Serious Incident

Aircraft Type and Registration:	Leonardo AW189, G-MCGT
No & Type of Engines:	2 General Electric Co CT7-2E1 turboshaft engines
Year of Manufacture:	2014 (Serial no: 92006)
Date & Time (UTC):	26 July 2021 at 1950 hrs
Location:	Ballintoy Harbour, County Antrim
Type of Flight:	Emergency Services Operations
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:	46 years
Commander's Flying Experience:	5,100 hours (of which 1,100 were on type) Last 90 days – 101 hours Last 28 days – 30 hours
Information Source:	AAIB Field Investigation

Synopsis

The Search and Rescue helicopter was on its third approach, in poor visibility, to collect a casualty from a site adjacent to high ground. The Pilot Flying (PF) selected a mode of the Automatic Flight Control System (AFCS) which would bring the helicopter to a hover. As he did so, the helicopter unexpectedly yawed towards the high ground. When a further selection was made on the AFCS to effect a go-around, the helicopter accelerated towards the terrain while maintaining height. The Helicopter Terrain Awareness Warning System (HTAWS) triggered a visual and aural CAUTION TERRAIN alert. The crew immediately made a climbing turn onto their planned escape heading during which a WARNING TERRAIN alert triggered. The helicopter recovered to a safe height and returned to its home base.

The unexpected yaw was caused by a mismatch between the previously selected AFCS heading reference and the heading flown by the PF. While the helicopter and the flight control system were found to be serviceable and performed as designed, the crew did not have a complete understanding of the functionality of all the AFCS modes. Other factors included:

- Overriding the engaged modes by manually flying the helicopter.
- A lack of clarity between the role of PF and Pilot Monitoring (PM).
- Ineffective communication and co-ordination between the pilots.
- Imprecise application of Standard Operating Procedures (SOPs).

The operator took a number of safety actions to raise awareness of the event, improve knowledge of the autopilot modes and include the event as part of their initial and recurrent training.

History of the flight

The Search and Rescue (SAR) helicopter, which was based at Prestwick Airport, had a crew of four consisting of two pilots, and two technical crew members situated in the cabin. On the event flight, the commander was in the right seat acting as PM, while the co-pilot, who was PF, was in the left seat.

At 2002 hrs the crew received a call from the Aeronautical Rescue and Co-ordination Centre with a task to collect a casualty from a beach at Ballintoy Harbour, Northern Ireland. The casualty was reported to be undergoing resuscitation and the helicopter landing site would be in a local car park. The crew briefing included the possibility of the task being cancelled before the helicopter arrived owing to the condition of the casualty and the transit time.

The helicopter departed Prestwick on a VFR clearance at 2011 hrs and flew west towards Ballintoy (Figure 1).

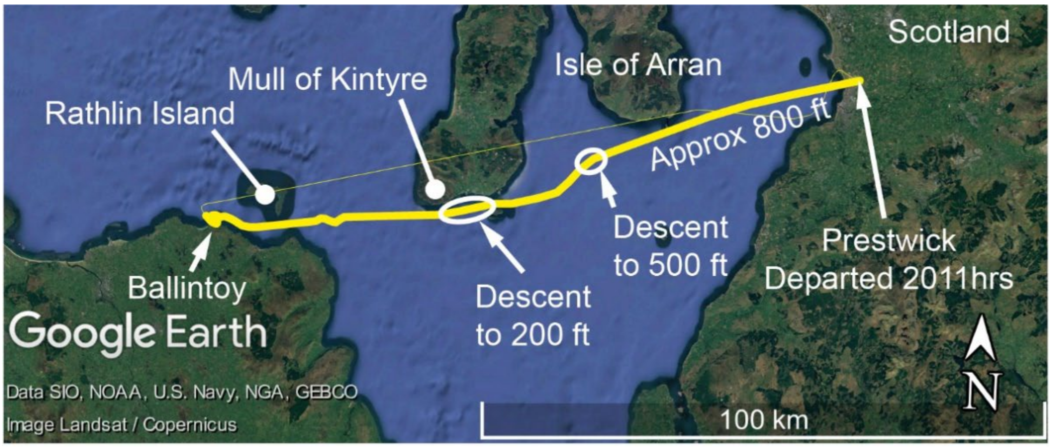

Figure 1
Overview of flight

The pilots noted that the cloud base outside the Prestwick zone was around 1,000 to 1,200 ft. The high ground on the Isle of Arran was in cloud, with some fog over the southern end of the island and the surrounding sea. As the flight progressed, the pilots observed that the cloud base was lowering, and as they travelled towards the southern end of the Mull of Kintyre the PF elected to descend to 500 ft; the PM remarked that it was getting dark and “claggy” up ahead.

The emergency services informed the technical crew member by radio that the weather at the landing site was “ok.” As the helicopter transited south of the Mull of Kintyre, the PF descended to 200 ft to remain below cloud. The pilots could not see the lighthouse on Rathlin Island, which they would normally expect to see in clear weather and encountered fog and low cloud during this phase of the flight.

First approach

Given the poor visibility, the PM recognised that a Radar / Forward Looking Infrared Approach (RFA) might be needed and set up a route on the Flight Management System (FMS) that ran south of Rathlin Island, converging on the coast east of Ballintoy Harbour (Figure 2). As the helicopter approached Rathlin Island, the pilots commented that the visibility was improving. The PM briefed the let down and approach with an escape heading of 300° which would take them to a clear area over the sea. However, they momentarily entered cloud, and surface radar contacts ahead of the helicopter required the PM to adjust the waypoints to avoid them.

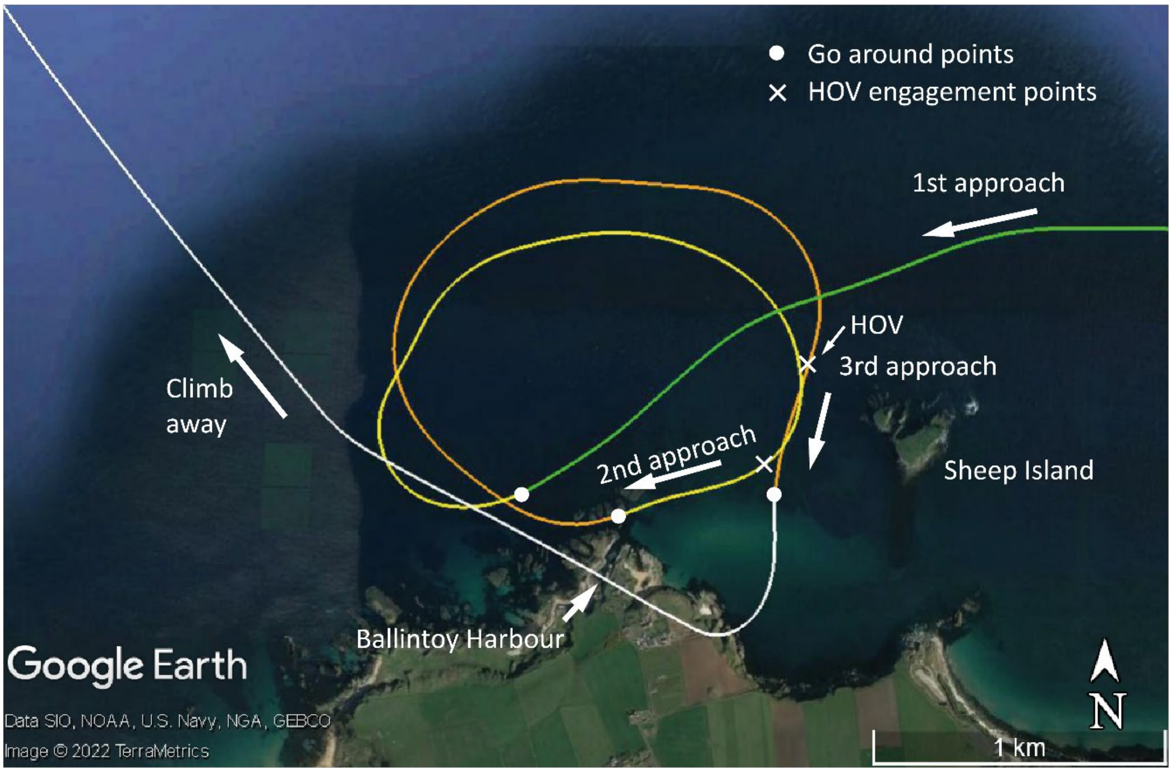

Figure 2

Flight paths during the three approaches to Ballintoy Harbour

Prior to turning to route north of Sheep Island, the PM commented that they had about 0.5 km visibility ahead, the weather to the north-west was better and he was happy to continue. Shortly afterwards, he advised that once they got closer they would bring the speed back and then he would ask the PF to select hover mode. The PM later reported that he could see that the north and west was clear of fog, but that it was partially foggy in the vicinity of the landing site.

While the PM completed the pre-landing checks, the PF off-set the helicopter heading into wind (to the right) to maintain a west-south-westerly track. The CVR recorded the PF saying that he could see the island, the coastline, and blue lights of the emergency vehicles. He subsequently informed the investigation that the blue lights were about 2 km away and he expected the final stage of the approach to be visual even though at the time he could not identify the exact location of the landing site. The PM was not able to see the island or the coastline from his position in the right seat.

The helicopter approached the landing site on a heading of between 230° and 240° on a converging track with the coastline. The PM suggested that the PF should select AFCS hover[1] (HOV) mode as the helicopter was abeam Ballintoy Harbour. However, as the PF was unable to visually identify the landing site, he informed the PM that he would reposition for another approach. The PM recalled looking up and seeing that the helicopter had entered a fog bank.

Second approach

Following the first approach the PF repositioned by turning right onto the briefed escape heading of 300º. The PM set up a waypoint on the FMS just to the north of Sheep Island. Although the AFCS had been captured on each of the four axes (collective, pitch, roll and yaw) for more than two minutes, the PF overrode the AFCS heading hold (HDG) mode captured on the roll channel by manually flying the helicopter. As the helicopter turned, a technical crew member reported that he was visual with land; this was in the direction of the landing site and indicated that visibility was approximately 1 km.

During the approach the helicopter maintained a heading of around 240° and converged with the coastline and cliffs, which were on the left side of the helicopter. At about 600 m from the harbour, the PF selected HOV mode. The PF controlled the rate of deceleration by manually flying the helicopter. At this stage the PF could see the blue flashing lights of the emergency vehicles at the landing site, whereas the PM who was sat on the other side of the cockpit could not. A few seconds after the PF selected HOV mode, the PM, perceiving that the approach was too fast, instructed him to go-around. The PF, who was still visual with the landing site, initially did not act on the PM's instructions. Therefore, the PM repeated the instruction, and the PF manoeuvred the helicopter into a right turn onto their pre-briefed escape heading.

Third approach

The PM outlined his plan for the next approach, which was to come to a hover over the sea to the north of the harbour then descend to 50 ft and hover taxi in. The PM created a waypoint 2 nm from the harbour to the north-east of Sheep Island. He then selected the AFCS to navigate directly to this waypoint. The pilots observed that it was getting darker and the approach would become more difficult. They considered using their night vision goggles (NVG), but thought it would not offer any significant benefit.

Footnote

[1] Hover (HOV) mode in the history of flight refers to the selection of Position Hold using the fifth position of the cyclic beep trim (Figure 8).

Before the helicopter reached the waypoint, with the landing site just in sight, the PM selected HDG on the AFCS for the PF; the heading the AFCS was to capture was the current helicopter heading of 087°. Shortly after the PF asked if he should turn right. The PM instructed him to turn right and reduce speed to 50 kt and to select HOV once the helicopter was established on a heading of 200°. The PF flew the helicopter to the right, inside and to the west of Sheep Island, and once established on the heading selected HOV mode when about 900 m from the harbour. Instantly, the helicopter began to yaw left by approximately 35° onto a southerly track. The helicopter was now flying east of the harbour at 200 ft above the sea, at a groundspeed of 52 kt, on a heading taking them directly towards cliffs that were between 100 ft and 160 ft high, with the ground rising to 700 ft amsl about 1 km inland.

Go-around from the third approach

The pilots expressed surprise at the unexpected yaw. One of the technical crew asked if they were going around, which the PM confirmed they were. The PF selected Transition-Up (TU) mode and the helicopter began a level acceleration towards 80 KIAS. The PM called "*ROUTING TOWARDS LAND TURN RIGHT TURN RIGHT*" which the PF acknowledged. The PM repeated his instruction to turn right. This was coincidental with the annunciation of the CAUTION TERRAIN visual and aural alert generated by the HTAWS. At the same time one of the technical crew, seeing the helicopter transiting over land, urged the pilots to climb. This prompted the PM to take control and disengaged the upper modes. Shortly after this the WARNING TERRAIN alert sounded. The PM, now the PF, flew a climbing right turn onto the escape heading.

With the helicopter safely over the sea, the crew discussed what had happened and, given the medical assets on scene and the weather conditions, decided to return to Prestwick. The helicopter landed at 2122 hrs.

Location of casualty

Ballintoy Harbour is located on the north coast of Northern Ireland. The small harbour is accessed via a steep road, with a car park, located between the beaches and harbour walls. The car park, which had been used on previous occasions by the operator with the same helicopter type, had been cleared to allow the helicopter to land.

The ground rises to 700 ft amsl about 1 km inland. A church is approximately 450 m south of the landing site at an elevation of 165 ft amsl (Figure 3). There are 100 ft high cliffs either side of the harbour, which to the east rise to 160 ft (Figure 4). The casualty was being treated on the beach to the west of the car park. Coast guard vehicles with flashing blue lights were parked on the road near the casualty and at the church.

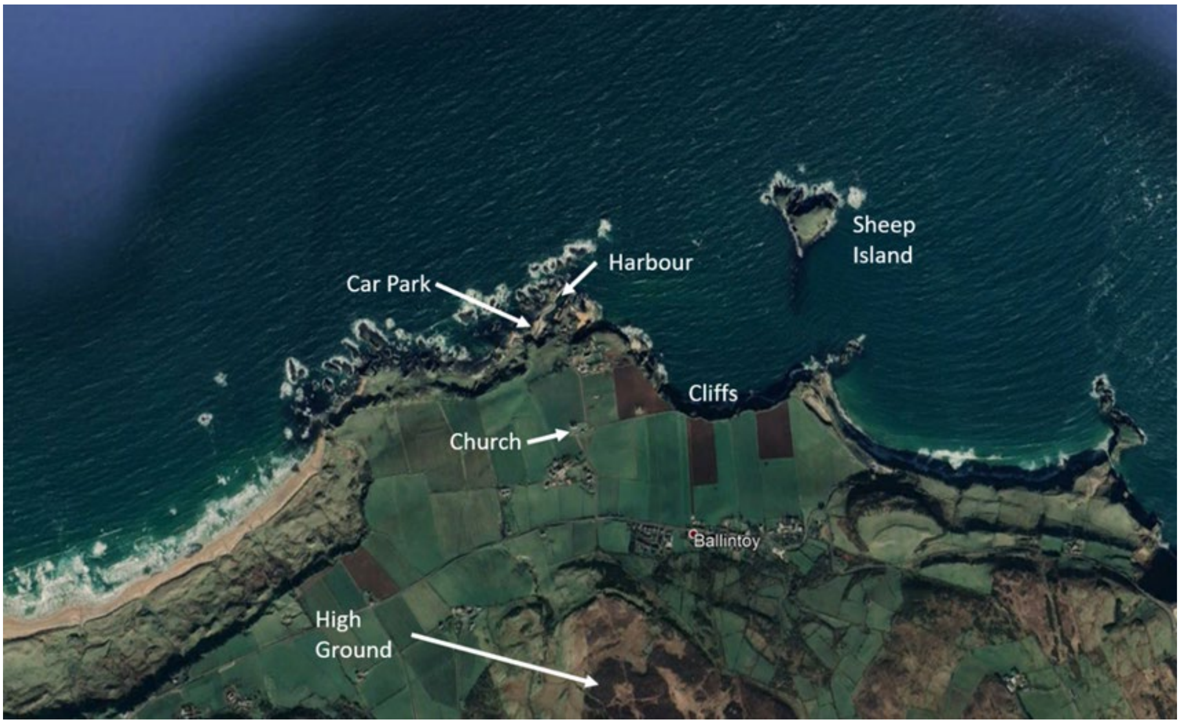

Figure 3

Ballintoy Harbour local area © 2021 Google, Image © TerraMetrics

Figure 4

Cliffs at Ballintoy Harbour
© 2021 Google, Image © TerraMetrics

Meteorology

The forecast indicated that the conditions for Prestwick would provide good visibility with a main cloud base between 2,000 and 4,000 ft. Isolated patches of mist and sea fog were expected along the windward coasts, which would reduce visibility to 3,000 m in mist with a cloud base of 400 to 600 ft; in fog the visibility was forecast to be 300 m.

The main cloud base in the area surrounding Ballintoy was forecast to be 1,000 ft, but areas of mist were expected along windward coasts with visibility of 3,000 m and cloud base of 400 to 800 ft. The wind was forecast to be light north-westerly.

The commander stated that the weather briefed during the shift handover earlier in the day set the expectation of a cloud base no worse than 800 ft overnight. This would allow for a VFR transit and approach for the task.

Sunset at Ballintoy was at 2041 hrs. A Met Office aftercast indicated that the light levels were not low enough to allow the use of NVG before 2100 hrs.

Helicopter examination

No system faults were identified on the helicopter prior to or during the flight. A pre-flight test of the AFCS carried out the day after the event identified no faults and the helicopter was assessed as airworthy.

Aircraft information

The AgustaWestland AW189 SAR helicopter (Figure 5) is a derivative of the commercial air transport version, which is equipped with specialist role equipment and a modified AFCS providing additional functionality for the SAR role.

Figure 5

An AgustaWestland AW189 (Used with permission)

Flight control system

The flight controls allow the crew to control the flight attitude, altitude, and direction of the helicopter. Control is transmitted to the main rotor swash plate and tail rotor pitch change mechanism through mechanical linkages connected to the cyclic stick, collective lever, and yaw pedals. The mechanical control is augmented by electric actuators mounted in series (linear) and parallel (trim) in each of the control systems (Figure 6).

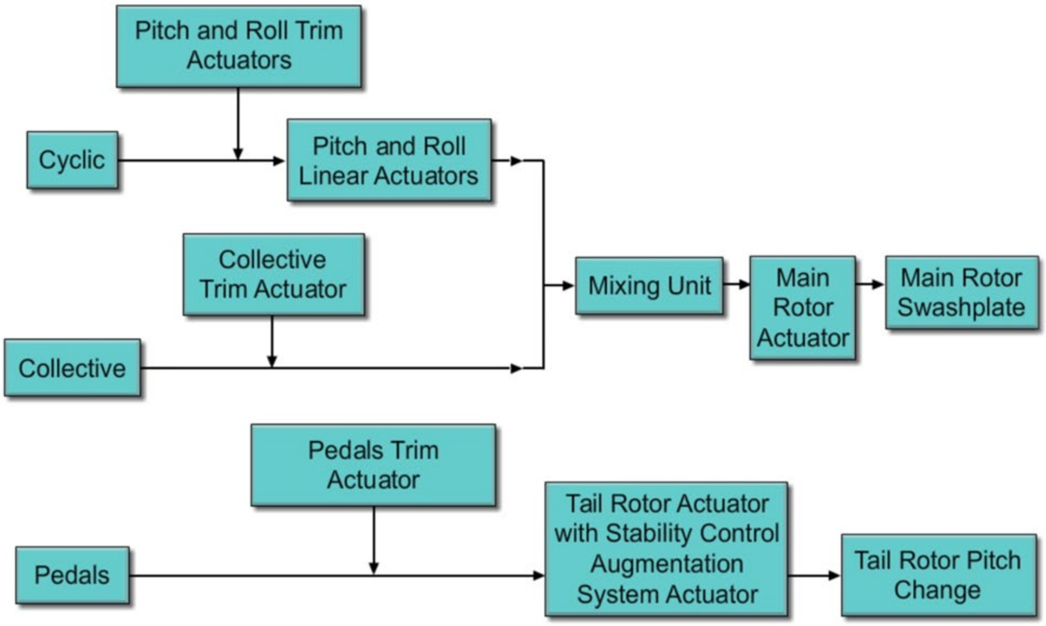

Figure 6

Flight control system (©Leonardo Helicopters)

Automatic Flight Control System

The four-axes AFCS assists aircraft handling and reduces pilot workload using the linear and trim actuators. The linear actuators have limited authority on the flying controls and counter short term external disturbances from a trimmed attitude. The trim actuators can move the flight controls through the full range of movement.

The AFCS performs a number of functions which are divided into two groups; Primary AFCS and AFCS upper modes. The Primary functions include turn co-ordination, stability command augmentation and autotrim. The AFCS upper modes can control the helicopter in four axes: longitudinally in the pitch axis; laterally in both the roll and yaw axes; and vertically in the collective axis. A more detailed description of the AFCS is provided at Appendix A.

Force Trim Release

The Force Trim Release (FTR) for the pitch and roll axes is located on the cyclic, and on the collective for the collective axis. The yaw pedals have microswitches which act as the FTR for the yaw axis. When AFCS upper modes are engaged, depression of the FTR suspends the upper modes for that axis, and the reference datum will track the changes in the relevant parameter. On release of the FTR, the current parameter will be captured as the new reference datum.

Flying-through AFCS modes

Each trim actuator includes a microswitch called a detent-switch which is activated when the flight control is moved by the pilot. When the detent-switch is activated the pilot is described as flying out-of-detent, or flying-through. This design allows the pilot to override captured AFCS modes at any time by flying-through, to direct the flight path of the helicopter. While doing so, the captured upper mode temporarily ceases to be in control of its axis. When a pilot is flying-through on any one axis, the reference datum for that axis is not changed, unless the pilot makes a separate input to change the datum.

There are no visual or aural cues to inform the pilots when an upper mode is not actively in control of its axis due to the pilot either flying-through or depressing the FTR.

AFCS mode status display

Autopilot upper modes are engaged by selecting the relevant mode button on the Autopilot Control Panel (APCP) which is located on the centre console. The button will illuminate green when the mode has been selected.

The Flight Mode Annunciator (FMA) located at the top of the Primary Flight Display (PFD) provides a visual display to the pilots of the modes which have been armed, captured, or are degraded (Figure 7). Captured modes are green, indicating the mode is in use, and is outlined by a green box which flashes for five seconds when first captured. Armed modes, which indicate that the mode has been selected but the parameters are not within range, are white and displayed next to the captured modes. A single aural tone sounds when a mode is engaged or disengaged.

The flight director select indication is a green triangle (Figure 7), which is displayed on the FMA on both PFDs and indicates the 'in-command' Flight Director (FD). It is selected by pressing the FD SEL button on the Display Control Panel. The PFD/multi-function display on the side with the 'in-command' FD supplies reference data to the AFCS. When power is first provided to the AFCS, the in-command FD defaults to the right. The operator's SOPs required that the in-command FD corresponded to the pilot acting as PF.

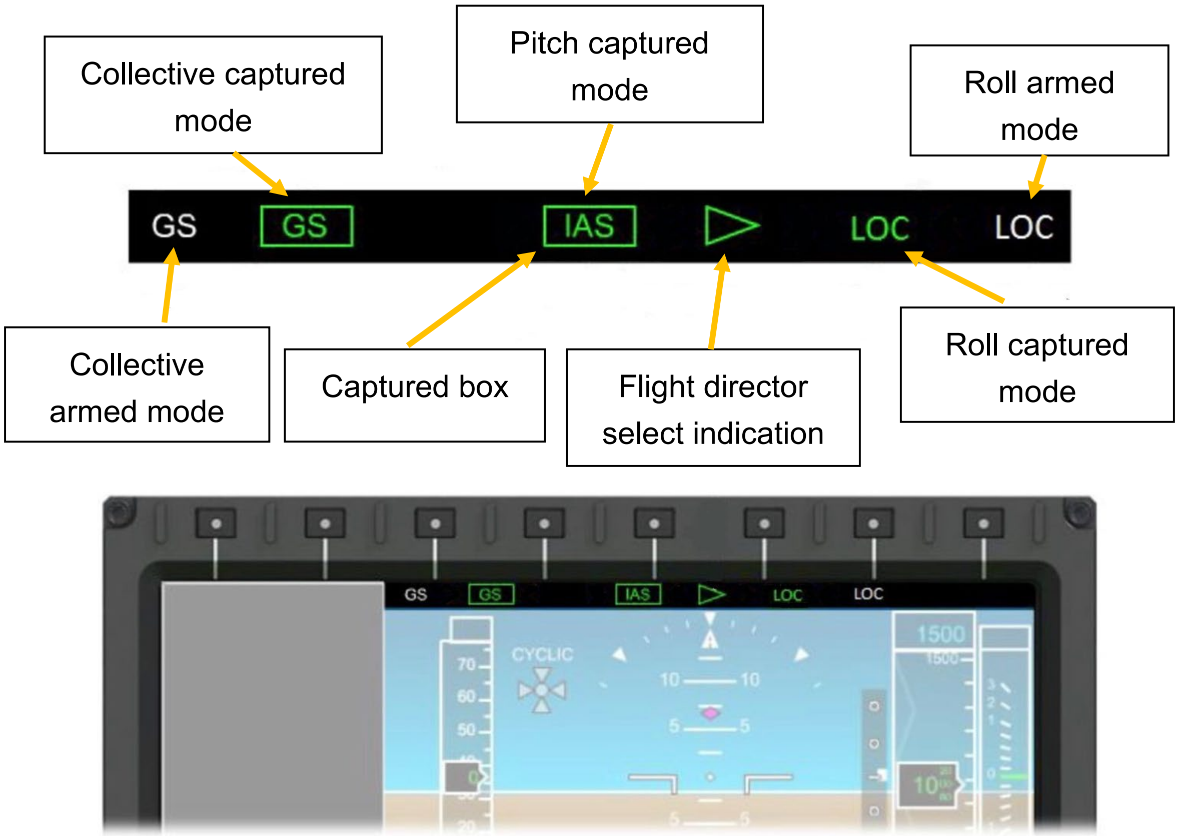

Figure 7
FMA located at the top of the PFD (©Leonardo Helicopters)

AFCS upper modes

The relevant modes for this investigation are:

- Radar Height Hold (RHT), captures and maintains a radio altimeter height.
- Heading Hold (HDG), captures and maintains a magnetic heading.
- Indicated Airspeed Hold (IAS), captures and maintains an indicated airspeed.
- Altitude Hold (ALT), captures and maintains a barometric altitude and is the default mode when the autopilot channels are engaged and the pilot is flying manually without any AFCS upper modes captured.
- Hover (HOV), establishes the helicopter in a velocity or position-hover.
- Transition down to the hover (TD/H), decelerates and descends the helicopter when operating at low level.
- Transition-Up (TU), accelerates and climbs the helicopter to 80 kt and 200 ft agl and automatically engages HDG on the present helicopter heading.

AFCS Heading hold (HDG) mode

The HDG mode provides the capability to capture and hold a magnetic heading. It operates on the roll and yaw axis during most phases of flight but below 40 KIAS, or if any other mode such as HOV is controlling the roll axis, it only operates on the yaw axis. The heading reference is either the heading pre-set by the pilot, or if the pilot has not pre-set a heading, the magnetic heading of the helicopter when the mode is selected.

The magnetic heading reference is displayed on the Horizontal Situation Indication (HSI) compass rose by a magenta bug (Figure 8).

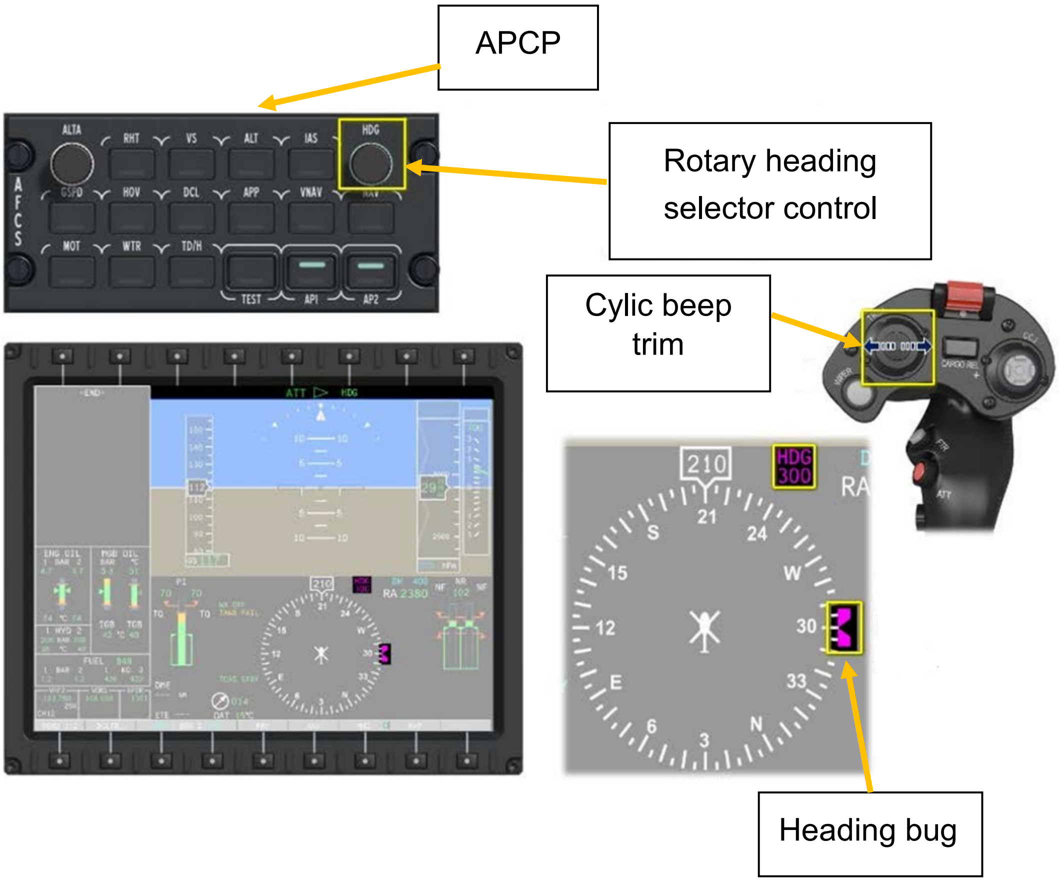

Figure 8

HDG mode controls and display (©Leonardo Helicopters)

The pilot can change the heading reference using the cyclic beep trim switch or the rotary heading selector control on the APCP. Below 40 KIAS, the heading reference is set using the collective/yaw beep trim. The heading reference can also be set when the HDG mode is not selected, by using the rotary heading selector control on the APCP; the heading reference is then displayed as a cyan bug.

When the pilot flies-through on the cyclic roll channel without pressing the cyclic FTR, the HDG bug will remain at its current heading as the helicopter turns. When the pilot releases the input on the cyclic, the detent-switch deactivates and the AFCS will regain control and turn the helicopter onto the previously set HDG bug reference.

AFCS Hover (HOV) mode

HOV mode performs one of two functions dependent on the method used by the pilot to select the mode (Table 1). These are either Velocity Hold or Position Hold.

Function	Action	Longitudinal and lateral groundspeed references
Velocity Hold	Captures current longitudinal and lateral groundspeed velocity	AFCS sets the references to the current values
Position Hold	Decelerates to a hover condition but not to a pre-determined geographical position	AFCS sets the references to zero to achieve zero kt groundspeed

Table 1

Functionality of HOV modes

The relevant mode function during the serious incident was Position Hold. While this mode brings the helicopter into a hover, it does not bring it to a pre-determined geographical position as the final position is dependent on the helicopter's weight and environmental conditions. There is no guidance from the manufacturer or operator on the time and/or distance to decelerate to the hover.

On capture of HOV mode, HOV is indicated on the FMA on both the pitch and the roll/yaw axes. The height reference used is radio height if a valid signal is received from the radio altimeter, otherwise the barometric altitude reference is used. The pilot also has the option to select either radio (RHT) or barometric height (ALT) reference in the collective channel.

The heading reference used when HOV mode is engaged is dependent on whether the HDG mode is captured. If HDG is captured, then the heading reference used is defined by the magenta bug on the HSI compass rose. If HDG is not captured, then the heading reference used is either the current magnetic heading of the helicopter, or the heading pre-set by the pilot and displayed on the compass rose as the cyan bug.

On selection of HOV mode, the HSI display changes to the hover mode symbology format (Figure 9). This symbology is overlaid on the compass rose and shows the current groundspeed and a velocity vector in green; the target groundspeed is indicated by the selected ground speed bug in magenta.

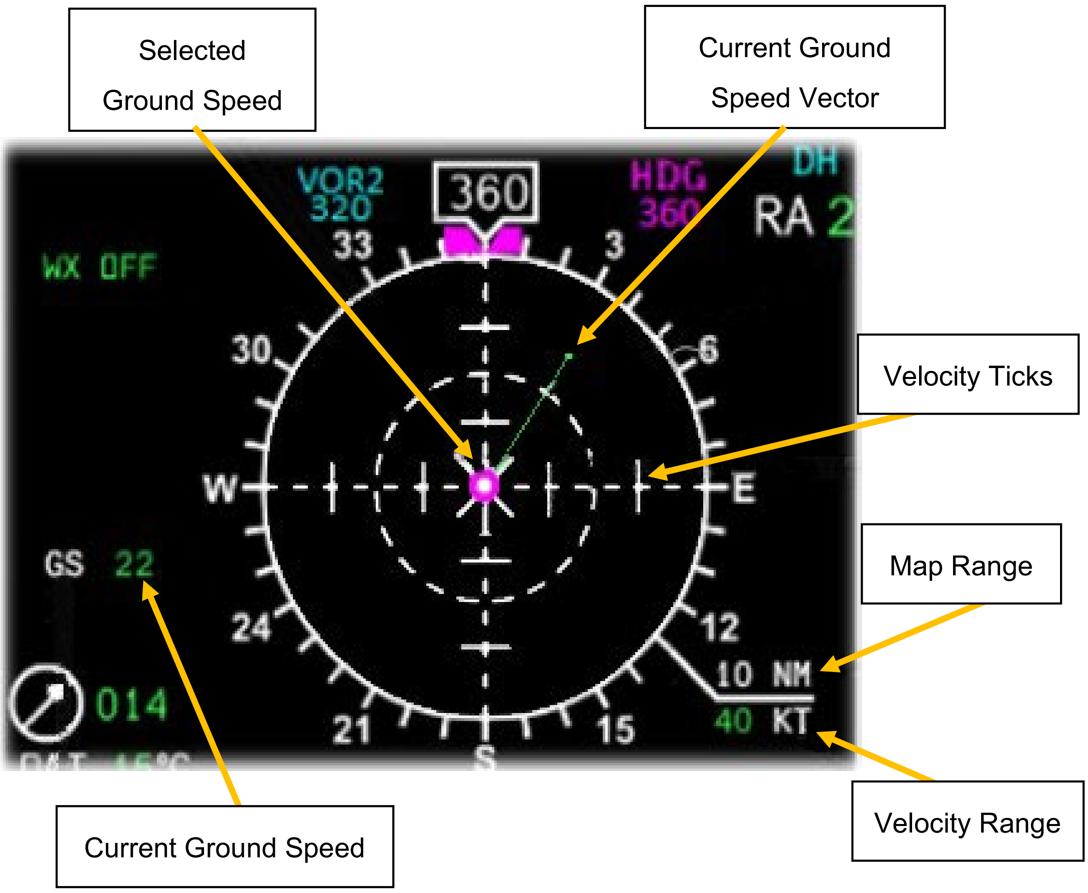

Figure 9

HSI Hover Speed mode symbology[2] (©Leonardo Helicopters)

Operator guidance on the use of automation

The helicopter operator uses the term 'coupled' and the helicopter manufacturer 'captured' to describe the active mode used by the AFCS.

Three axis coupling is pitch, roll and yaw; four axis coupling is pitch, roll, yaw and collective. The operator's guidance in their operations manual on the use of automation states:

> *'It is strongly recommended however, that at all times below 500 ft, amsl/agl, and especially in poor visual reference conditions, or at night, the aircraft should be coupled 3 or 4 axis.'*

Footnote

2 The figure shows all the symbology that may be shown on the HSI when HOV mode is captured, though not all the symbology can be shown at the same time.

The operator's SOP for engagement of automation followed the *'select, engaged, captured'* procedure. The PF will select or call for the PM to select an AFCS mode. The following guidance was provided to crews for operating at low altitude or in poor conditions:

> *'When operating below 500ft amsl/agl and in conditions of poor visual reference the pilot monitoring (PM) will normally make all AUTOPILOT (AP) Upper Mode selections. During times of high cockpit workload, the pilot flying (PF) may also make AP Upper Mode selections, provided that the PM is informed of any selections made at the earliest convenient moment. The pilot flying (PF) may dis-engage certain modes using the cyclic and collective buttons but this, and all other selections, will be carried out as a challenge and response action.'*

The operator emphasised the importance of the crew understanding which modes were engaged at all times.

Mixed mode flying

The operator defined mixed mode flying as when:

> *'the autopilot is only controlling some of the axis and the pilot is controlling the remainder.'*

The operator's procedures stated that mixed mode flying should be avoided except as allowed within the Operating Manual (OM) and stated that:

> *'Loss of situational awareness and loss of control can quickly occur as a result of mixed mode flight, especially during high workload and critical phases.'*

With regard to SAR operations, the operator explained that the use of mixed mode flying was sometimes required when a more rapid rate of turn was required than was available in HDG mode.

Crew's understanding of operation of the AFCS heading reference datum

The pilots' understanding was that on selection of HOV mode, the heading reference datum would capture the current magnetic heading of the helicopter. This was consistent with the manufacturer's type rating ground course notes for the Position Hold function which stated:

> *'…the AFCS maintains the current Radar Height and Heading (Low speed heading hold).'*

However, this is a partial explanation of the operation of the HOV function. Following this event, the manufacturer clarified that on selection of HOV mode, the heading reference datum is dependent on whether the HDG mode is already captured (Table 2). The heading reference datum is displayed on the compass rose as either a magenta or cyan bug.

HDG mode captured	HDG mode not captured
The heading reference datum will be the existing reference datum displayed as a magenta bug.	The heading reference data will either be: • The current magnetic heading of the helicopter, or • The pre-set heading reference datum input by the pilot and displayed as a cyan bug.

Table 2

HDG reference datum used on selection of HOV mode

Flight Mode Annunciator - AFCS upper mode indications

Throughout the flight, the active Flight Director of the AFCS was selected to the right, the side of the PM. While the roll axis was flown out-of-detent by the PF for most of the time during the three approaches, the FMA indicated that the AFCS was controlling the roll axis throughout.

During the second approach, about eight seconds after HOV was engaged, the PM commented that "IT'S NOT STOPPING." During those eight seconds, either the cyclic pitch, roll, or both, were out-of-detent, thereby suspending the HOV function. The PF was slowing the helicopter by flying-through, but not at the rate the PM was expecting from the engaged, but suspended, HOV mode. There was no indication on either the FMA or Flight Director that would have informed the PM that the PF was manually controlling the helicopter.

Other helicopter types from other manufacturers do indicate to pilots when a pilot is overriding an engaged AFCS mode through manual control inputs.

RFA Approach

The operator did provide a SOP for a RFA, which allowed the helicopter to make an approach to a hover close to terrain at night or in poor visibility using radar guidance and TD/H mode of the AFCS. If the PF could achieve visual references for the hover, the helicopter could then be manoeuvred visually to the required position.

Helicopter Terrain Awareness Warning System (HTAWS)

The helicopter was equipped with HTAWS to enhance the pilot's awareness of the flight path in relation to threats from terrain and obstacles. HTAWS has two alerting functions:

- Forward Looking Terrain and Obstacle Avoidance (FLTA).
- Ground Proximity Warning System (GPWS).

The FLTA alerting area is shown in Figure 10. It uses the aircraft position and the altitude data from the GPS combined with vertical speed to compute a predicted aircraft flight path which it compares to the terrain and obstacle databases. Alerts are generated if there is a potential conflict. For terrain the alert is either CAUTION TERRAIN or WARNING TERRAIN.

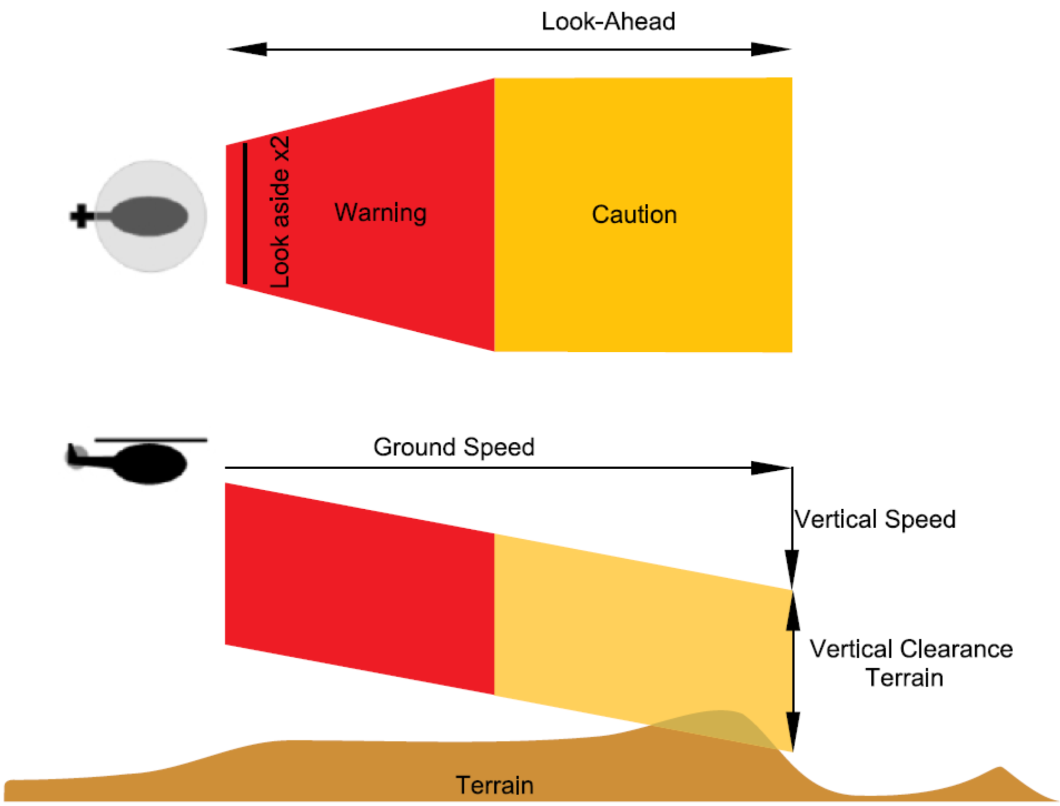

Figure 10

FLTA alerting envelope (©Leonardo Helicopters)

The pilot can select OFF AIRPORT mode to suppress alerts when landing at locations which are not in the database as designated airports. With OFF AIRPORT mode selected, the FLTA alerting envelopes are reduced when operating below 75 kt groundspeed and a height of 350 ft.

The pilot can also select one of three FLTA alert sensitivity modes: NORMAL, LOW ALT, TAC ALT. The LOW ALT mode reduces the alerting distance and, therefore, the time before a caution or warning is provided.

During the event, OFF AIRPORT mode and LOW ALT sensitivity had been selected which was consistent with the advice in the operator's SOPs. Table 3 shows the alert times at NORMAL and LOW ALT sensitivity using the speed and height the aircraft was flying when the HTAWS alerted CAUTION TERRAIN.

	Normal sensitivity (Caution / Warning)	Low Alt sensitivity (Caution / Warning)
Time to threat	21 s / 10 s	14 s / 7 s
Distance to threat	750 m / 375 m	550 m / 250 m

Table 3

FLTA alert time in OFF AIRPORT mode at 72 kt and 200 ft agl

On the third approach, prior to the selection of HOV mode, both the PF and the PM had the HTAWS overlayed on the compass rose of the PFD. However, on selection of HOV mode, this overlay was replaced by the hover speed mode symbology. Whilst either pilot could then have selected the HTAWS display either on their PFD or the MFD, neither did so. Consequently, while HTAWS remained active, neither pilot had HTAWS displayed on their screens.

Vision imaging system

The aircraft was equipped with a Forward Looking Infrared imaging system, and each pilot was equipped with a set of NVG. The PM had his NVG fitted to his helmet and the PF's were stored in the cockpit. The NVGs were not used during the flight.

Recorded information

Sources of data

The helicopter was fitted with a flight recorder which combined the FDR, CVR and Airborne Image Recorder (AIR) functions in one unit. It recorded more than 65 hours of data, 30 hours of audio and 3 hours of cockpit images.

Audio was captured from the three crew channels and the cockpit area microphone.

The cockpit imagery recording captured a snapshot of the general cockpit area four times a second, which provided context to the activity captured by the audio and data recordings - an overview of the use of AIR in this investigation is at Appendix B. The imagery also provided evidence of some of the activity not captured by the data or audio recordings and included:

- The pilot focus on the FMS. The resolution was not sufficient, and nor was it required to be, to read the information on the displays.
- The position of the pilots' hands and whether they were on the controls, pointing at waypoints on the displays, or referencing check lists or the content on tablets.
- Assessing the external conditions. Occasionally the terrain was visible in the top right and top left of the image frame, which when coupled with the terrain and helicopter locations allowed an estimate of the visibility.

Third approach and go-around

The initial part of the circuit was flown mainly with the RHT mode on the collective axis set at a reference height of 198 ft, and the IAS mode on the pitch axis set at a reference airspeed of 60 KIAS. The NAV mode was engaged on the roll axis but flown with the cyclic roll control out-of-detent. The AFCS had full control for about 18 seconds of the circuit, until the PM declared that he was selecting HDG mode. At this point the heading reference updated to the current heading of 087°. The turn rate as the PF manoeuvred onto the approach heading exceeded the rate-one turn capability of the engaged HDG mode, indicating that the PF was applying a manual input to the cyclic control and the cyclic roll was out-of-detent.

The later stage of the third approach is shown at Figure 11 (recorded data) and Figure 12 (flight path). The following significant events occurred during this stage of flight, some of which are annotated on Figure 11 and 12 using the numbers in brackets as the reference points:

- The heading diverged from the HDG bug datum of 087° (1) with HDG mode captured (2) and the cyclic roll control out-of-detent (3).
- The PM stated that he wanted the PF to select HOV once on a heading of 200°.
- The PF engaged HOV mode using the cyclic beep trim (4).
- The heading reference datum remained at 087° and the AFCS used the yaw axis to yaw the helicopter left from its heading of 200° to acquire the heading reference datum of 087°. This action generated an increasing drift angle to the left (5).
- Ten seconds after capturing HOV mode, the PF put his feet on the pedals and said, "LET'S GO" (6). The drift reached a maximum of 35° and then started to reduce, with a change in direction of the yaw rate to the right.

- The heading datum updated to 163° and started following the helicopter heading (7).
- At this point the helicopter was flying towards the cliffs about 700 m ahead, at 52 KCAS at an altitude higher than the cliffs, but with rising ground further inland.
- The helicopter pitched nose-down (8) and accelerated, maintaining a radio height of about 200 ft. The helicopter yawed slightly right, then started yawing back to the left (9).
- TU/HDG modes were engaged, which increased the speed datum to 80 KIAS and marked the end of the HDG datum being updated.
- The PF was flying-through in roll (10) and pitch almost continuously at this point.
- The heading trend returned to the right and the helicopter continued to accelerate and maintain a radio height of between 190 and 200 ft.
- A HTAWS CAUTION TERRAIN alert was triggered (11) at a speed of about 72 KCAS.
- Between two and three seconds later, the PM stated, "I HAVE CONTROL" and the helicopter AFCS modes changed to ATT; no collective mode was selected. The helicopter started to pitch up and the roll increased further to the right (12).
- Two seconds later, just after the helicopter started to climb, a HTAWS WARNING TERRAIN (13) briefly triggered. The climb rate reached a peak of 2,000 ft/min and the bank angle peaked at approximately 43° to the right.
- The lowest recorded radio height over terrain was 380 ft (14).
- The helicopter headed out to sea climbing, and returned to Prestwick.

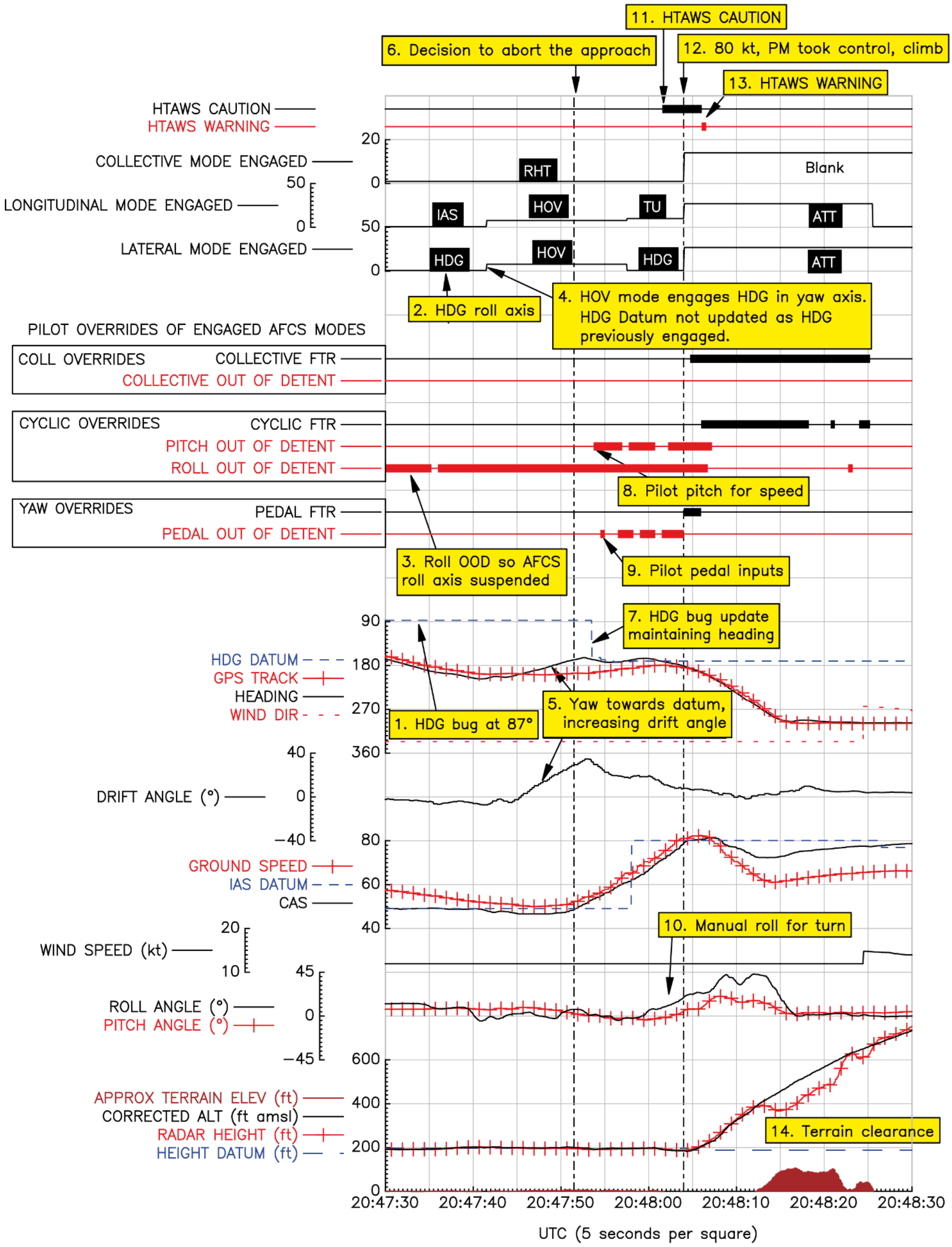

Figure 11

Recorded data for the later stage of the third approach and HTAWS alert

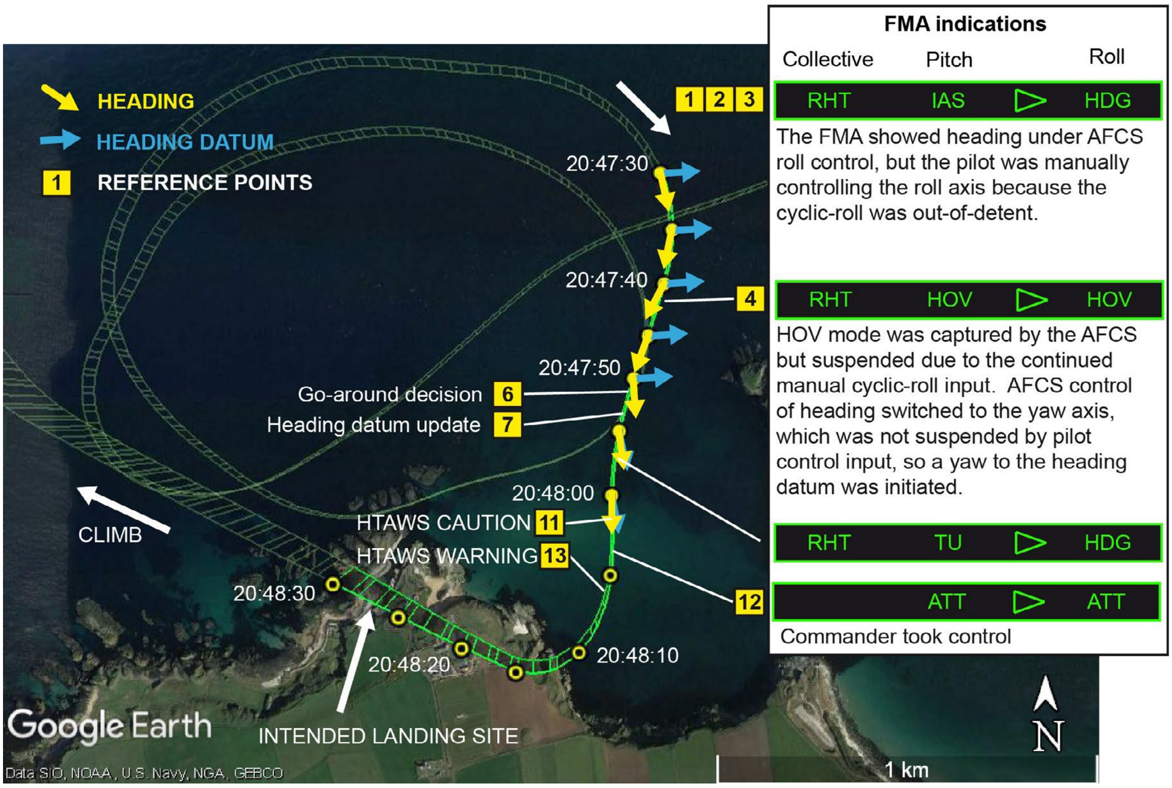

Figure 12

Overhead view of third approach showing FMA indications
(Reference points relate to Figure 11 and the report text)

HDG mode – use of reference datum

AFCS HDG mode was captured as the helicopter passed Rathlin Island and remained until HOV mode was captured during the second approach. Throughout this period the heading reference datum did not change and apart from a few brief periods, roll was controlled by the PF flying-through on the cyclic roll channel.

After the second approach was abandoned, NAV mode was captured followed by the HDG mode once the helicopter was flying in an easterly direction when the heading reference datum updated to 087°. The heading reference remained at 087° until after the third approach was abandoned. The data recorder did not capture any yaw pedal FTR activity at the time of the heading reference update.

HTAWS alerts

During the three circuits, the HTAWS was in OFF AIRPORT and LOW ALT sensitivity mode. The timing of the alerts during the third circuit indicates that these were triggered by the presence of the cliff. The approach altitude leading up to the HTAWS alerts was above the elevation of the cliffs, but level with terrain approximately 0.5 km further inland (Figure 13). At the point of transitioning to flying over land, the helicopter was at about 380 ft amsl and climbing. The highest terrain overflown was at an elevation of approximately 130 ft. The lowest radio height recorded while overflying the terrain was 380 ft.

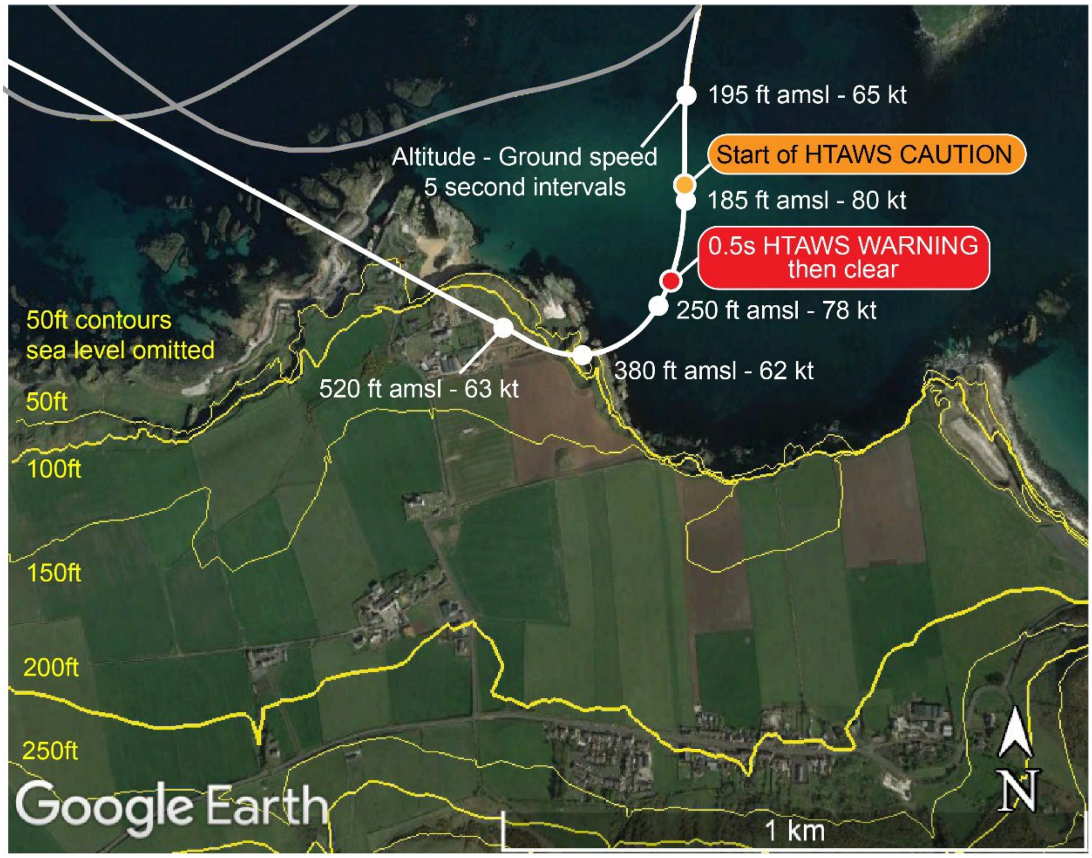

Figure 13

Flight path and speeds relative to terrain with associated HTAWS alerts
(The go-around decision was made while just north of the area shown)

Manufacturer assessment of recorded data

The manufacturer confirmed that for the third approach, as HDG mode was already engaged prior to the selection of HOV mode, HDG mode operated in the yaw axis alone and the heading datum reference was not updated. The manufacturer also confirmed that there is no display indication to the crew when a pilot is flying-through and the trim actuator is out-of-detent.

Personnel

Prior experience

Both pilots were qualified SAR commanders who had previously served as a SAR commander in the military flying Sea King helicopters. They both joined the operator approximately five years previously, when the operator began SAR operations, flying the Sikorsky S92 helicopter before converting to the AW189. The pilots undertook the type and operator role conversion training on the AW189 with the operator's own training organisation. Following the conversion training, each pilot underwent an operator proficiency check every six months and a licence proficiency check every 12 months in the simulator. Both pilots had over 1,000 hours on type; the PF was a type rating examiner for the operator.

Crew rostering

During the period of the COVID-19 restrictions, the operator implemented consolidated crewing as one of the measures to manage the health risk. As a result, the two pilots had been crewed together for six months during the previous year.

The shifts operated on a 24-hour pattern, with handover occurring at 1300 hrs. The duty crew were on 15 minutes notice to move until 2200 hrs and then 45 mins until 0800 hrs the following day. At the end of the shift, crew members had the next 24 hours off as a duty rest period. This pattern could be repeated up to four times in a row.

The commander and co-pilot had been crewed together for their previous shift. On the day of the event, the commander was on his second shift of two following three days off. He had operated for five shifts that calendar month and flown 19 tasks. The co-pilot was on his second of three shifts, and it was his eighth shift that month.

Both pilots reported that the month had been very busy month and their previous shift had included six taskings. The PM spoke of “mental tiredness rather than physical tiredness” following the level of tasking experienced on the previous shift, 48 hours before. The crew had met all the requirements of the flight time limitations, and both pilots spoke of having gained what they described as proper rest from the night before.

Although the effects of any fatigue on the performance of the crew cannot be ruled out, there was no observable evidence on the CVR or AIR.

Division of crew responsibilities

The operator’s OM defined the duties of the PF as:

> *‘The pilot flying a particular sector is to assume the responsibilities and duties of the Captain. These will include making decisions affecting the routine operation of the aircraft and its systems.’*

Degraded Visual Environment

A Degraded Visual Environment (DVE) encompasses environmental conditions such as rain, fog or low light levels that degrade the effectiveness of visual cues. This can decrease the ability of the pilot to maintain situational awareness and aircraft control.

During a previous AAIB investigation[3] in which a helicopter flew unintentionally to within 28 ft of rising terrain while operating in a DVE, the AAIB made the following Safety Recommendation to the CAA on 11 June 2021:

> **Safety Recommendation 2021-028**
>
> It is recommended that the Civil Aviation Authority revise its guidance on helicopter flight in degraded visual conditions to include further information on managing the associated risks.

The CAA responded by highlighting that there already exists significant research material, associated papers and guidance documents relating to operating in a DVE. To ensure that the existence of this material is widely known, the CAA issued SkyWise Notification[4] SW2022/133 on 20 June 2022, which recommended that organisations include this guidance in their training programmes and future safety meetings.

EASA guidance on automation and flight path management

In 2015 the EASA European Helicopter Safety Team (EHEST) issued guidance[5] on best practice in the use of automation and flight path management. The guidance identified a number of operational and human factors which are often seen in accidents and incidents when the use of automation is considered a factor. These factors include:

> *'· Insufficient understanding of mode transitions and mode reversions (i.e., mode confusion, automation surprise)*
>
> *· Untimely override action interfering with automation*
>
> *· Inadequate task sharing and/or CRM* [Cockpit Resource Management] *practices preventing the PF from monitoring the flight path and airspeed (e.g., both pilots being engaged in the management of automation or in solving an unanticipated situation or abnormal condition)'*

The EHEST suggested that to mitigate the risk when using automation to control the flight path, crews should always be aware of who is flying the helicopter whether it is the PF or the AFCS, and to announce call changes using standard calls as defined by the operator's SOPs.

Footnote

[3] AAIB-26196 G-LAWX *'Near controlled flight into terrain, private landing site near Shipston-on-Stour, Warwickshire, 14 October 2019'*, https://www.gov.uk/aaib-reports/aaib-investigation-to-sikorsky-s-92a-g-lawx. [Accessed December 2023].

[4] Skywise - Alert: Helicopter flight in degraded visual conditions (caa.co.uk) [accessed December 2023].

[5] EASA, September 2015 '*EHEST HE 9 Training Leaflet – Automation and Flight Path Management'* Available at https://www.easa.europa.eu/en/document-library/general-publications/ehest-leaflet-he-9-automation-and-flight-path-management [accessed December 2023].

Analysis

The event

Having made two unsuccessful attempts to land at Ballintoy Harbour to retrieve a casualty, the crew of G-MCGT set up for a third approach. The plan for this approach was to fly a converging track with the coastline that would keep the helicopter clear of the cliffs and high ground. At a suitable point, the AFCS HOV mode would be engaged to bring the helicopter to a hover, the crew would then descend over the sea to the north of the harbour and hover taxi south to the landing site in the car park.

On the third approach the heading of around 200° was now 30° to 50° to the left of that previously used. Consequently, rather than flying on a converging approach with the coast, the helicopter was flying towards the cliffs.

The helicopter was at a height of 200 ft amsl and airspeed of 52 KIAS when HOV mode was selected approximately 900 m from the cliffs. The helicopter immediately yawed to the left, which despite a cyclic right roll applied by the pilot, resulted in a significant drift to the left. The crew decided to abort the approach and the PF moved the cyclic stick and yaw pedals out-of-detent on three occasions during which the drift to the left decreased. During this period the TU mode was selected by the PF, which caused the helicopter to accelerate to 80 KIAS while still continuing to fly at a height of approximately 200 ft amsl towards the cliffs and rising ground; a HTAWS caution and warning alerted.

Once the decision had been made to go-around, the delayed response by the PF in climbing and turning onto the escape heading contributed to the reduced terrain separation with the ground. This resulted in the PM taking control at about the same time as the HTAWS caution alerted.

HTAWS was set to OFF AIRPORT and LOW ALT for all the approaches at Ballintoy. This meant that the warning time for terrain available to the crew was reduced. It is unlikely that this was a factor in this serious incident as the crew had already commenced a go-around when the caution and warning were triggered. The crew were also aware of the high ground and were on their third approach to the landing site.

Cause of the unexpected yaw

Prior to manoeuvring onto the approach heading of 200°, the PM selected HDG mode which captured the helicopter's current heading of 087° as the reference heading. This reference heading would have been displayed on the compass rose as a magenta bug. As the PF turned onto and maintained a heading of 200° the cyclic roll was out-of-detent, indicating he was flying the roll axis manually. Neither pilot updated the reference heading.

When the PF then engaged HOV mode to automatically bring the helicopter to a hover, the AFCS, as designed, commanded a left yaw to acquire the reference heading that was still set at 087°. About 10 seconds later the PF decided to abort the approach and moved the yaw pedals to counter this yaw which opened the detent-switch on the pedal trim actuator, updating the reference heading to the helicopter's current heading of 180°.

The sudden yawing of the helicopter was unexpected by the pilots as they believed that the heading reference datum would align with the helicopter heading when HOV mode was captured. This understanding was consistent with the description of the HOV Position Hold mode in the manufacturer's type rating course notes which stated:

> *'…the AFCS maintains the current Radar Height and Heading (Low speed heading hold).'*

During this investigation, the manufacturer clarified that on selection of HOV mode, the heading reference used is dependent on whether HDG mode is already engaged. The heading reference on selection of HOV mode will either be the current magnetic heading of the helicopter, or the heading pre-set by the pilots, or the heading reference if HDG mode is captured. The manufacturer confirmed that the AFCS operated as designed and there were no faults found with the helicopter or software.

The operator took the following safety action to ensure that their crews are aware of this serious incident and the expected behaviour of the AFCS in HOV mode:

> The operator briefed all crews on the behaviour of the AFCS reference datum on selection of HOV mode and reinforced it during recurrent simulator training.

The manufacturer also plans to revise the type rating ground course to be clear on the operation of the HOV mode.

Human performance

The review of the AIR / CVR revealed a lack of clarity between the pilots on their roles during the flight, which consequently influenced their ability to work as an effective team.

The operator's OM defined the PF as the pilot that acts as '*captain*' directing the flight path of the helicopter. However, throughout the flight, the PM took the lead in directing the flight path through the FMS, mostly unprompted by the PF. This ambiguity of roles and leadership was reflected in the communication between the two pilots. The PF exhibited a reserved manner during the flight, which contrasted with the commander's style as PM who frequently updated the PF about waypoints input into the FMS and the intended flight path to be flown. At times the PM selected AFCS modes unprompted by the PF. However, the PM's actions did not always appear to be actively acknowledged or acted upon by the PF. It also ran counter to automation management SOPs which required the PF to call for, or action and announce, AFCS upper mode selection, and thereby contributed to both the imprecise application of SOPs and inconsistent use of automation.

There was little discussion between the pilots evaluating and reviewing the plan of how to make the approach to the site of the casualty. Both pilots assumed they would fly visual approaches, based on the expectation that conditions would allow this; this assumption took the place of a shared operating intent. While the PF did voice at times what he could see, this was not augmented by an expression of his intent, nor did the PM share what he himself could see. It is, therefore, likely that there was not a shared understanding between the pilots of what each could see.

There was a lack of explicit recognition as a crew that they were in DVE and that further visual approaches might not be the most appropriate way to manoeuvre the helicopter after the first attempt. The conditions did not appear to prompt the crew to review their course of action and consider using an alternative procedure available to them such as an RFA.

As a result of this serious incident the operator took the following safety action.

- Issued further guidance to their crews on managing the threat of a DVE.
- Added additional guidance in the OM including:

  'If DVE conditions are likely to occur, SAR crews should consider planning for an Instrument Flying profile, i.e., Instrument Let Down, RFA. Even if the route is visually flown the overlay of an RFA type approach will aid planning and allow a rapid conversion to IF techniques.

  Increased communications within the crew are vital to determine the actual environmental conditions, it is likely that one side of the aircraft could have significantly better visibility than the other, particularly in the mountains or coastal environment. In this case, communications within the crew are vital to provide a shared mental model of the situation and the best way to proceed.'

The diminished visual acuity probably degraded the effectiveness of the pilots' visual cues while the differing visual cues that each pilot could see also contributed to the differing mental models that each developed. The differing mental models may explain why the PF did not immediately respond to the instruction to go-around on the second approach as he felt he retained sufficient visual references.

The CVR recorded the use of colloquial or ambiguous language and a breakdown in SOP protocol for the selection and confirmation of AFCS modes, which occurred during periods of higher workload. This relaxation of SOP discipline may have arisen, in part, from familiarity of flying with each other for extended periods.

Additionally, while the PM instructed the PF more than once to turn right following the decision to go-around on the third approach, the absence of a clear instruction by the PM, emphasising the escape heading to be flown, probably compromised the effectiveness of the response by the PF. This resulted in the PM taking control, at a time of confusion caused by the 'unexpected yaw' and high workload.

Operation of the AFCS and flying-through

By flying-through, the PF had disconnected the captured AFCS upper modes from the actual aircraft path. The heading bug remained at its value of 087° despite the actual heading of the helicopter being around 200°. This difference in headings represented a latent threat, which set up the conditions that resulted in the unexpected yaw.

It may be appropriate at times to fly-through on an axis while an upper mode is captured, particularly on SAR operations where there may be terrain or obstacle constraints; however, it is essential for pilots to recognise the threats that flying in this manner may present and to manage them accordingly.

As a result of this serious incident the operator took the following safety action:

Amended their OM to:

- Clarify when mixed mode flying might be appropriate.
- Emphasise the importance of good communications and CRM within the whole crew in the use of automation.

The FMA is the core tool to provide awareness to crews on the state of automation. On this helicopter type, the FMA provided no indication that the PF was flying-through on an axis when an upper mode was captured. This resulted in a degradation of the awareness of the PM as to who or what was controlling the flight path of the helicopter – the AFCS or the PF.

With the more widespread use of advanced digital automation, awareness of whose inputs are controlling the flightpath of the helicopter - the AFCS or the pilot – is essential to ensure that threats are not introduced that cannot be recognised by crews.

Conclusion

The HTAWS activated during the third approach to the hover after the helicopter unexpectedly yawed and flew towards high ground after the PF selected Position HOV mode. The investigation established that the AFCS was serviceable and operated as designed.

The unexpected yaw occurred as a result of flying out-of-detent and the pilots' incomplete understanding of the heading reference used by the AFCS when HOV mode was selected. When the PF engaged HOV he was flying out-of-detent, thereby overriding the engaged HDG mode. Consequently, the reference heading used by the AFCS did not capture the helicopter's current heading, but instead remained at the heading selected when HDG was last engaged. When the PF stopped flying out-of-detent, the AFCS yawed the helicopter towards the previously captured reference heading which resulted in the aircraft tracking towards high ground.

In mixed mode flying it is important that both pilots have a clear understanding as to which axis the AFCS and pilot are controlling, and the effect this might have on parameters such as the heading reference. However, SOPs on the selection of automation were not always followed and communication between the pilots, and lack of annunciation on the FMA, meant that it might not have been obvious to the PM when the PF was flying out-of-detent.

The flight took place in weather conditions that can be described as DVE, which meant the visual cues available to the crew were diminished. On the second approach the PF did not immediately respond to the PM's instruction to go-around. During the go-around on the third approach, to avoid the high ground, the PM took control because he believed that the PF's response to the threat was not sufficient. A lack of effective communication and co-ordination between the pilots resulted in them forming different mental models of the situation.

Safety actions

During this investigation the operator took the following safety action:

- The operator has briefed all crews on the behaviour of the AFCS reference datum on selection of HOV mode and reinforced it during recurrent simulator training.
- Issued further guidance to their crews on managing the threat of a DVE
- Added additional guidance in the OM including:

  If DVE conditions are likely to occur, SAR crews should consider planning for an Instrument Flying profile, i.e., Instrument Let Down, RFA. Even if the route is visually flown the overlay of an RFA type approach will aid planning and allow a rapid conversion to IF techniques.

  Increased communications within the crew are vital to determine the actual environmental conditions, it is likely that one side of the aircraft could have significantly better visibility than the other, particularly in the mountains or coastal environment. In this case, communications within the crew are vital to provide a shared mental model of the situation and the best way to proceed.'
- Amended their OM to:
  - Clarify when mixed mode flying might be appropriate.
  - Emphasise the importance of good communications and CRM within the whole crew in the use of automation.

Appendix A

Use of Airborne Image Recorders in accident investigation

Cockpit Airborne Image Recorders (AIRs) became a requirement for UK State helicopters following Safety Recommendations made by the AAIB to the CAA during an investigation into a fatal police helicopter accident, G-SPAO[6], in 2013. G-SPAO was not required to be fitted with any kind of accident recorder. Consequently, key evidence on the information displayed to the crew, and use of switches in the cockpit was not captured.

AIR provides investigators with a source of evidence that might otherwise not be available, even with a conventional FDR and CVR fitted. This might include capturing data that cannot practically be captured by a data recorder, or as was the case for G-MCGT, capturing a general view of the cockpit area. This appendix briefly highlights some of the strengths and limitations found with the AIR recording analysed for this investigation that may be relevant to other investigations where an AIR is fitted, or when considering certification requirements for future installations.

The installed camera had a resolution of 2,000 by 1,520 pixels. While the wide-angle lens on the camera captured a significant proportion of the cockpit controls (Figure A-1), activity associated with the overhead panel and the left collective lever was not captured. Evidence the AIR provided included:

- Who operated the controls.
- The pilots' general focus on activities in the cockpit, albeit not including where they were specifically looking
- The pilots' use of reference material.
- Non-verbal communication between the pilots; though some head movements and facial expressions were not captured.
- Ground references, when in view through the small section of the cockpit windows.

The use of cockpit images also allows investigators to gain a rapid appreciation of the information presented to the pilots, that would otherwise take time to build from other data. Examples include display settings, modes and availability, system status, use of controls etc. While the images do not provide the level of detail available from data recorders, they are useful in helping to quickly identify where the initial recovery and analysis of data might be focused.

Footnote

6 https://www.gov.uk/aaib-reports/aircraft-accident-report-aar-3-2015-g-spao-29-november-2013 Report on the accident to Eurocopter (Deutschland) EC135 T2+ (G-SPAO), Glasgow City Centre, Scotland, on 29 November 2013. Safety Recommendations 2015-032, 2015-033 and 2015-034 [accessed December 2023].

Appendix A (cont)

Figure A-1

Image from the cockpit camera.

Figure A-2 shows a zoomed-in view of the PFD. A combination of the AIR resolution and the use of a wide-angle lens meant that the displays were not readable, but there was no requirement for this. It is not known to what extent, if any, image compression affected the readability of the display images; however, there was still sufficient resolution to identify key features and the type of information displayed to the crew.

Figure A-2

Cropped image of the left PFD showing the benefits and limitations of the camera's resolution.

Appendix A (cont)

While the general light levels across most of the image were relatively dark, the map display had a light background which meant that it appeared mostly white on the recordings, thereby losing the information that was displayed. This can be seen in Figure A-3 where the detail on the map displayed on the Multi Functional Display (MFD) on the right side of the cockpit is ‘washed out’ compared with the MFD on the left side of the cockpit.

Figure A-3

Image showing crew communication and focus (pointing), NVG’s fitted to the helmet, detail displayed on the MFDs and the effect of the limitation of the dynamic range of the video recording system.

In the G-MCGT investigation, the loss of detail on some of the displays due to the limitations of the dynamic range of the camera did not affect the investigation. A similar dynamic range limitation associated with an AIR recording from a different AAIB investigation resulted in the loss of information displayed on the PFD. It is not clear how the dynamic limitations of AIR recordings can be overcome with current technology, but developments to improve the dynamic range of cockpit cameras would greatly benefit safety investigations.

Appendix B

Automatic Flight Control System modes

Introduction

The appendix provides additional information on some of the functions of the AFCS modes and how they are selected.

AFCS modes

Attitude Hold (ATT) is the default mode of the system in normal operation when the AP channels are engaged, and the pilot is flying manually without any AFCS upper modes captured. It provides the capability to acquire and hold an attitude reference in the pitch, roll and yaw axes independently. Stability command augmentation functions any time a pilot is 'flying-through' any of the AFCS upper modes and prevents the AFCS counteracting attitude changes induced by the pilot on the pitch and roll axes.

RHT mode captures a radio altimeter height through the collective axis.

ALT mode captures a selected barometric altitude through the collective axis.

IAS mode captures a pilot selectable reference airspeed through the pitch axis.

NAV mode provides AFCS coupling to roll steering provided by the FMS. This operates through the roll axis with roll co-ordination achieved through the yaw axis.

TD/H mode provides a fully automated descent down to 50 ft agl (or current height if lower) and 0 kt groundspeed. On reaching those parameters, RHT and HOV modes are captured. This mode requires the height to be between 30 ft and 210 ft and below 85 KIAS.

TU mode provides a fully automated climb to the reference height of 200 ft agl on the radio altimeter while accelerating to 80 KIAS. On reaching 200 ft, the AFCS will capture RHT; at 40 KIAS, HDG mode captures on the roll axis and on reaching 80 KIAS, the AFCS captures IAS mode on the pitch axis. It may be selected from either collective GA/TU pushbutton. TU mode captures when the relevant conditions are met which include airspeed between 40 KIAS and 80 KIAS with groundspeed greater than 30 kt with one of the specific SAR modes, including HOV, is captured.

The reference height can be modified by the collective beep switch and the airspeed by the cyclic beep switch. The TU mode can be cancelled by selecting another upper mode or selecting the collective/cyclic FTR buttons.

AFCS controls

The control panel for the AFCS, referred to as the APCP, provides controls for the arming or engagement of a mode and display of its associated status. It is also used for pre-flight testing. The APCP is in the centre of the inter-seat console between the pilots. It has 16 push buttons and two rotary/push knobs. Each button or rotary knob has its function annotated above it (Figure B-1).

Appendix B (cont)

Figure B-1

Autopilot Control Panel

The cyclic and collective grips have several controls for the AFCS (Figure B-2). While most modes are selected and deselected using the APCP, control of the AFCS datums and some specific modes can be selected on the cyclic or collective grips.

The cyclic beep trim switch is a 5-position rocker switch which allows small attitude adjustments in pitch or roll axes when the helicopter is in ATT mode by pressing it forward/aft/left/right. If an AFCS upper mode is captured the beep trim can be used to amend the reference datum for the relevant axis. For example, the IAS reference datum when IAS mode is captured, and the heading reference datum when HDG mode is captured and above 40 KIAS. When HOV mode is selected, the trim in pitch and roll is used to adjust and select the overall groundspeed vector reference on the HSI. A fifth position, by depressing the cyclic beep trim, is used to select the position-hover function of HOV mode.

The collective/yaw beep trim is a 4-way position rocker switch. Pressing the switch fore/aft adjusts the reference datums of the upper modes on the collective axis while pressing left/right adjust yaw trim when in ATT mode. Below 40 KIAS, or when HOV mode is captured, low speed heading hold is active, and the heading reference datum can be adjusted by pressing the switch left/right.

The cyclic FTR button suspends attitude hold in the pitch and roll axes when it is depressed and should be used for any large stick movements used to adjust the attitude of the helicopter. On release, attitude hold is restored. The collective FTR button suspends the mode captured on the collective axis. A yaw trim clutch mechanism on the pedals can be de-activated by depression of microswitches on the pedals.

The reference datums of the upper modes will synchronise the helicopter's actual datums with the movement of the controls when the FTR is depressed; the new datum is set on release of the FTR button.

Appendix B (cont)

The ATT button is used to deselect all the upper modes and engages ATT mode in all axes.

GA/TU switch is used to select the GA /TU mode, depending upon the helicopter parameters at the time.

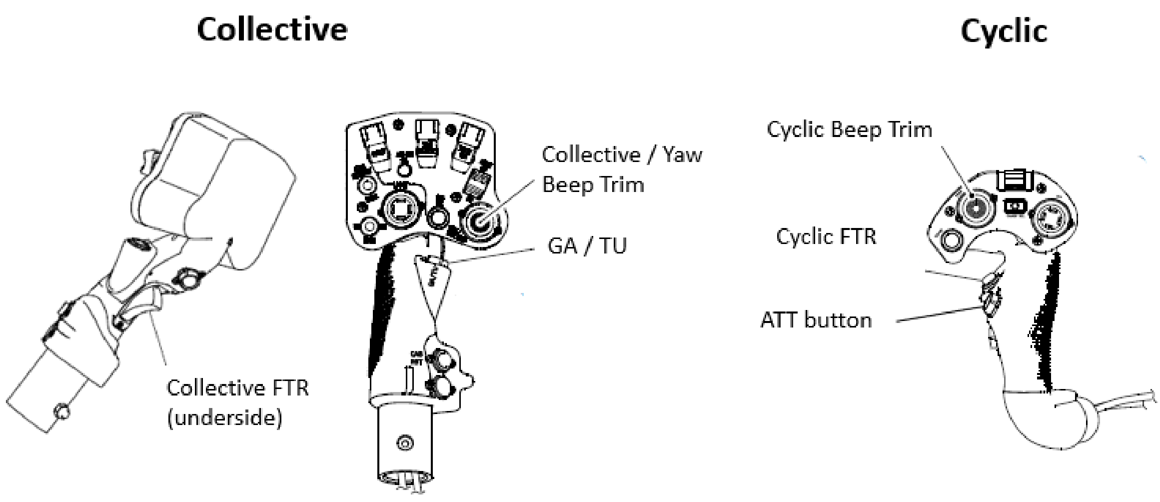

Figure B-2

Collective and Cyclic AFCS Controls

Published: 15 February 2024.