ACCIDENT

Aircraft Type and Registration:	Agusta Bell 206B Jet Ranger III, G-OMDR	
No & Type of Engines:	1 Allison 250-C20B turboshaft engine	
Year of Manufacture:	1981 (Serial no: 8610)	
Date & Time (UTC):	27 June 2014 at 1553 hrs	
Location:	Near Gamston Airport, Nottinghamshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to main rotor transmission driveshaft couplings, isolation mount, transmission stop mount, swashplate support, tachometer generator and freewheeling unit	
Commander's Licence:	Private Pilot's Licence (Helicopters)	
Commander's Age:	44 years	
Commander's Flying Experience:	850 hours (of which 500 were on type) Last 90 days - 32 hours Last 28 days - 12.5 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The helicopter was attempting to transit an area of forecast poor weather and inadvertently climbed into cloud, where control was lost. During the loss of control, significant damage occurred to the gearbox isolation mount, rendering the helicopter un-airworthy. This damage was not discovered until two further sectors had been completed. The pilot was then advised that the helicopter was safe to fly to the owner's maintenance facility and two further sectors were completed, before the helicopter was withdrawn from service. Subsequent inspections revealed numerous items of additional damage that were not immediately apparent. The extent of the damage meant that this occurrence met the definition for an accident. It was reported in February 2015.

History of the flight

On Friday, 27 June 2014, the pilot departed from a private site near Beaconsfield to attend a business meeting near Bicester. At Bicester, he refuelled the helicopter to full fuel and departed at 1504 hrs, intending to fly to Breighton Airfield in Yorkshire, to refuel again. His ultimate destination was a private site near Scarborough, where the helicopter was to remain for two days, until Sunday, 29 June 2014.

The pilot recalled that the weather was very good at the departure point, although he was aware that the weather would deteriorate further north due to a weather front. However, he did not consider there would be cloud low enough to affect his flight.

The pilot intended to cruise at a height of about 1,000 ft agl and a speed of 100 kt IAS. As he approached East Midlands Airport, the cloud base was 2,000 to 3,000 ft agl. However, he began to encounter one or two octas of cloud at about 400 to 500 ft agl but recalled being in clear air between the layers of cloud, with good sight of the surface.

To the north of East Midlands Airport, the weather deteriorated more rapidly than had been expected. The pilot's iPad GPS navigation application showed Gamston Airport a few miles away to the north-west but the sky appeared brighter to the east, suggesting better weather. He was considering whether to divert to Gamston or route further to the east when he entered cloud.

The pilot attempted to regain visual conditions by slowing the helicopter towards 60 kt and conducting a 180° turn. He believed he successfully completed the 180° turn but, as he was still in cloud, he lowered the collective lever and commenced a descent. He then noticed that the airspeed was decreasing rapidly and that the IAS needle was decreasing below the 0 kt mark. There was also high vibration and he believed he was experiencing the symptoms of being in a vortex ring state (VRS): descending rapidly, with low airspeed, power applied and uncommanded yaw changes.

Consequently, the pilot moved the cyclic stick forward, in an attempt to increase airspeed and recover from VRS. After an undetermined period of time, the helicopter seemed to start to recover from the VRS but the attitude indicator then rolled to almost 90° of bank, possibly to the right, and the pilot felt that the helicopter was not responding to control inputs.

The helicopter then recovered towards a more normal attitude, before the pilot thought he was in VRS, once more, and had little control of the helicopter. He selected forward cyclic again and attempted to transmit a MAYDAY call, though he was later unsure he had achieved this; no such call was received by ATC. The helicopter descended into clear air below cloud and the pilot was able to recover the helicopter to normal flight and carry out a precautionary landing at Gamston Airport.

Events following the loss of control

After landing at Gamston, the pilot reported that he conducted a thorough inspection of the helicopter, without using a checklist, and did not find any damage. He paid particular attention to the drag pin, located on the underside of the gearbox, as he believed that to be the most critical indicator of excessive movement of the transmission (see Figure 1). He did not consider the drag pin to be damaged and thought that the helicopter had operated normally after the loss of control. He, therefore, conducted some hovering at Gamston to check for any unusual vibrations and, finding none, decided to continue to Breighton.

Figure 1

Transmission stop mount assembly (not accident aircraft)

On arrival at Breighton the pilot changed his plans and, having embarked a passenger, departed without shutting down or refuelling. He then proceeded to Scarborough, arriving at 1745 hrs.

During the weekend (28/29 June 2014) the pilot discussed the event with the helicopter owner's duty engineer, by telephone. Based on his information, the duty engineer was not willing to approve the helicopter for further flight. He advised the pilot to contact the maintenance manager, who would be available after the weekend.

On the morning of Monday, 30 June 2014, the pilot spoke to the maintenance manager, by telephone, to seek advice before flying the helicopter again. He described the loss of control event and advised the maintenance manager that he had continued to fly the helicopter to his destination, after his precautionary landing at Gamston Airport, and that the helicopter was "flying OK, with temperatures and pressures all OK". The maintenance manager asked the pilot to check and photograph certain areas of the helicopter, in addition to carrying out a normal daily 'A' check. These additional inspection items included the top surface of the isolation mount, which the pilot did not normally check.

Amongst the photographs the pilot sent by email were images of the transmission drag pin and stop mount, and the main transmission driveshaft, forward coupling and isolation mount. The maintenance manager examined the photographs and, when looking at the stop mount support plate (see Figure 2), he did not see any damage or cracked paint on the domed heads of the attachment rivets. Furthermore, he did not see any disturbance of the sealant between the stop mount support and the fuselage upper deck. He observed that the drag pin attachment hardware appeared undamaged, as did the drag pin itself, apart from some loss of paint on the side of the pin. This, in his experience, was not an abnormal condition. He did not notice the absence of the stop mount plate, which had detached.

Figure 2

Pilot's photograph of damage to transmission drag pin and stop mount assembly

When looking at the driveshaft area (see Figure 3), the maintenance manager observed that the dots on the red temperature indicator stickers, on the forward driveshaft coupling, were white, indicating that the coupling had not been overheated excessively. He noted a gouge in the isolator mount top plate, which was similar in his experience to previous B206 heavy landing events, but he did not ask the pilot to measure the gouge depth and did not refer to the AMM for allowable damage limits. The pilot advised the maintenance manager that the mast was "free to move left and right" and photographs taken by the pilot showed no visible contact marks on the main rotor pitch links or the mast cowling. The maintenance manager verbally approved the helicopter to fly back to Biggin Hill Airport for further examination at the owner's maintenance facility, and no defects were recorded in the helicopter's technical log either before or after these flights.

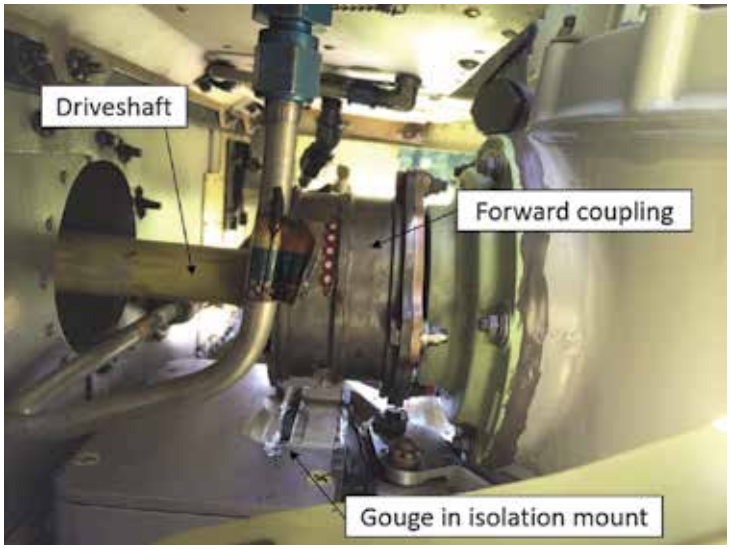

Figure 3

Pilot's photograph of damage to isolation mount

The pilot then flew the helicopter to Breighton Airfield, to refuel, and on to Biggin Hill Airport, where it was taken out of service.

The AAIB was advised of the accident in February 2015. No Mandatory Occurrence Report (MOR) had been filed.

Aircraft description

The AB (Agusta Bell) 206B is a single-engine helicopter of conventional layout and is only certified for VFR flight. It has teetering two-bladed main and tail rotors, driven by an Allison 250-C20B gas turbine engine mounted on the fuselage roof behind the main rotor transmission. The engine delivers power to the main rotor transmission via a freewheeling assembly and a transmission driveshaft that features flexible couplings at both ends. Temperature indication labels are adhesively bonded to each driveshaft coupling. Each label contains five dots that change colour from white to black to indicate whether the coupling has exceeded certain temperature limits during operation. Each coupling should feature two yellow #6000-3 'low-temperature' stickers, with dots that turn black at 330°F, and two red #6000-1 'high-temperature' stickers, with dots that turn black at 370°F.

The main rotor transmission is attached to the fuselage by two pylon support links. Transmission vibrations are attenuated by an elastomeric vibration isolation mount that is bolted to the fuselage roof and attached by a lug to the bottom of the transmission housing. During normal operation there is approximately 12 mm of vertical clearance between the forward driveshaft coupling and the isolation mount top plate. If the main rotor transmission is excessively displaced, such as can occur during heavy landings or with extreme cyclic control inputs, the forward driveshaft coupling can strike the top plate, creating a gouge in the plate's surface.

A tachometer generator unit, that generates an electrical signal proportional to the main rotor rpm, is attached to a hydraulic pump assembly, which is mounted to the rear of the main transmission housing.

The bottom of the transmission housing features a vertical steel drag pin that projects through an opening in a stop mount assembly (see Figure 1). The stop mount assembly consists of a stop mount plate that is attached to a stop mount support by eight rivets. These rivets are intended to fail in shear and the stop mount plate to detach from the support plate when heavy contact with the drag pin occurs during extreme movement of the main rotor transmission.

Damage description

The gear teeth of both the forward and aft main driveshaft couplings were found to be damaged beyond allowable limits, due to chipping of the gear tooth material. The freewheeling unit's attachment flange, which is bolted to the main driveshaft rear coupling, was deformed beyond allowable limits.

The isolation mount top plate was gouged through its entire thickness and the internal elastomeric damper material had mostly dis-bonded due to overload, rendering the isolator incapable of providing significant vibration damping.

The main driveshaft rear coupling had two temperature indication stickers fitted, which were both of the red 'high-temperature' type, and both of these had white dots showing that the rear coupling's temperature had not exceeded 370°F.

The main driveshaft forward coupling had four temperature indication stickers fitted. Two were red 'high-temperature' stickers and two were yellow 'low-temperature' stickers, of incorrect part number #6000-2, which are designed to turn black at 270°F[1]. The red stickers both had white dots and the yellow stickers both had black dots, indicating that the forward coupling's temperature had exceeded a temperature of 270°F but had remained below 370°F.

The transmission drag pin had made heavy lateral contact with the stop mount plate and the rivets attaching the stop mount plate to the support plate had failed in shear, releasing the stop mount plate which was found lying loose beneath the support plate. The drag pin's paint finish had been abraded, revealing the bare metal surface beneath.

The degree of transmission movement was sufficient to permit the transmission tachometer generator to be damaged due to mechanical contact with a cyclic control tube support bracket, although the unit was still functional. The internal bore of the swashplate support had been scored by the main rotor mast, indicating that the mast had flexed significantly.

Inspection criteria listed in the Aircraft Maintenance Manual (AMM)

Chapter 63-00-00 *'Main Rotor Drive System'* of the helicopter's AMM contains a detailed *'Pylon Whirl Inspection'* which must be carried out if the following criteria are reported:

> *PYLON WHIRL INSPECTION*
>
> *NOTE*
>
> *Perform pylon whirl inspection following pilot report or evidence of abnormal landing, excessive slope landing, operation in severe turbulence, low rotor RPM during flight (power ON or OFF), rapid and extreme cyclic input, excessive spike knock[2] or main driveshaft contact with isolation mount.*

The pylon whirl inspection consists of a detailed three-page flow-chart of component and rotor system inspections, many of which require substantial disassembly of the rotor system.

One of the required checks is to inspect the isolation mount for any contact with the main rotor driveshaft coupling and, if the isolation mount is damaged beyond permitted limits, to overhaul the main driveshaft. The Bell 206 Component Repair and Overhaul Manual

Footnote

[1] The requirement to apply #6000-1 and #6000-3 temperature indicating stickers to the driveshaft couplings was promulgated in Agusta Mandatory Technical Bulletin 206-219, dated 24 October 1995.

[2] '*Spike knock'* refers to contact of the transmission drag pin with the stop mount assembly.

states that the maximum allowable depth of damage to the isolation mount top cover plate is 0.080" (2.0 mm). The top cover plate thickness is 5.2 mm.

The assessment of damage to an aircraft is outside the privileges of pilot maintenance, as defined by EASA Part M[3]. Therefore, determination of continued airworthiness, based on AMM allowable damage limits, is a task that must be certified by an EASA Part 66 licensed aircraft engineer.

Chapter 63-11-01 of the AMM, entitled *'Main Driveshaft',* contains information for interpretation of the temperature indication stickers on the main driveshaft couplings. A combination of black dots on the yellow 'low temperature' stickers and white dots on the red 'high temperature' stickers is stated to have a probable cause of *'Elevated temperature'*. The remedial actions required for this condition are stated as:

> *Elevated coupling temperature is indicated. Determine probable cause of elevated temperature indication and take corrective action before continued operation. Accomplish checks in steps a. and b. If probable cause is not revealed from steps a. and b., perform steps c. and d. Replace affected TEMP-PLATE[4].*
>
> *a. Check driveshaft coupling for any signs of grease leakage. If leakage is detected, the coupling must be serviced before returning to service.*
>
> *b. Review current operating conditions to determine probable cause of elevated coupling temperature. Make appropriate adjustment to correct condition.*
>
> *c. Inspect engine and transmission pylon mounts for condition.*
>
> *d. Verify engine-to-transmission alignment.*

Meteorology

Pilot planning

The pilot could not recall exactly what he had done on the morning of 27 June 2014 but stated that he would normally obtain an overview of the weather from various BBC services before using the Met Office website to gain specific airfield forecasts and actual weather for his route.

The Met Office

The UK Met Office provided details of the forecast weather that had been available before the pilot departed from Beaconsfield, and an aftercast for the same day.

The forecast Metform F215 (see Figure 4), issued at 0317 hrs on 27 June 2014 and valid between 0800 hrs and 1700 hrs, showed an occluded front located across the pilot's planned route. In the overall area of the front (Area B), the visibility was forecast to be generally 15 km, with about 50% of the area having 7 km visibility in moderate rain or showers of rain.

Footnote

[3] EASA Part M, Section A, Subpart H, M.A.803 Pilot-owner authorisation.
[4] *'TEMP-PLATE'* is an alternative name for the temperature indication stickers.

Near the front, up to 25% of the area would have 2 km visibility in mist and drizzle, with hill fog covering between 25% and 50% of the area.

A trough (Area C) was located to the south of the front and moving north more quickly than the front. Near the trough, the visibility was forecast to be 7 km in showers of rain, with between 25% and 50% of the area having 2 km visibility in heavy showers of rain and heavy thunderstorms and rain. Up to 25% of the area was forecast to have hill fog, with visibility below 200 metres.

In relation to cloud, 25% to 50% of Area B was forecast to have scattered or broken stratus, with the base between 400 ft and 1,000 ft amsl and tops at 1,500 ft amsl. Above that, between 1,500 ft and 3,000 ft amsl, scattered or broken cumulus or stratocumulus, incorporating moderate icing and moderate turbulence, was forecast.

The updated chart issued at 0900 hrs, indicating the forecast positions of the fronts at 1800 hrs, showed a narrowing of the gap between the trough and the occluded front.

Met Office reported that the actual conditions on 27 June 2014 were consistent with the forecast.

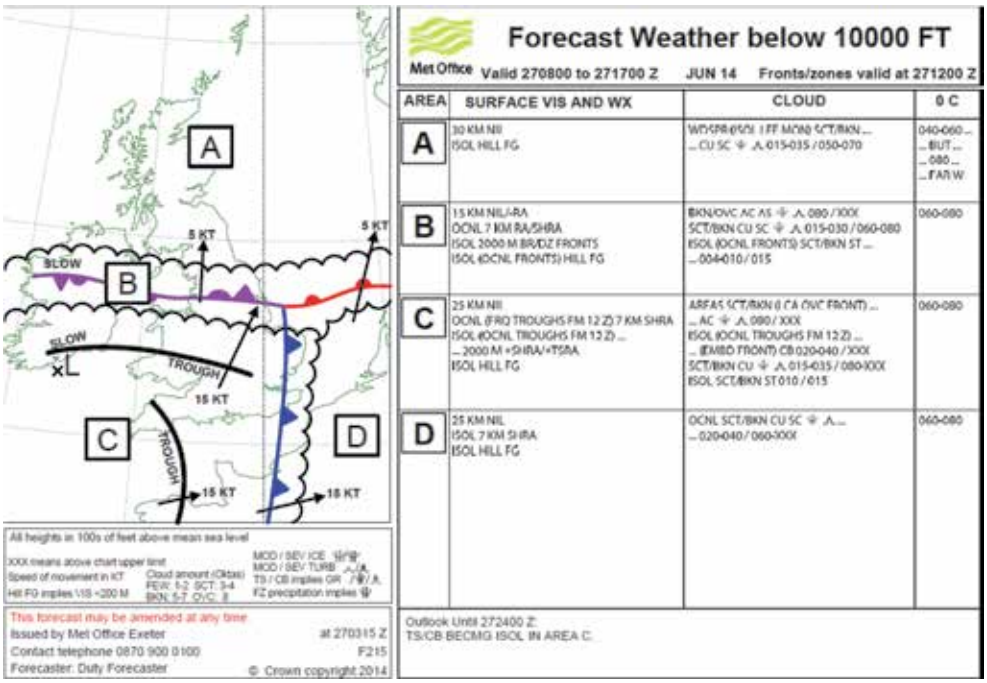

Figure 4

F215 valid for flights between 0800 hrs and 1700 hrs on 27 June 2014

Pilot

The pilot held an EASA Private Pilot's Licence (Helicopters) (PPL(H)), with a valid Bell 206 Jet Ranger type rating. He had held a UK PPL(H) since 2001 and his Bell 206 Jet Ranger type rating had initially been issued in 2002.

The PPL(H) training syllabus includes '*Basic Instrument Awareness*', in case a pilot inadvertently encounters poor visibility or cloud. The pilot had received no additional training in flying on instruments.

Recorded data

The pilot was using an iPad navigation application during the four flights on the day of the event and the two return flights three days later. The application recorded tracks for all these flights (see Figure 5).

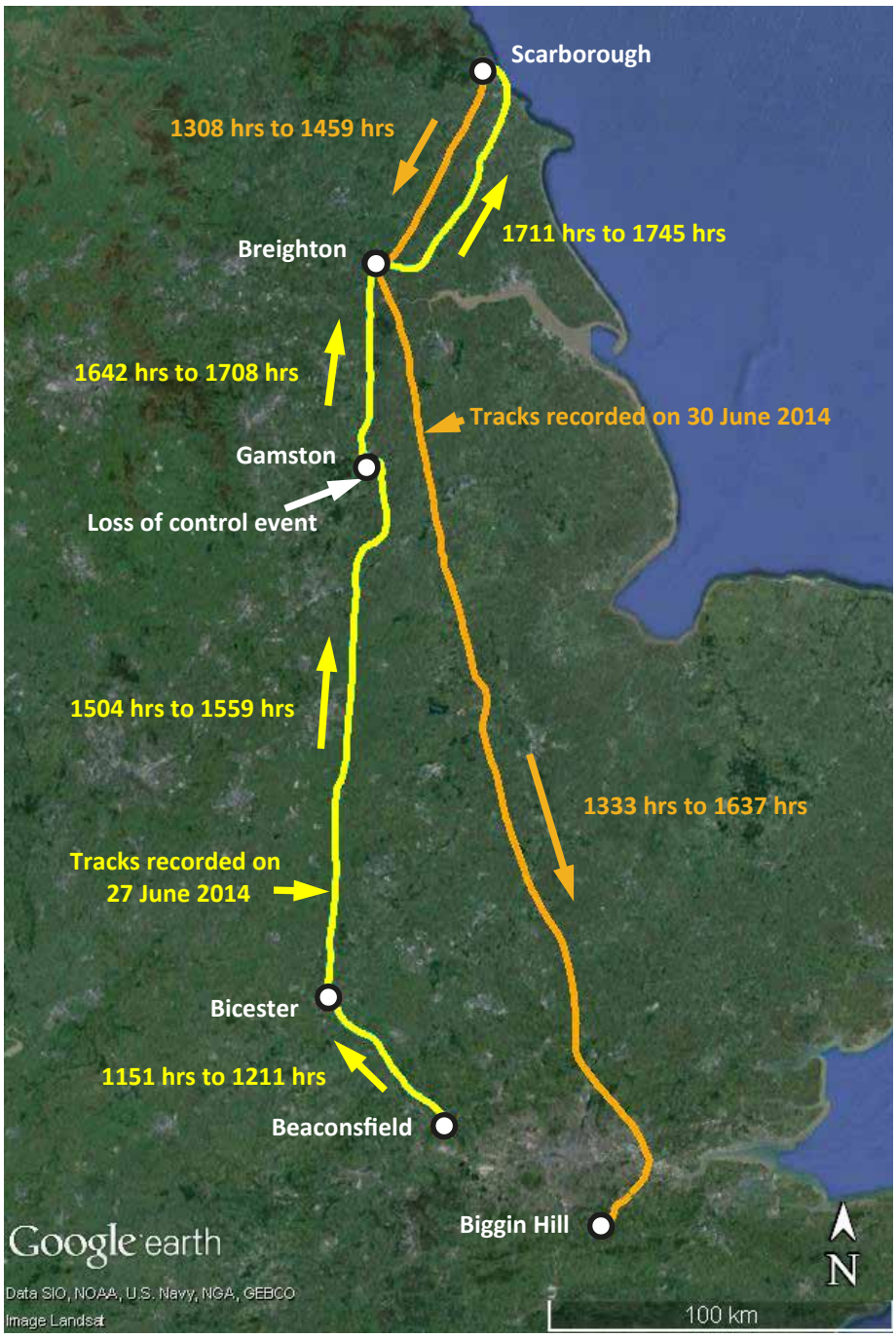

Figure 5

Tracks recorded on the iPad for 27 June 2014 and 30 June 2014

The flight from Bicester (see Figure 6) started at 1504 hrs on 27 June 2014. The helicopter initially tracked north at a height of approximately 1,000 ft agl. At 1533 hrs, it descended to approximately 600 ft agl, before descending further to approximately 400 ft agl. After this, the helicopter climbed to a height of approximately 2,000 ft agl over a four-minute period.

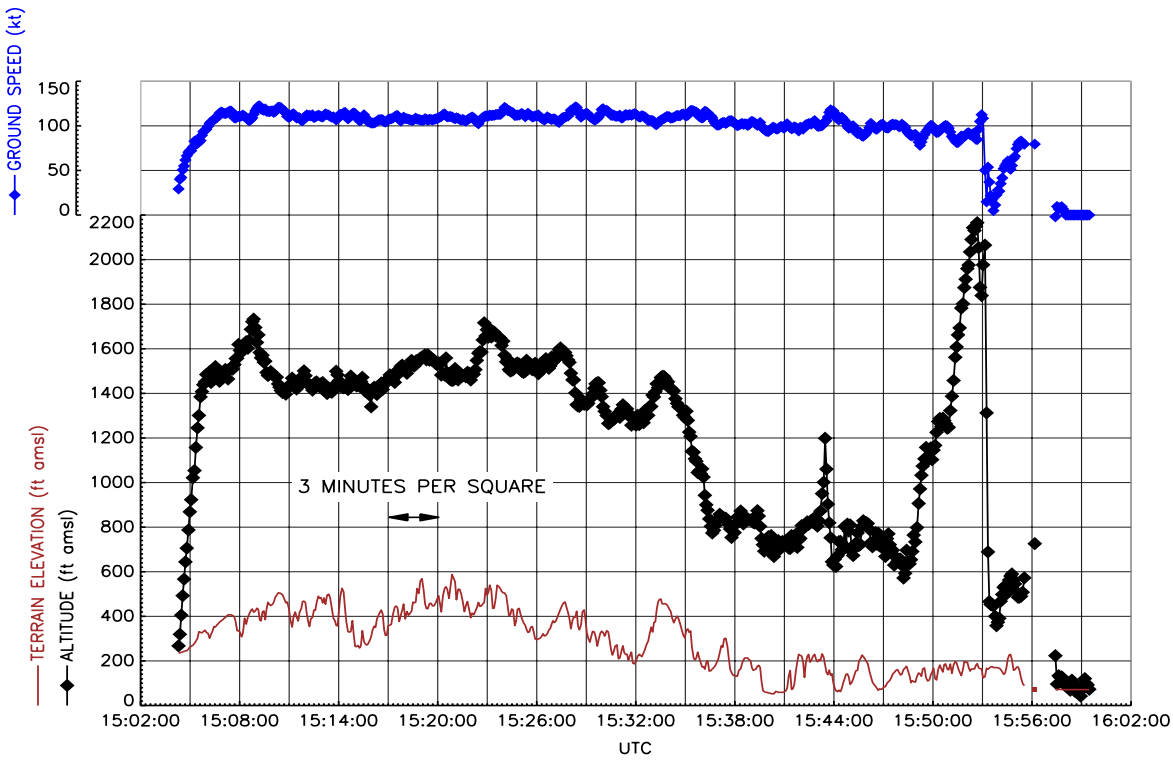

Figure 6

Flight from Bicester to Gamston

On reaching this height, the helicopter began a turn to the left, achieving a track change of 90° in approximately 20 seconds, and a descent was initiated (see Figure 7). As the data becomes less reliable under dynamic situations, it could not be used to accurately assess the dynamic manoeuvres that followed.

The highest rate of descent indicated by the data was 6,000 ft/min but this is unlikely to be accurate. The data indicated that the helicopter then flew level at a height of approximately 300 ft agl but with a reducing ground speed. The helicopter then descended further, the speed increased and the helicopter then climbed again. After control was regained, the aircraft proceeded to Gamston Airport.

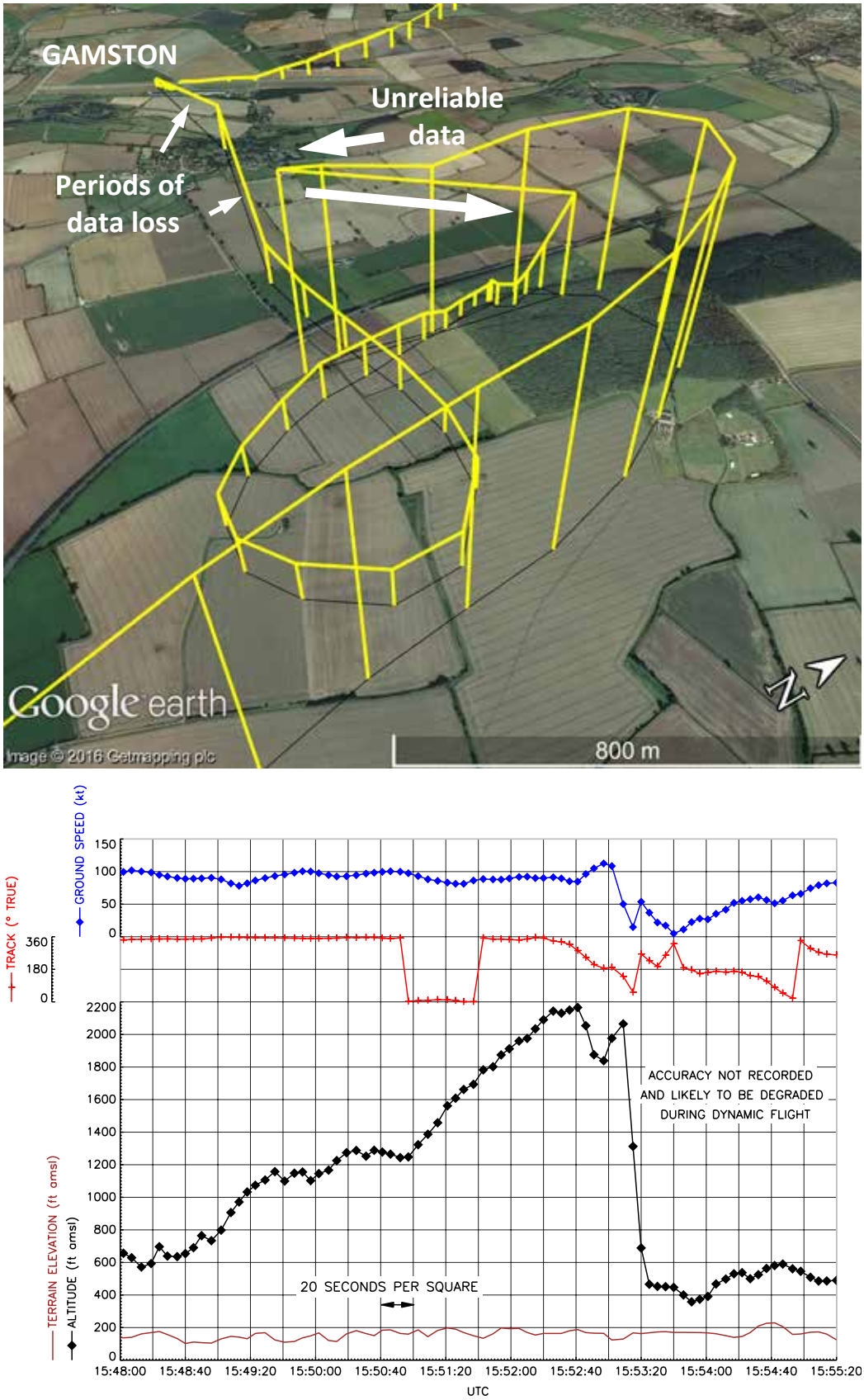

Figure 7

Loss of control

Aircraft accident and serious incident reporting

The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996 defines an accident as an occurrence associated with the operation of an aircraft during which:

> *'A person suffers a fatal or serious injury*
>
> *or*
>
> *The aircraft sustains damage or structural failure that would normally require major repair or replacement of the affected component.'*

Where an accident …. occurs:

> *'The relevant person shall give notice by the quickest means of communication available.'*

Civil Air Publication (CAP) 382 Mandatory Occurrence Reporting (MOR) scheme

The Mandatory Occurrence Reporting (MOR) scheme is run by the CAA with guidance material published in CAP 382. Reports should be dispatched to the CAA within 96 hours of the occurrence of a reportable event.

Pertinent sections of the scheme include: *Categories of Aircraft Under the Scheme,* which states:

> *'The ANO specifies the aircraft covered by the MOR Scheme as:….*
>
> - *any turbine-powered aircraft which has a certificate of airworthiness issued by the CAA.'*

And the Categories of Persons Required to Report, which include:

> *'The operator and the commander of a turbine powered aircraft which has a certificate of airworthiness issued by the CAA….*
>
> *A person who carries on the business of maintaining or modifying a turbine powered aircraft, which has a certificate of airworthiness issued by the CAA…'*

Appendix B of CAP 382 provides examples of occurrences which must be reported. For the operation of aircraft, it includes:

> *'1.1 (f) Loss of Control, regardless of cause.*
> *1.2 (g) An event leading to the declaration of an emergency.'*

For engineering-related occurrences, it includes:

> *'2.3.1 (b) Damage or defect of main rotor gearbox/attachment which could lead to in-flight separation of the rotor assembly and / or malfunctions of rotor control.'*

Published safety advice

The CAA Safety Sense Leaflet 1, '*Good Airmanship',* advises pilots to:

> *'Get an aviation weather forecast, heed what it says and make a carefully reasoned GO/NO–GO decision. Do not let 'Get-there/home-itis' affect your judgement and do not worry about 'disappointing' your passenger(s). Establish clearly in your mind the current en-route conditions, the forecast and the 'escape route' to good weather. Plan an alternative route if you intend to fly over high ground where cloud is likely to lower and thicken'*

The CAA Safety Sense Leaflet 17, '*Helicopter Airmanship',* advises pilots that:

> *'Return or land early if the weather deteriorates. Maintain a safe altitude.'*

Flight Manual pre-flight inspection

The AB206B '*Flight manual section II normal procedures: preflight check'* directs the pilot to inspect (amongst other items):

> *'Isolation Mount : Condition.*
>
> *Drag Pin : Security and evidence of contact with static stop plate.*
>
> *Main Driveshaft forward and rear couplings: Condition and grease leakage. Check paint stripe(s) for evidence of overheating indicated by brown colour.'*

The isolation mount is inspected from both the left and the right side of the helicopter.

Safety action

> The reference to *'paint stripe(s)'* on the driveshaft couplings refers to the configuration of the couplings prior to embodiment of Agusta Mandatory Technical Bulletin 206-219, which replaced the paint stripes with *'TEMP-PLATE'* temperature indication stickers. The manufacturer has amended the AB206B flight manual to correct this anomaly.

Analysis

Flight planning

The hazard presented by the combination of a trough and an occluded front that lay laterally across the planned route, with the latter extending beyond the coastline, was not identified prior to the flight. The forecast combination of low cloud, poor visibility, heavy thunderstorms and showers of rain indicated that there was limited prospect of the flight being completed in VMC.

The flight

After the pilot departed from Bicester, he flew some 80 nm without reported incident. Nearing Gamston Airport, he began to encounter the degraded visual conditions associated with the trough and occluded front. While considering whether to route to the east or divert to Gamston, he entered cloud. The helicopter had climbed steadily over a period of almost four minutes until it entered the base of the cloud, depriving the pilot of visual references.

The PPL(H) syllabus requires pilots to be trained in basic instrument flying techniques. This does not permit planned flight into instrument conditions but provides knowledge on what to do following inadvertent entry into cloud. The pilot successfully completed an approximately level 90° level turn on entering cloud. The helicopter remained in cloud, the pilot had no visual references and control was lost.

The pilot's description and the recorded data show that a variety of extreme manoeuvres occurred during the temporary loss of control, resulting in the helicopter sustaining significant damage.

Continued flight following the loss of control

Given the extent of the damage to the helicopter's main rotor drive system, it is most probable that the damage occurred during the loss of control event. Consequently, the helicopter operated four sectors in an un-airworthy condition before the full extent of the damage was discovered at the owner's maintenance facility.

The first opportunity to detect the damage would probably have been during the pilot's pre-departure inspection at Gamston Airport. The pilot stated that he found no damage to the helicopter but added that the isolation mount was not part of his normal inspection routine. His inspection had focussed on the condition of the drag pin, which he considered as a critical identifier of serviceability. Inspection of the condition of the isolation mount and stop mount plate is contained within the AB206B flight manual section detailing the normal pre-flight exterior checks.

A second opportunity to detect the damage occurred when the maintenance manager reviewed the pilot's photographs of the helicopter. These showed the missing stop mount plate and the gouge in the isolation mount. The maintenance manager stated that his decision to approve the helicopter for the return flight was influenced by the pilot's positive report of how the helicopter had performed on the sectors following the loss of control event, and also by the fact that the driveshaft couplings had not been excessively overheated. It is possible that these factors promoted confirmation bias[5] when he reviewed the photographs of the damaged isolation mount, which was similar to, but more severe than, previous examples he had seen. He did not detect the absence of the stop mount plate that was missing in one of the pilot's photographs, as his attention was drawn to

Footnote

[5] Confirmation bias is the tendency to interpret new evidence as confirmation of one's existing beliefs or theories.

other features in the photograph which supported his belief that the helicopter was not seriously damaged.

The maintenance manual requires a pylon whirl inspection to be carried out if the isolation mount damage limits are exceeded or the pilot reports extreme cyclic inputs. Had the maintenance manual been consulted, it is improbable that the helicopter would have been approved for continued flight.

Reporting

The pilot was unaware that the MOR scheme applied to private pilots and that this event should also have been reported to the AAIB as soon as the extent of the damage was evident. The regulations and other guidance for both accident investigation and the MOR scheme are available on the AAIB and CAA websites, respectively, to assist pilots and others in determining whether an event is reportable.

Conclusion

The flight was planned to route through an area of deteriorating weather and conducted in a helicopter cleared for VFR flight only. The helicopter entered cloud and the pilot temporarily lost control. Serious damage occurred during the recovery to normal flight which rendered the helicopter un-airworthy. However, this was not detected until two subsequent flights had been completed. When the damage was identified, it was assessed incorrectly as acceptable and two further flights were completed before the helicopter was withdrawn from service and the full extent of the damage was discovered. The occurrence was reported eight months later.