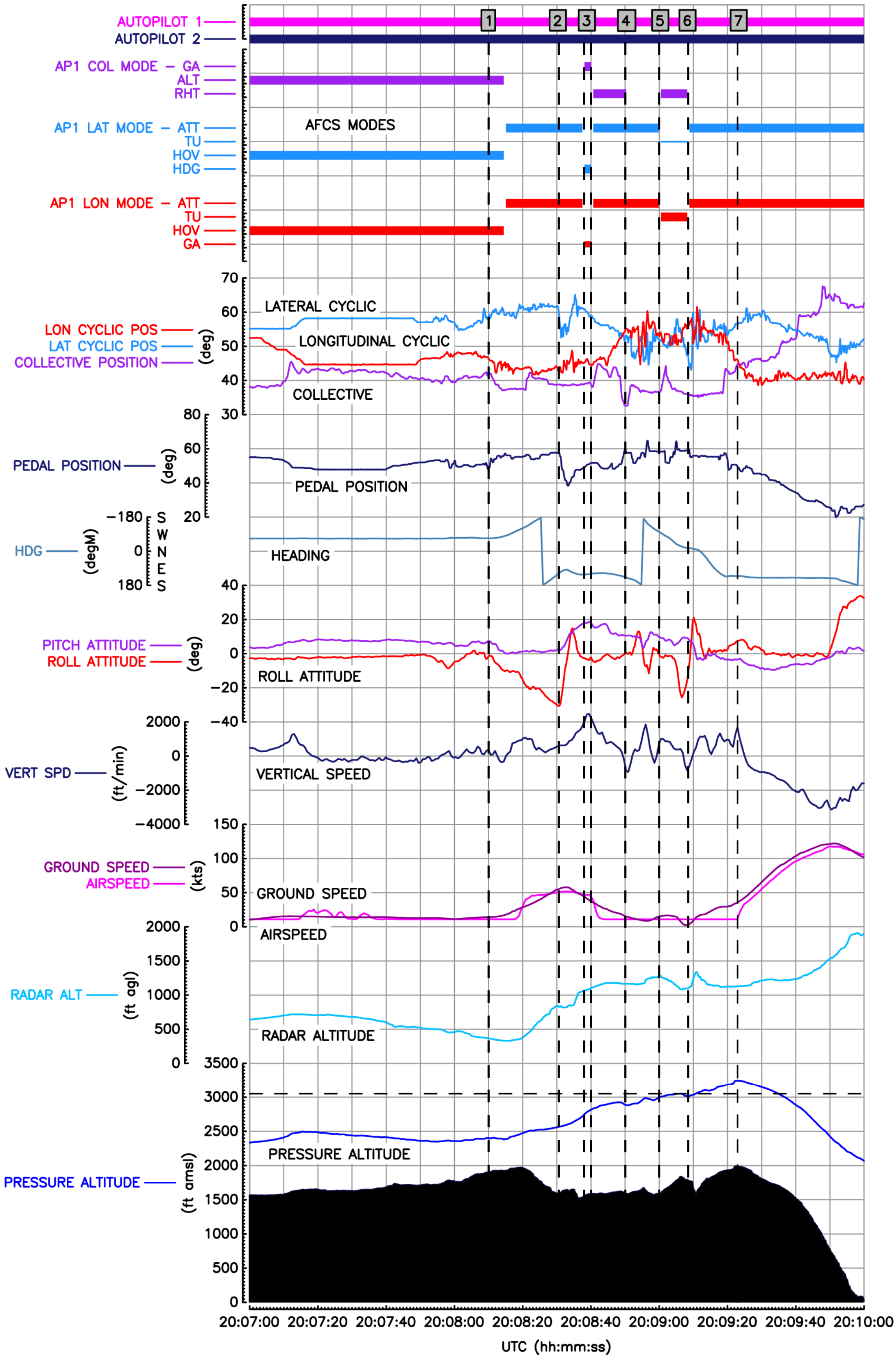

Figure 2

Salient parameters from recorded with the terrain elevation immediately below the helicopter in black

Aircraft information

General description

The SAR AW189 helicopter is a derivative of the commercial Air Transport version with specialist role equipment and an enhanced AFCS. The incident helicopter is shown at Figure 3.

Figure 3

G-MCGR in the SAR equipped role

The helicopter has EASA certification to be flown by two pilots and carry up to 19 passengers on VFR or IFR flights. Two General Electric CT7-2E1 turboshaft engines equipped with Full Authority Digital Engine Control (FADEC) power the five-bladed main, and four-bladed tail rotors. Flight in icing conditions is permitted using the ice protection system. The helicopter is equipped with retractable main and nose landing gear with flotation equipment for overwater flight. It has a maximum permitted all up weight of 8,600 kg, a Velocity Never Exceed (V_{NE}) of 169 KIAS and a maximum cruise speed of 155 KIAS.

Automatic Flight Control System (AFCS)

The AFCS is a dual-duplex redundant, predominantly electromechanical system, that provides varying degrees of automatic control of flight. The operating modes of the AFCS are split into attitude stabilisation and upper modes.

In attitude stabilisation modes, the controls operate in three axes (pitch, roll and yaw), and Attitude Hold (ATT) is the default operating mode of the system. Stability Augmentation System (SAS) is the degraded mode of operation when ATT is not available. SAS provides short term corrections in response to turbulence.

Upper modes, which consist of Primary and Flight Director (FD) upper modes, control the helicopter in four axes (pitch, roll, yaw and collective). Primary upper modes control basic helicopter parameters and performance such as heading (HDG), altitude (ALT), airspeed (IAS), vertical speed (VS), Wings Level (WLVL) and Go Around (GA). FD upper modes control the flight path of the helicopter; for example, the navigation mode allows the helicopter to be flown automatically to the active flight plan or tactical steering patterns from the Flight Management System (FMS), and Approach (APP) modes allow automatic control of a precision approach. Additional SAR modes relevant to the incident are Transition Up (TU), Radio Height (RHT) and Hover (HOV).

The pilot can override the AFCS at any time by manually moving the controls. When the pilot takes command of the helicopter, AFCS operation is suspended. When the pilot relinquishes control, AFCS operation resumes.

The AFCS has a Flight Control Computer (FCC) which has two independent but connected channels (Channel 1 and 2). AFCS actuation (that is movement of the control surfaces, main and tail rotor blade pitch) is carried out using linear (series) and trim (parallel) actuators.

AFCS Control Panel (AFCS CP)

The AFCS CP provides controls for mode arming/engagement and mode status display. It is also used for pre-flight testing. The AFCS CP is in the centre of the inter seat console between the pilots (Figure 4).

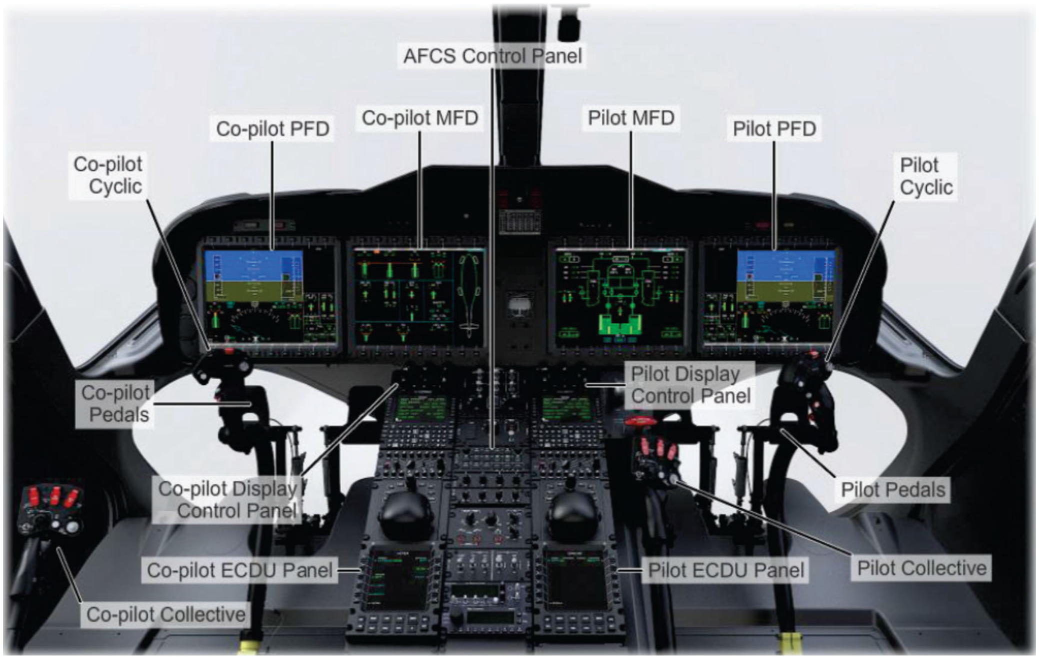

Figure 4

AFCS Control Panel location

It has 16 push buttons and two rotary/push knobs. Each button and rotary knob has its function annotated above it (Figure 5).

Figure 5

AFCS Control Panel

The mode selected is displayed on the PFD Annunciator Area (AA) which shows whether the mode is active or armed as well as any values for the available mode (Figure 6). A triangular green pointer in the centre of the AA indicates which pilot has command of the AFCS. The AA displays from left to right the armed/captured collective modes, the armed/captured pitch modes, captured roll/yaw modes and armed roll/yaw modes. Captured modes are in green and armed modes in white. Modes are selected and deselected using the AFCS CP.

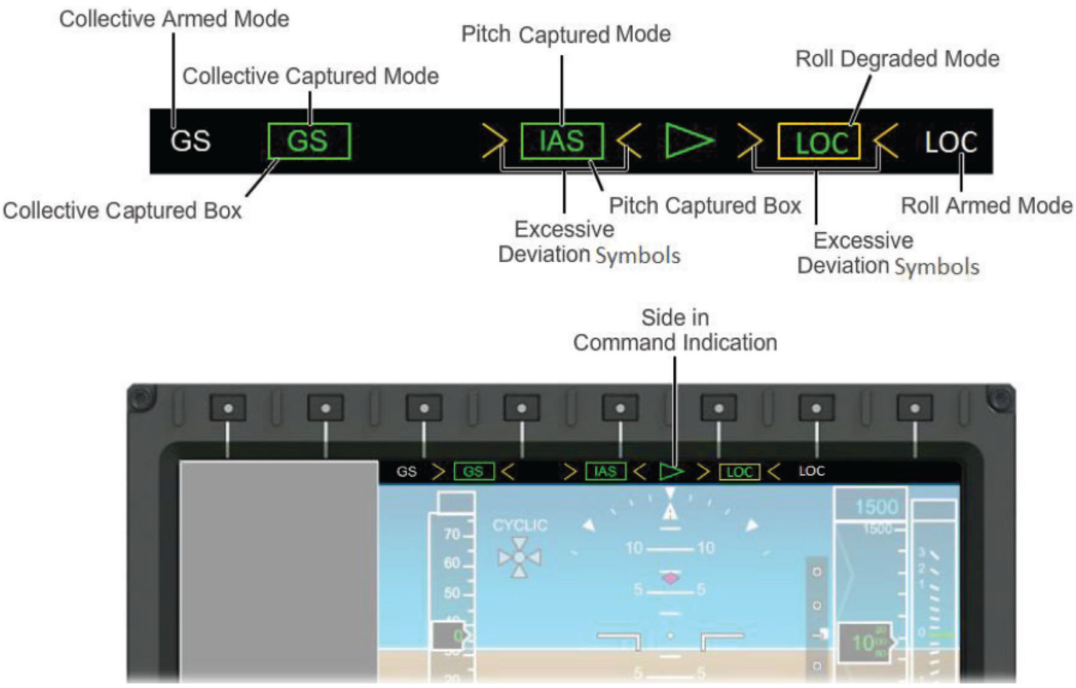

Figure 6

Pilot's Flight Display Annunciator Panel

AW189 SAR Limitations and Airworthiness Approval

Limitations

The SAR modes of the AFCS were approved under EASA Certification Standard CS 29, '*Certification Specifications and Acceptable Means of Compliance for Large Rotorcraft*', Appendix B, and Special Condition CRI B-03. This permits flight in Instrument Meteorological Conditions (IMC) below the Instrument Flight minimum speed (V_{MINI}) of 50 KIAS but only with the AFCS coupled in the four-axis SAR mode. The use of the SAR and associated RHT modes in IMC is authorised only over flat surfaces which are clear of obstructions with a minimum Flight Crew for SAR operations of two pilots.

Airworthiness Approval

Applicable criteria for airworthiness approval of SAR modes are established under the Special Condition CRI B-03. The CRI B-03 is intended to provide adequate safety standards for the rotorcraft when flown below V_{MINI} in IMC using the SAR modes. CRI B-03 applies:

1. To the SAR system and dedicated higher modes of the AFCS;
2. To single/dual pilot operations over water during automatic approach to the hover, departure from the hover and in the hover;
3. Under IMC in an area which is clear of obstructions.

There are neither Airworthiness Criteria nor adequate safety standards established/agreed with EASA to certify a rotorcraft that is intended to fly in IMC below V_{MINI} in an area that is not clear of obstructions eg mountains, cliffs.

Operational capability

The SAR mode that permits manoeuvring vertically and horizontally whilst in the hover is the Hover (HOV) mode. Automatic transition from the hover into climb and acceleration of the helicopter is the TU mode, and both modes are relevant to the incident flight. GA is a mode which is included in the normal AFCS system and is not a dedicated SAR mode, but it is also relevant to the incident flight. Those modes and others available for the situation encountered are:

Go around (GA) mode

GA mode is mainly used when carrying out a missed approach; it is operative above 40 KIAS and disengages automatically if the airspeed reduces below 38 KIAS. It controls the aircraft in a climb profile at a fixed, non-adjustable climb rate, and HDG mode is engaged simultaneously. GA is engaged by pressing the GA/TU button on the collective grip. Once the helicopter reaches 200 ft radio height, 1,000 fpm and 80 KIAS, the GA mode disengages and VS, IAS and HDG modes are then engaged. The GA/TU button and displays are shown at Figure 7.

Figure 7

Go around push-button location on the collective lever and PFD presentation

Hover (HOV) mode

The HOV mode performs two functions:

- Acquire and hold the current longitudinal and lateral groundspeed (Hover Speed Hold)
- Acquire and hold zero kt longitudinal and lateral groundspeed (Hover Position Hold)

Hover Speed mode is engaged by pressing the HOV button on the AFCS CP which automatically changes the Horizontal Situation Indication (HSI) display to the hover mode symbology format (Figure 8). At Hover Speed mode engagement, RHT and HDG modes are simultaneously engaged; the AFCS maintains the current radio height and heading, but both can be adjusted using the collective beep trim switch. The cyclic beep trim switch can be used to control groundspeed.

Hover Position mode is selected by pressing the cyclic beep trim switch (Figure 9) which causes the HSI to display the hover mode format. At Hover Position mode engagement, RHT and HDG modes are simultaneously engaged; as the helicopter reduces its groundspeed to 0 kt and the AFCS maintains the current radio height and heading (Low speed heading hold). Radio height and heading are controlled by the collective beep trim switch, and groundspeed can be controlled by the cyclic beep trim switch.

Figure 8

Horizontal Situation Indication (HSI) Hover Speed mode symbology

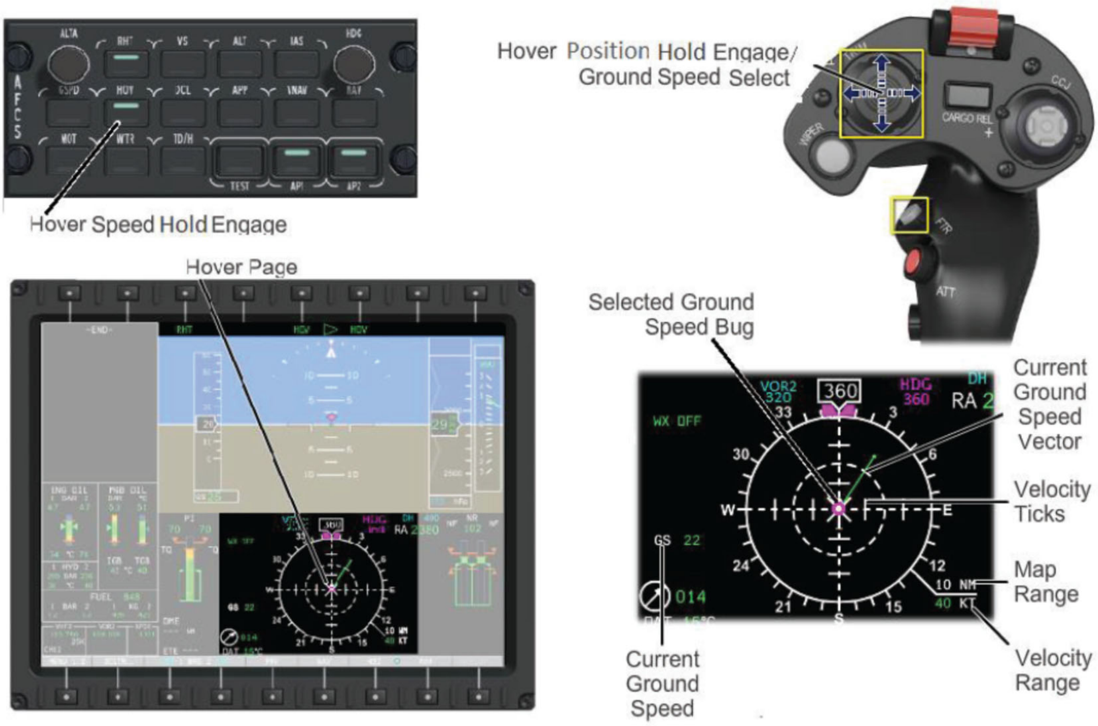

Figure 9

Hover Position Hold mode selection display and operation

Radio Height (RHT) mode

Pressing the RHT button on the AFCS CP engages the RHT mode and the current radio height is captured and held by the AFCS. RHT operates on the collective axis only. When the RHT mode is engaged, radio height can be controlled using the collective beep trim switch.

Manual control of the collective lever is achieved by pressing the Force Trim Release (FTR) 'trigger' under the collective hand grip. The collective lever can then be moved up and down with the pitch and roll modes being maintained by the AFCS. Radio height is maintained by the AFCS where the FTR was released.

Manual control of the collective without pressing the collective FTR causes the RHT bug to remain at its previously set value as the helicopter's height increases or decreases. When the pilot releases the input on the collective the AFCS resumes control and returns to the original radio height. The controls and displays are shown at Figure 10.

Figure 10

Radio Height (RHT) mode selection, display and operation

Altitude (ALT) mode

Altitude (ALT) mode provides the capability to maintain a selected barometric altitude and operates on the collective axis. Pressing the ALT button on the AFCS CP engages the ALT mode. A magenta bug is displayed on the barometric altitude scale positioned at the current value. The barometric altitude is captured and held by the AFCS. When ALT mode is engaged, the position of the ALT bug can be changed using the collective trim switch.

Transition up (TU) mode

This mode is used during the climb-out phase from the HOV mode or to abandon a Transition Down (TD) to HOV during SAR operations. TU mode provides a fully automated ascent combining rate of climb to 200 ft pre-set radio height and acceleration to 80 KIAS. Roll angle is controlled throughout the ascent profile to maintain the heading on selection of the mode.

Attitude (ATT) mode

On both cyclic control grips there is an Attitude Hold (ATT) push button that allows the pilot to acquire and hold attitude. When the ATT mode is engaged pitch, roll and (low speed) heading reference bugs are displayed on the PFD. ATT will annunciate both aurally and on the PFD. If the button is pressed, other modes are disengaged, and pitch, roll and yaw attitude hold modes are activated.

Wings Level (WLVL) mode

The Wings Level (WLVL) mode (Figure 11) is a safety feature which allows the pilot to return to near straight and level flight with one key press. This mode has high priority and momentarily pressing it will disengage all other AFCS modes and place the helicopter in a wings level, 6° nose-up pitch attitude. The key is on the left side of both cyclic controls and WLVL mode can be disengaged by pressing the ATT button on either cyclic control or engaging any other AFCS mode.

Figure 11

Wings Level (WLVL) mode

Heading Hold (HDG) mode

The Heading Hold (HDG) mode provides the capability to acquire and hold a magnetic reference heading. The cyan heading bug on the HSI can be selected to a required heading using either the rotary heading selector knob on the AFCS CP or the cyclic beep trim switch.

When IAS is greater than 40 KIAS, selecting a new heading will cause the AFCS to carry out a balanced, rate one turn onto the new heading. Below 40 KIAS, the heading can be adjusted in the same manner as when HOV or ATT mode is active.

For the HDG mode to function normally, pilots must keep their feet clear of the tail rotor control pedals. The pedals are fitted with micro switches which, if pressed with the feet, prevent the yaw actuator from changing tail rotor pitch and maintaining HDG.

Synthetic Vision System (SVS)

The helicopter was equipped with SVS, which assists a crew by improving situational awareness in relation to terrain and helicopter flight path by displaying a visual picture on the PFD. SVS provides the pilots with displays of the helicopter position relative to the surrounding terrain and known obstacles. The system components are a navigation database and obstacle database stored in each PFD/MFD, and a complete terrain database stored in a Data Transfer Device (DTD).

The Flight Path Vector (FPV) symbol represents the current trajectory of the helicopter and is removed from the display below 20 kt groundspeed.

The PFD with SVS presentation and the Field of View (FOV) in the horizontal and vertical planes are shown at Figure 12.

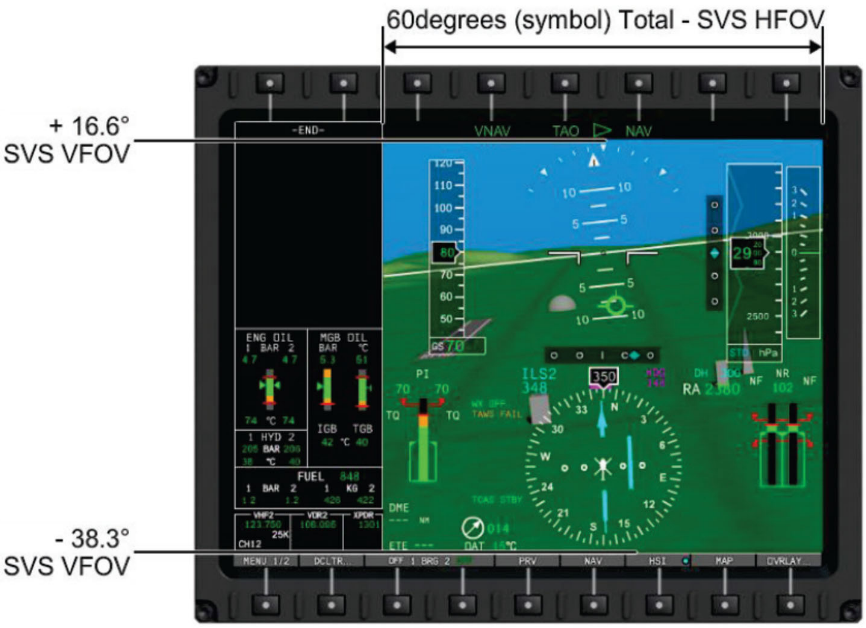

Figure 12

PFD SVS presentation and FOV display

On the PFD (with SVS active), the horizon line is always represented as a white line as shown at Figure 13.

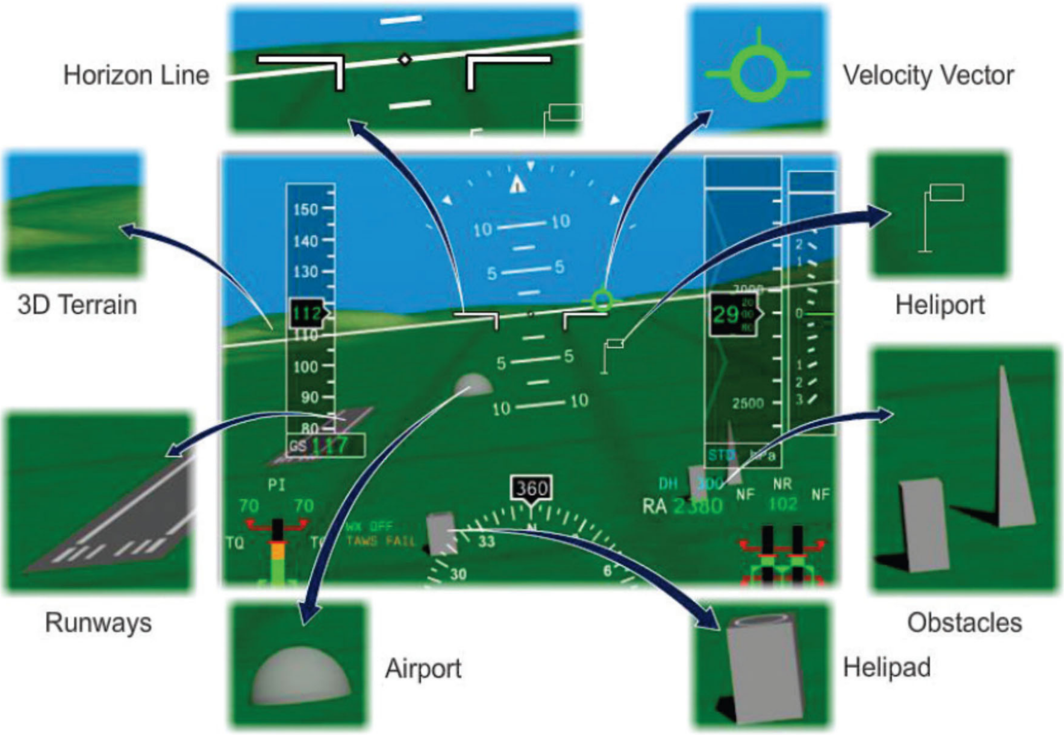

Figure 13
SVS Symbology displayed on the PFD

Terrain consists of the earth's natural surface. Terrain data is derived from a high-resolution database. The SVS image contains terrain consisting of 3D terrain and bodies of water such as oceans, and major lakes and rivers. By texturing the terrain surface, the SVS presentation provides useful cues to the pilot. Colour indicates the absolute elevation of the terrain features and distinguishes the land from the blue of the sky and dark blue of the water. Shading is used to create shadow components which help provide a 3D look and feel to the terrain surface. An example of the SVS terrain display is shown at Figure 14.

The operating manual contains the following statement:

> *'**CAUTION:** FPV is NOT a primary flight instrument. Always use FPV in combination with raw data, an altimeter and/or Visual Cues.'*

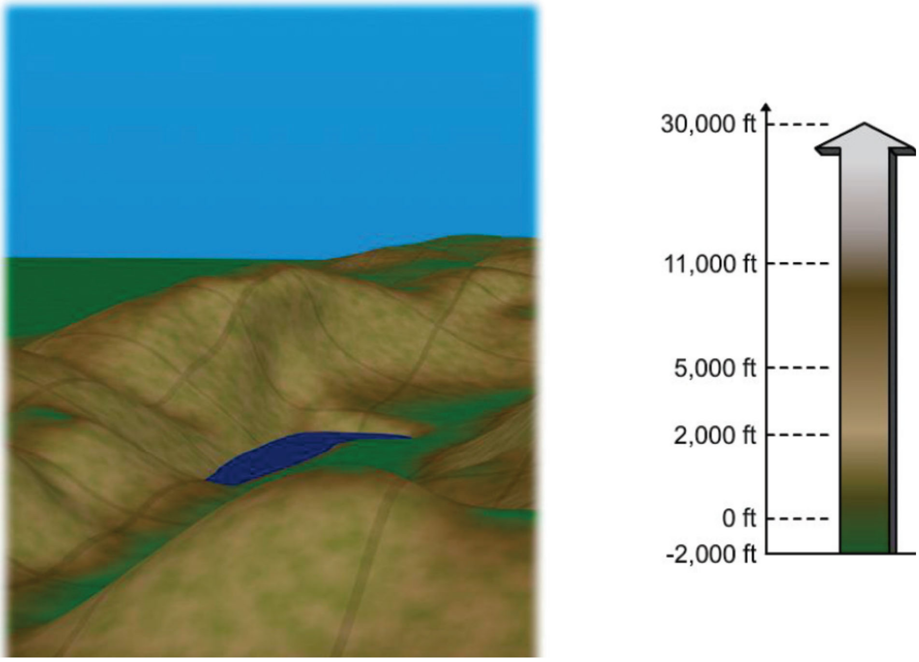

Figure 14

SVS Presentation of the terrain in 3D with texturing, shading and colour coding

Helicopter Terrain Awareness Warning System (HTAWS)

The helicopter was equipped with HTAWS which uses the same databases as SVS and provides the pilot with a display of the helicopter position relative to surrounding terrain. The outputs of the system include: terrain and obstacle display, visual cautions and warnings, voice alerts, warnings and callouts. The HTAWS has two alerting functions described below.

The Forward Looking Terrain and Obstacle Avoidance (FLTA) Alerting Area is an area mostly in front of and to both sides of the helicopter. Through lookahead algorithms, alerts are generated if terrain or an obstacle conflict with the flightpath of the helicopter.

The Ground Proximity Warning System (GPWS) has a downward looking alert capability which generally uses the radio altimeter as an alerting source. The GPWS alerting function operates in accordance with six GPWS Modes.

The HTAWS MFD display and controls are shown at Figure 15.

In relation to the incident, the FLTA offered the crew of G-MCGR an indication of terrain and its proximity to the helicopter. Where a helicopter is operating in close proximity to terrain or obstacles, it is normal to inhibit the audio or the complete HTAWS to prevent nuisance warnings. In the bottom right of the display are options for inhibiting the capabilities of the HTAWS. When INHIBIT is selected, a TAWS INHB caption is shown in the top left of the display, and the terrain image, obstacle symbols and alerts are removed from the display. In addition, all FLTA and GPWS audio alerts, except for GPWS Mode 6 (altitude callouts), are inhibited.

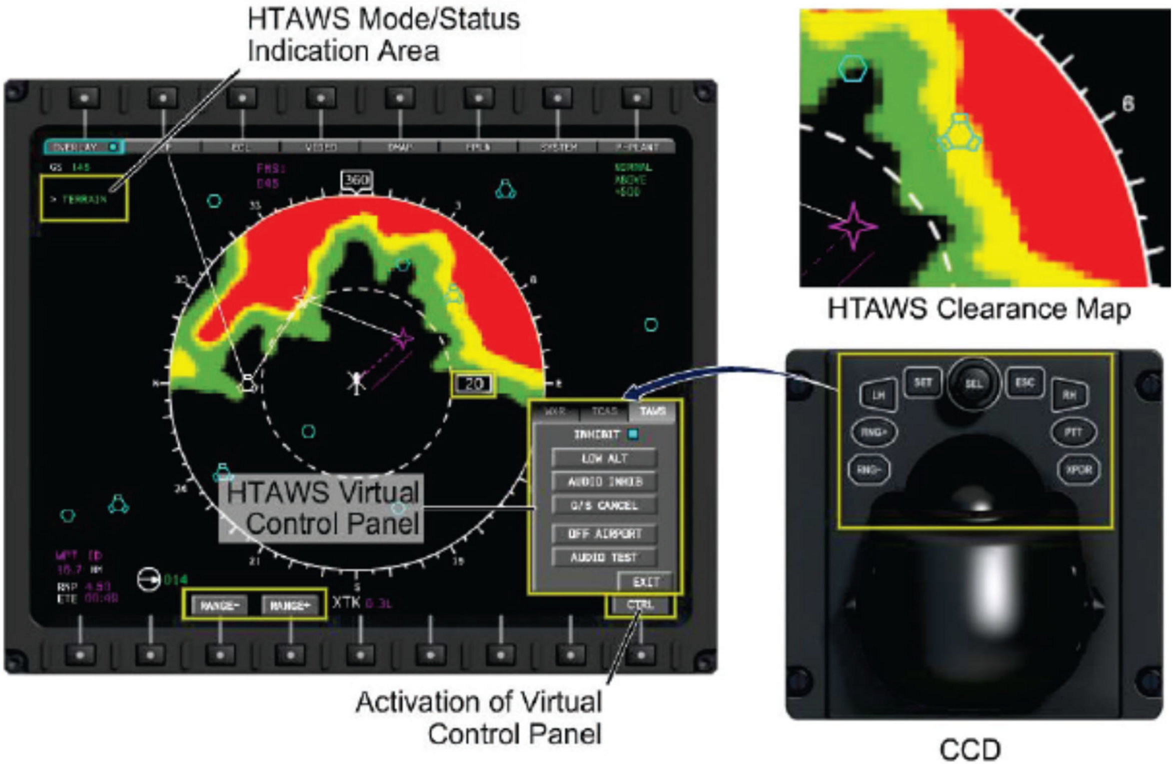

Figure 15

HTAWS MFD display and controls

If just the AUDIO INHIB is selected, only aural FLTA and GPWS cautions are muted. HTAWS aural warnings and altitude callouts cannot be muted. With AUDIO INHIB selected, a MUTE caption appears in the top left of the display. The audio reactivates automatically after five minutes.

The HTAWS terrain display is colour coded and is used to make potentially conflicting terrain appear distinctive. Different elevations will be coloured to give the pilot a cue of the relative elevation of any piece of surrounding terrain. The colour coding is shown at Figure 16.

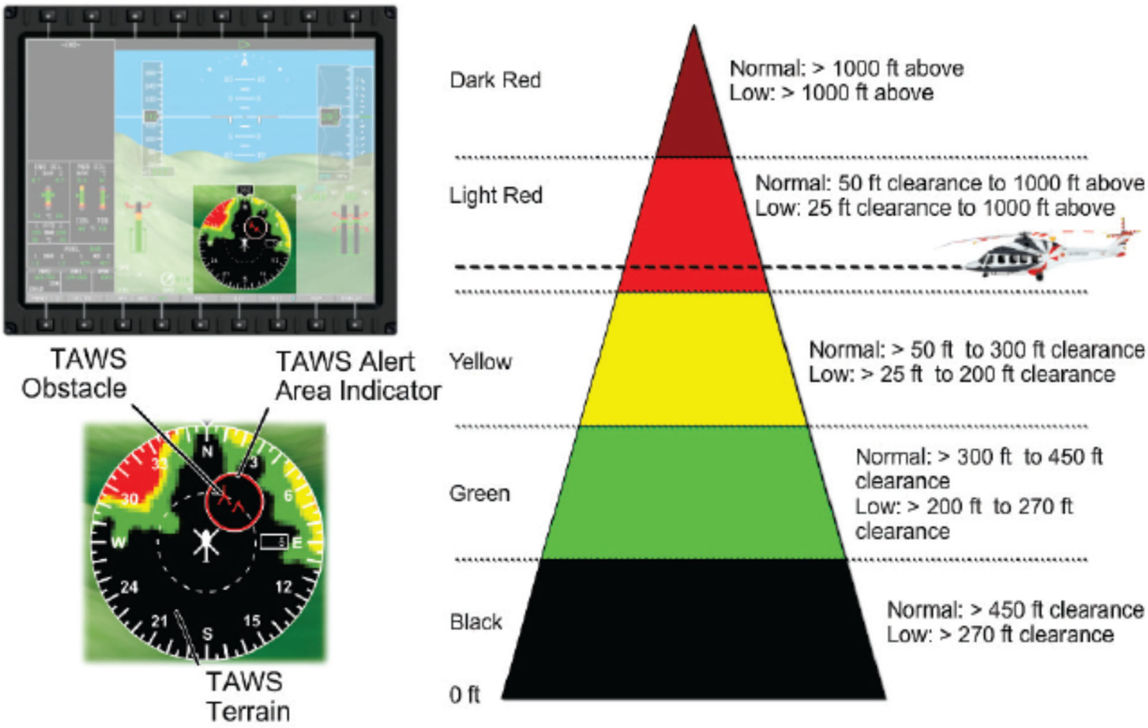

Figure 16

HTAWS Terrain colour coding showing relative elevation of surrounding terrain

Night Vision Imaging System

The crew were all using helmet mounted NVIS sometimes referred to as Night Vision Goggles (NVG). Two image intensifying tubes are mounted side by side on a frame attached to tracks on the front of the helmet. A battery pack, which also contains backup batteries, is mounted at the rear of the helmet and acts as a counterweight to the goggles. They can be in the lowered position when in use and the raised position when not required, as shown at Figure 17. An example of an image through NVIS is shown at Figure 18.

Figure 17

The helmet mounted NVIS in the lowered position on the left and raised position on the right

Figure 18

An example of an NVIS image illustrating the green monochrome picture[3]

Forward Looking Infra-Red (FLIR)

The helicopter is equipped with a Star Safire 380HD passive camera system that collects infra-red (IR) and visible light for detection, recognition and identification allowing pilots to see in total darkness, through smoke and in other low visibility, low contrast situations. It is installed under the nose of the helicopter, allowing 360° rotation and visibility. The images produced are displayed on 'fold-down' flat screens in the rear of the passenger cabin and an adjacent moveable hand controller panel is operated by one of the rear crewmen. The images can also be displayed on the pilots' MFDs. The camera turret is gyro stabilised and has a camera zoom, auto tracking and laser range finding capability. The IR image is displayed in monochrome which can be selected to black or white indicating hot or cold temperature differences.

Footnote

[3] This image is for illustration purposes and was not produced from the systems worn by the crew of the incident helicopter.

SAR Operations

The Operator's Flight Operations Manual (FOM) contains the two following statements relating to SAR operations that permitted the incident flight to be undertaken in the conditions experienced:

> *'SAR Operating Minima*
>
> *For the purposes of SAR operational flights, the Authority grants alleviations from standard operating minima. These alleviations are granted on the condition that crews have successfully completed the operator's approved SAR OCC and training course. When conducting SAR operational flights, it is beholden on the SAR Commander (utilising the best information available) to use his judgement as to whether the risk to the aircraft and crew, balanced against the perceived gain to the casualty, justifies the application of the full use of these alleviations.'*

And:

> *'Weather minima*
>
> *When piloted by a qualified SAR crew, company SAR helicopters that are equipped with a fully serviceable SAR auto-hover system with a 'transition down' function are cleared to* [Rotorcraft Flight Manual] *minima in IMC. For SAR operational flights there are no restrictions on weather minima.'*

Meteorology

At the time of the incident flight, there were a series of low-pressure systems to the north and north-west of the British Isles with frontal systems approaching south-west England. A moderate south-westerly airflow produced a wind at 2,000 ft amsl which was from 250° at 20 kt and at a temperature of -2°C. Cloud was generally a thin layer with a main cloud base of 2,000 ft amsl but with isolated showers of sleet and snow. Visibility outside the showers was generally good but reduced to 800 m in sleet or snow.

The crew reported that they experienced sleet and snow showers at their altitude which reduced visibility in the rescue area at times to less than 1,000 m.

Personnel

The flight crew comprised two pilots, the helicopter commander seated in the right seat who was the PF and the co-pilot in the left seat who was the PM.

The commander

The commander had served in the armed forces as a helicopter pilot flying large helicopters, three years of which were spent on SAR operations. He joined the company which operated G-MCGR in 2013, initially flying the Sikorsky S-92 in the 'oil and gas' support role before transitioning to the SAR role as a co-pilot later that year. He became a SAR commander on the type in 2014 moving from the northern operations to Prestwick SAR in late 2015 also operating the S-92. In February 2017 he converted onto the AW189 followed by SAR line training before returning to Prestwick in May 2017. He had 400 hours experience of flying using NVG.

The co-pilot

The co-pilot had flown fixed wing aircraft initially before moving onto helicopters in 2002. He had flown a mixture of oil and gas support operations and SAR on the Super Puma L2 and Sikorsky S61 before transitioning onto the AW189 SAR operation in 2014. He commenced NVG flying in 2017 and had accumulate 40 hours using them at the time of the incident.

Analysis

The helicopter was being operated in difficult flying conditions of low cloud, reduced visibility and darkness, over largely featureless terrain with no cultural lighting, which was compounded by a light covering of snow on the upper slopes. These conditions were still viable for visual contact flight using NVIS, given the high levels of crew training and helicopter equipment, and were within the weather minima for SAR. The nature of the task placed a strong desire on the part of the helicopter crew to try and recover the climbers as quickly but as safely as possible.

The crew had planned their approach to attempting the rescue and, when the weather prevented their progress, the pilot executed valley turns using the NVIS and AFCS in ATT mode to return to the lower ground. The upper SAR modes, which had reduced workload progressing up the re-entrant, allowed greater capacity for the pilot to manage the flight but were disengaged during the valley turns.

After the initial attempts at rescue in the first two re-entrants, the final entry into the 'bowl' was made in conditions of low cloud base and visibility much the same as those experienced earlier. During the low speed progress into the bowl, the weather deteriorated rapidly, resulting in the pilot abandoning further progress but also causing a loss of visual references at a critical time in the valley turn. His concentration in attempting to regain the external visual references distracted him from monitoring the heading on his HSI and he passed through the escape heading required for exiting the bowl to the lower ground. Believing that the left turn and the resulting helicopter ground track was taking them towards the high ground, he reversed the turn to the right, but the helicopter's airspeed reduced rapidly due to the nose pitching up 18°. His priority was to climb, so he raised the collective significantly to achieve a maximum rate of climb and the helicopter responded. It is probable that his feet were on the tail rotor control pedals but he did not have enough left pedal applied to prevent the helicopter yawing to the right. The airspeed reduced below 11 KIAS, and with the same tail rotor pedal position and maximum power applied the helicopter yawed to the right continuing through some 370°.

The crew had inhibited the HTAWS, which was normal when flying in the mountains visually and close to the terrain to prevent 'nuisance' warnings. This meant that as the helicopter manoeuvred the pilot had no information on the relative height and proximity of the terrain. The PF recalled that the SVS was selected off on his display and therefore the information from that presentation was not available.

The PF tried to use the AFCS to assist with correcting the difficult situation, initially using the GA mode. He expected it to establish the helicopter on a heading, adopting a wings level attitude with a climb and acceleration. Due to the existing high rate of climb of 1,800 fpm, however, the AFCS lowered the collective lever to achieve the 1,000 fpm and 80 KIAS targeted in the GA mode. This concerned the pilot as he wanted to climb quickly but at that moment, as the airspeed dropped below 38 KIAS, the GA mode de-coupled. The RHT mode engaged as it was designed to, until it was decoupled by the PF. He next tried engaging the TU mode, which also caused the collective lever to lower but this time the helicopter had no airspeed. This was also not what he wanted or expected, especially considering the possibility of entering vortex ring state, and so he decoupled the AFCS and 'hand flew' the recovery. He did not want to select the WLVL mode as this would have set a nose-up pitch attitude of 6° and he wanted to maintain a lower, accelerating pitch attitude. Despite the unintended yaw to the right, the pilot was able to maintain a relatively wings level attitude with the nose on, or near the horizon using his basic instrument flying (IF) skills assisted by the PM stating that they were above the high ground. While the PF was correcting the yaw to the right, the helicopter became clear of the cloud and he saw visual references through his NVIS. He was then able to use the GA mode to transition the helicopter into safe and stable flight.

Conclusion

The incident happened when visual references were lost as the helicopter made an inadvertent entry into cloud during the valley turn. The escape heading required to exit the re-entrant was missed due to the pilot attempting to locate visual references which, due to being IMC, were not available. Use of the AFCS modes, which operated correctly, did not improve the situation but created concern at the unwanted lowering of the collective control lever, and this resulted in the AFCS modes being disengaged. The situation was being resolved, by the PF using his basic IF skills and with the assistance of the PM announcing that they were above the high ground, when the helicopter regained VMC on top of the cloud.

Safety action

Shortly after the incident, the operator introduced a scenario-based training exercise for all pilots that reproduced the incident during six-monthly recurrent training and testing. The training was continued with an emphasis on unusual attitude recovery.

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