ACCIDENT

Aircraft Type and Registration:	Piper PA-46-350P Malibu Mirage, N186CB	
No & Type of Engines:	1 Lycoming TIO-540-AE2A piston engine	
Year of Manufacture:	1990 (Serial no: 46-22085)	
Date & Time (UTC):	14 November 2015 at 1134 hrs	
Location:	Buttles Farm, Churchinford, Somerset	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 3
Injuries:	Crew - 1 (Fatal)	Passengers - 3 (Fatal)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	56 years	
Commander's Flying Experience:	600 hours (of which 260 were on type) Last 90 days - 17 hours Last 28 days - 4 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft was approaching Dunkeswell Airfield, Devon after an uneventful flight from Fairoaks, Surrey. The weather at Dunkeswell was overcast, with rain. The pilot held an IMC[1] rating but there is no published instrument approach procedure at Dunkeswell. As the aircraft turned onto the final approach, it commenced a descent on what appeared to be a normal approach path but then climbed rapidly, probably entering cloud. The aircraft then seems to have stalled, turned left and descended to "just below the clouds", before it climbed steeply again and "disappeared into cloud". Shortly after, the aircraft was observed descending out of the cloud in a steep nose-down attitude, in what appears to have been a spin, before striking the ground. All four occupants were fatally injured.

The investigation was unable to determine why the aircraft made the initial rapid climb but there was some evidence to suggest that the pilot may have manually overridden the autopilot, during the initial descent, without realising it was still engaged. This would have caused an out-of-trim condition that could have contributed to the aircraft pitching up rapidly. Evaluation flights showed that the pitch attitude achieved during this manoeuvre would have been disorientating for the pilot and may explain why control was not regained.

Footnote

[1] An IMC rating allows a pilot to fly in Instrument Meteorological Conditions (IMC), such as in cloud, but it is not a full Instrument Rating and its restrictions include: no flight in IMC in Class A, B or C controlled airspace; no takeoff or landings with a flight visibility of less than 1800 m, and no flight in IMC outside UK airspace.

History of the flight

At approximately 0930 hrs, the pilot, who was the owner of the aircraft, telephoned Dunkeswell Airfield to let them know that he was planning to fly there and to enquire about the weather. He was informed by an air/ground radio operator that Dunkeswell had a 500 ft agl cloudbase, with rain. The radio operator recalled the pilot asking if the weather had been "coming and going in patches" and advising him that "it had been constantly raining throughout the morning". The pilot replied that he would delay his departure and planned to arrive at Dunkeswell at about 1130 hrs.

The weather at Fairoaks Airport was good for flying with over 10 km visibility, and at 1041 hrs the aircraft departed for Dunkeswell. The flight proceeded uneventfully via the Southampton VOR, with the aircraft climbing progressively to an altitude of 5,000 ft amsl. At 1106 hrs, the pilot called Bournemouth ATC and was provided with a Traffic Service[2]. Subsequently, he requested a descent to 3,000 ft to "TRY AND BECOME VISUAL".

At 1113 hrs, ATC passed the pilot the following unofficial[3] weather observation from Dunkeswell: "VISIBILITY TO THE NORTH OF THE AIRFIELD IS FIVE KILOMETRES, TO THE SOUTH-WEST ITS FOUR KILOMETRES, ITS OVERCAST BETWEEN EIGHT HUNDRED AND A THOUSAND FEET, MODERATE RAIN, SURFACE WIND IS ONE NINE ZERO DEGREES TWELVE KNOTS, THEIR QNH ONE ZERO TWO FOUR." At 1117 hrs, the pilot reported he was going to "DESCEND TO TWO THOUSAND FEET TO TRY AND REMAIN VISUAL." ATC advised him that on descending below 2,300 ft he would be "BELOW THE MINIMUM TERRAIN LEVEL[4]" for the controller's radar and would be responsible for his own terrain separation. At 1123 hrs, the pilot reported that he was VMC[5] and was changing radio frequency, to speak to Dunkeswell.

When contact had been established, the air/ground radio operator at Dunkeswell advised the pilot that Runway 22 was in use and provided him with the QFE pressure setting of 994 hPa and the circuit direction. The pilot informed 'Dunkeswell Radio' that he was intending to join left base for Runway 22 and subsequently requested a wind check. He was advised that the wind was from 220° at 16 kt. The last transmission the operator recalled hearing from the pilot was that he was joining "for a three mile finals to Runway 22". After several minutes, during which the aircraft did not appear, the operator tried calling the pilot but there was no response. To establish if the aircraft had diverted to Exeter Airport, a radio was tuned to the Exeter Approach frequency. When the radio operator heard that a police helicopter was en-route to investigate reports of an aircraft accident to the north of Dunkeswell, he suspected that the aircraft had crashed.

Footnote

2 Air Traffic providers in the UK offer different levels of Air Traffic Service: Basic, Traffic, Deconfliction and Procedural. These are described in the UK CAA Publication CAP 774.

3 This unofficial weather was obtained by telephoning a second air/ground operator at Dunkeswell who made a visual observation.

4 Minimum terrain level refers to the Minimum Vectoring Altitude which is the lowest altitude, expressed in ft amsl, to which a radar controller may issue aircraft altitude clearances during vectoring/direct routing except if otherwise authorized for radar approaches, departures and missed approaches.

5 VMC, in the airspace and at the altitude and speed of N186CB at the time of this call, was a minimum of 5 km flight visibility, clear of cloud and in sight of the surface.

During the latter part of the flight, the aircraft was observed and heard by a number of witnesses in the area between Crewkerne and Dunkeswell. The sounds from the aircraft during its final manoeuvres were likened to the noise of an aircraft performing aerobatics, before it was seen descending at a steep angle and high rate of descent into a field. All four occupants in the aircraft were fatally injured in the impact.

Since the phone call from the pilot that morning, all Dunkeswell's planned training flights had been cancelled as a result of the weather, which the air/ground radio operator considered had deteriorated.

Witness information

A map showing the location of several of the witnesses is at Figure 1.

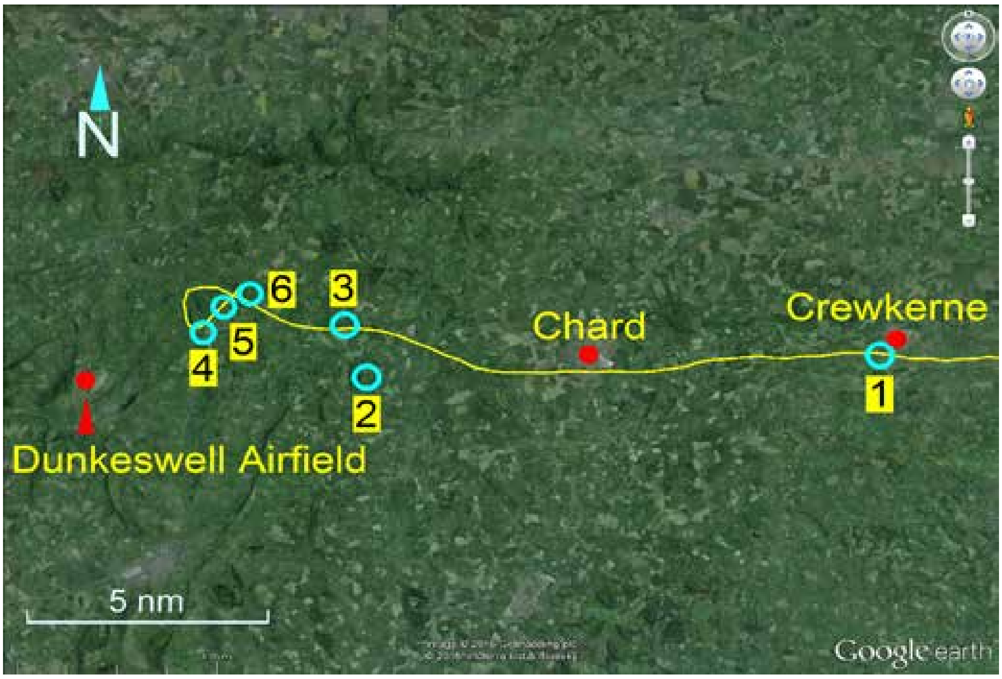

Figure 1

Witness locations and radar track of the accident flight

The witness at location 1 was an experienced general aviation pilot. He described seeing an aircraft at "around 1130 [hrs]", matching the description of N186CB, flying straight and level in a westerly direction. He estimated the aircraft was flying "below 500 feet" agl and the engine sounded loud, as though it was operating normally at a high power setting.

In locations 2 and 3, at about 1130 to 1140 hrs, witnesses reported seeing a small aircraft flying in a westerly direction at a height of approximately 300 ft agl, close to the base of cloud.

In location 4, many people reported hearing an aircraft performing what they perceived as aerobatics, overhead. They assumed the aircraft was above the clouds, as the weather was "bad" and they could not see it.

In location 5, a witness was working in his garden. He described hearing what he thought was an aircraft performing aerobatics. He looked up and saw an aircraft fly low over his head, then pitch up steeply to an estimated 70° nose-up, before disappearing into cloud.

In location 6, another witness was working in his yard with a young assistant. He described the weather conditions at the time as “not good, it was raining and there was low cloud”. He heard the “sound of an aircraft that sounded as though it was doing aerobatics“. Then he saw an aircraft appear from the base of the clouds, about 500 m from his position. It was in a steep nose-down attitude, descending rapidly. It then disappeared below the horizon and, on hearing a noise, he realised the aircraft must have crashed. His young assistant described the aircraft as rotating as it descended. The elder witness ran to the scene whilst telephoning the emergency services. When he arrived, it was apparent that none of the occupants had survived.

An air ambulance and police helicopter arrived at the accident site shortly afterwards. The pilots of these helicopters later described there being poor weather conditions in the area.

Dunkeswell

Dunkeswell Aerodrome is situated in the Blackdown Hills, approximately 4 nm north-west of Honiton. At 839 ft amsl, it is the highest licensed airfield in the United Kingdom. The airfield is situated in uncontrolled airspace and has no published instrument approach procedures. It is equipped with an air/ground radio, which is used to provide airfield information to aircraft. The air/ground radio operators are not, nor are they required to be, trained meteorological observers. There is an automated weather station at the aerodrome, which produces a Surface Synoptic Observation (SYNOP) of the weather on the hour, every hour. These SYNOPs are available on several weather information websites. They were not routinely accessed by the air/ground operators at Dunkeswell.

Meteorology

At the time of the accident, the region between Fairoaks and Dunkeswell was being affected by an approaching warm sector and large amounts of cloud were being generated ahead of the surface front.

At Exeter and Yeovilton, light rain was being reported with visibility greater than 10 km. Surface winds were reported to be from the south west at between 9 and 14 kt, with scattered cloud at 2,000 ft and a broken layer at 3,500 ft.

The conditions at Dunkeswell were worse. The 1100 hrs Dunkeswell SYNOP gave the weather as: 7 km visibility in moderate rain, with $\frac{7}{8}^{th}$ broken cloud cover at 300 ft aal. The surface wind was reported as being south-westerly at 9 kt and the QNH was 1024 hPa. The 1200 hrs SYNOP was the same, except the south-westerly wind had increased to 17 kt.

Recorded information

Sources of recorded information

RTF recordings relating to the flight were obtained from Farnborough and Bournemouth ATC. Communications between the aircraft and the air/ground operator at Dunkeswell were not recorded.

Recorded radar information (Mode A, C and S[6]) was available from ground-based sites located at Clee Hill, Bovingdon, Burrington, Heathrow Airport and Pease Pottage. When combined, the radar provided an almost complete record of the accident flight, with the data starting shortly after the aircraft had taken off from Fairoaks and ending shortly before it struck the ground. The aircraft's approach to Dunkeswell was recorded by two radars located at Burrington (31 nm to the west of the accident site); these radars are referred to as Burrington Comb and Burrington SSR. Due to their relative alignment, the aircraft's position and altitude were recorded at a rate of up to four data points every ten seconds.

A GPS unit[7] installed in the aircraft's instrument panel was examined with the assistance of the manufacturer. Evidence indicated that it had been powered by the aircraft's electrical system until the aircraft struck the ground. The GPS has a touch-screen colour display (5.27 inches high and 4.46 inches wide), which provides, among other information to the pilot, the aircraft's horizontal position on a moving map display that includes topographical features, airports and waypoints. To aid navigation on to the final approach to a runway, a dashed line extending 5 nm along the runway centreline can be displayed for airfields that are stored in the GPS database. The GPS database included Dunkeswell. Upottery disused airfield, which is 2.7 nm to the north-east of Dunkeswell, was not in the GPS database. The GPS unit had been installed in the aircraft in September 2014.

The GPS unit contained a flight plan[8] from Fairoaks to Dunkeswell. This correlated closely with the aircraft's route recorded on radar. A waypoint had also been manually entered into the GPS. This was positioned on Runway 22's extended centreline just less than 2 nm from the runway threshold. This GPS unit did not record track logs.

A tablet computer[9] belonging to the pilot was recovered from a bag found inside the aircraft and downloaded. The tablet computer contained records of a number of previous flights recorded by a flight navigation software application[10]. It did not contain a record of the accident flight, indicating that the navigation software application was not in use

Footnote

6 Mode A refers to the four-digit 'squawk' code set on the transponder. Mode C refers to the aircraft's pressure altitude which is transmitted in 100 ft increments. Mode S provided parameters of groundspeed and track angle from the aircraft's GPS unit.

7 Garmin model GTN 750.

8 A GPS flight plan consists of sequentially ordered waypoints to assist in horizontal navigation. A typical flight plan consists of the departure airport, a series of turning points, such as radio navigation beacons or topographical features, and the final destination. If a flight plan is selected, the GPS displays a track line on the moving map display that the pilot can follow.

9 Apple manufactured iPad mini, model A1455.

10 Skydemon.

during the accident flight. Historical records included 25 flights to Dunkeswell between September 2013 and October 2015, of which 14 had departed from Fairoaks. Evaluation of these flights and the software application showed:

- The pilot was familiar with the route between Fairoaks and Dunkeswell and had made regular use of the software application on the tablet computer.
- The pilot had flown within 2 nm of Upottery disused airfield during 24 of the 25 approaches to Dunkeswell and had flown almost directly over Upottery during four of these approaches.
- Over half of the 25 landings at Dunkeswell were on Runway 22.
- The pilot typically positioned onto the final approach between 2 nm and 3 nm from the runway threshold when landing at Dunkeswell.

Interpretation of recorded data

Figure 2 provides the track of the flight from Fairoaks to Dunkeswell. Figures 3, 4 and 5 provide the aircraft's track and salient parameters during the final minutes of the flight. The aircraft's altitude amsl is derived from Mode C, corrected for a QNH pressure of 1024 hPa, with a tolerance of ±50 ft.

Figure 2

Combined radar track of the flight from Fairoaks

At 1120 hrs, 32 nm to the east of Dunkeswell, the aircraft was flying level at about 2,000 ft amsl and at a groundspeed of 130 kt (Figure 2). It maintained an altitude of between 1,900 ft and 2,000 ft amsl whilst following a course towards Dunkeswell, consistent with the flight plan found in the GPS. As the aircraft overflew the town of Chard, which is 10 nm to the east of Dunkeswell, the aircraft altered course towards the GPS waypoint positioned on Runway 22's extended centreline, just less than 2 nm from the runway threshold. As the aircraft closed to within 3 nm of the waypoint, and approximately 1 nm from Upottery disused airfield, it altered course to the right before starting a gradual left turn towards the final approach course for Runway 22.

At an altitude of about 2,000 ft amsl[11] (about 1,375 ft agl) and a range of 3 nm from the runway threshold (consistent with a vertical approach path of 3.5°), the aircraft proceeded to close to within approximately 150 m of the extended centreline (Figures 3, 4 and 5). However, rather than establishing onto the final approach, the aircraft continued to turn to the left whilst also descending The aircraft's groundspeed at this point was 144 kt and its estimated airspeed was 153 KIAS, based on the reported wind of 220° at 16 kt. During the turn towards the extended centreline, the turn rate progressively increased from 0.25º/sec to 1.8º/sec over a 24 second period.

Over the next 16 seconds, the rate of turn increased to an average of 3.8º/sec and then reached 8.1º/sec, whilst the aircraft descended about 300 ft to an altitude of 1,700 ft amsl (about 1,030 ft agl), at an average descent rate of 1,125 ft per minute (fpm) (±375 fpm). The aircraft then climbed rapidly, at an average vertical speed of 3,660 fpm, whilst continuing to turn to the left. Eighteen seconds later the aircraft reached a peak recorded altitude of 2,900 ft amsl, which coincided with the groundspeed having reduced to approximately 32 kt (an estimated airspeed of 33 KIAS). Shortly after, the aircraft descended rapidly at an average vertical speed of 6,000 fpm over a period of 16 seconds, before reaching a minimum recorded altitude of 1,300 ft amsl (about 460 ft agl). As the aircraft descended, its groundspeed increased rapidly to a recorded maximum of 176 kt (an estimated airspeed of 160 KIAS) and the turn to the left was arrested, with the aircraft tracking north-east. The aircraft then climbed again at an average rate of 1,600 fpm. Twenty-four seconds later, at 1134:36 hrs, the final radar return was recorded; the aircraft's altitude was 1,900 ft amsl (about 1,075 ft agl) and its groundspeed was 84 kt (an estimated airspeed of 68 KIAS). The final radar point was close to where the aircraft struck the ground; the calculated direct flightpath angle between the two positions was 60°.

Descent rate following final radar return

After 1134:36 hrs, there were no further radar returns from the aircraft. This could be because it was not detected by the radars during their next scan of the area, it had descended below the radar floor or the aircraft had already struck the ground by the time of the next radar scan.

Footnote

[11] The Mode C altitude recorded by radar is referenced to the international standard atmospheric pressure of 1013.25 hPa. A correction of 293 ft (27.3 ft per hPa) for the QNH of 1024 hPa has been applied to the Mode C altitude (ie 1,700 ft Mode C + 293 ft QNH correction = 1,993 ft). The corrected altitude has then been rounded to the nearest 100 ft (ie 1,993 ft has been rounded to 2,000 ft).

The radar data was analysed to determine the aircraft's descent rate during the final seconds, based on the radar scan period and radar floor coverage. Although it was found that coverage from the Burrington radars extended almost to ground level in the area of the accident site, evidence obtained during the evaluation flight (see section 'Evaluation flights') showed that it was possible for an aircraft of the same size as N186CB occasionally not to be recorded by radar when its flightpath is altered quickly. Therefore, it could not definitively be concluded when N186CB struck the ground. However, from the witness accounts, the close proximity of the final radar position to the accident site and the aircraft's low forward speed, it is likely that the aircraft struck the ground shortly after the final radar return at 1134:36 hrs. Table 1 provides average rates of descent for different possible times of impact, based on the three proceeding scan times (a period of 14 seconds) of the two radars at Burrington.

Time of ground impact (hrs)	Average rate of descent (fpm)
1134:42	10,750
1134:44	8,060
1134:50	4,600

Table 1

Possible final average descent rates based on radar scan timings

Transponder altitude data validity

The altitude input to the transponder was provided by the primary altimeter installed in the left instrument panel. This encoding altimeter was removed and examined at an approved facility under AAIB supervision. The barometric function of the altimeter could not be tested due to damage sustained during the accident, however there was no evidence of a pre-existing defect. Analysis of the encoder's electrical output signals, wiring to the transponder and radar data revealed no evidence of a pre-accident fault.

During the series of final manoeuvres shortly before the aircraft struck the ground, the aircraft had descended to a minimum indicated height of about 460 ft agl. The aircraft did not strike the ground at this time and therefore, if a discrepancy had existed within the altimeter or its static input that caused it to overread, the maximum error could not have been greater than 460 ft.

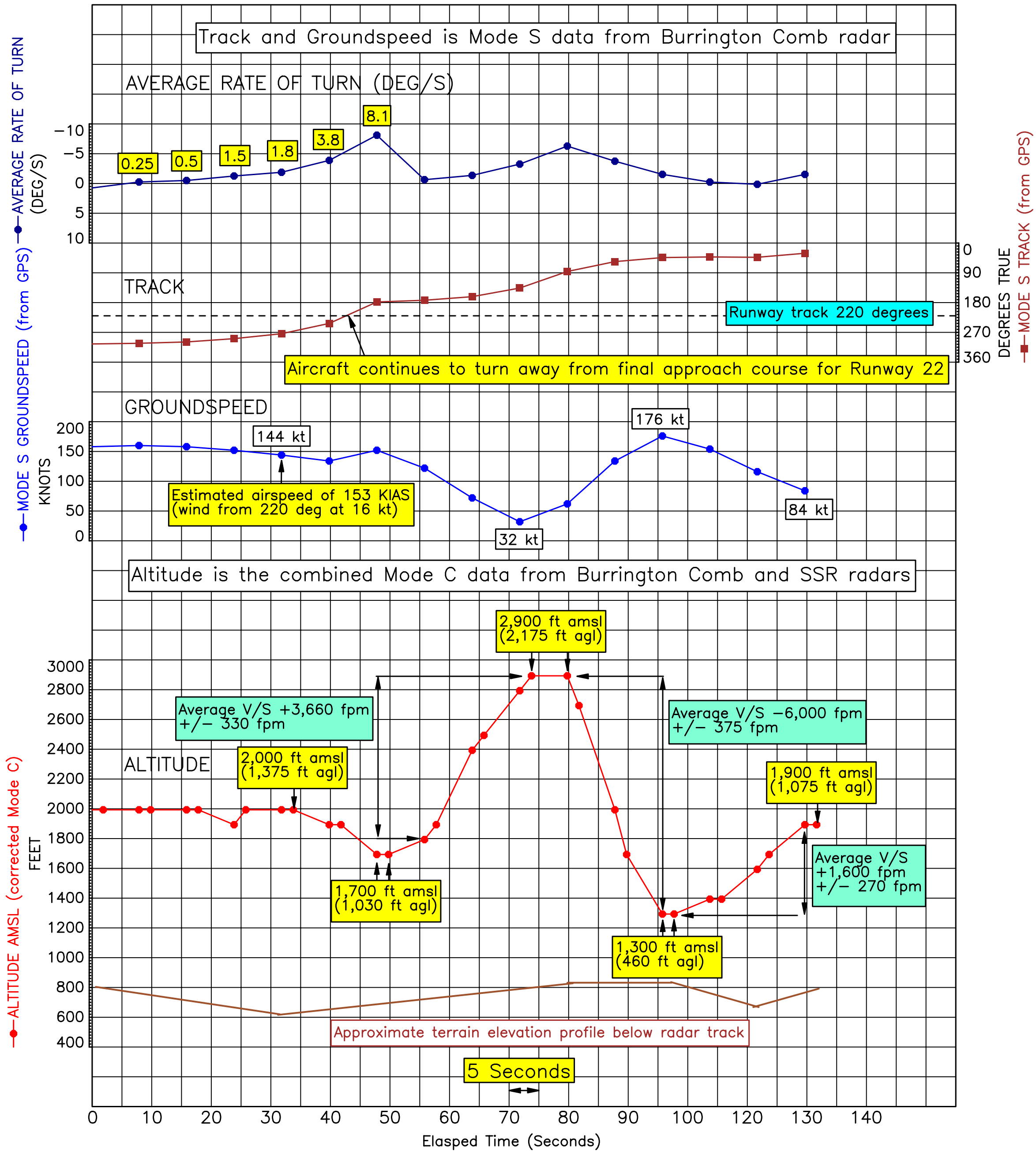

Figure 3

Accident flight radar data from Burrington Comb and SSR radar heads

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Bulletin correction

When this report was originally published, the above plot of recorded radar data for the accident flight contained an incorrect height measurement.

In the middle of the figure, under the altitude '2,900 ft amsl', the height should read '***2,175 ft agl***', not '1,175 ft agl' as originally stated. The supporting text, analysis and conclusions were unaffected by this error.

The online version of this report was corrected on 22 November 2016.

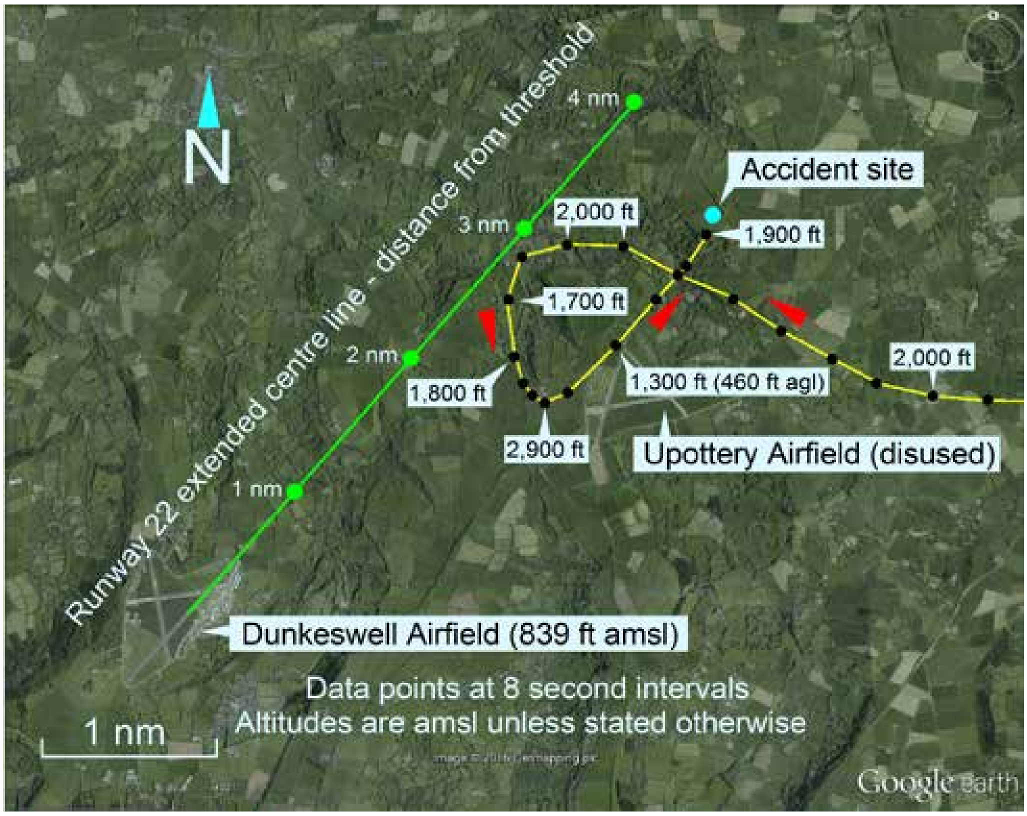

Figure 4

Approach to Dunkeswell (Burrington Comb radar) – plan view

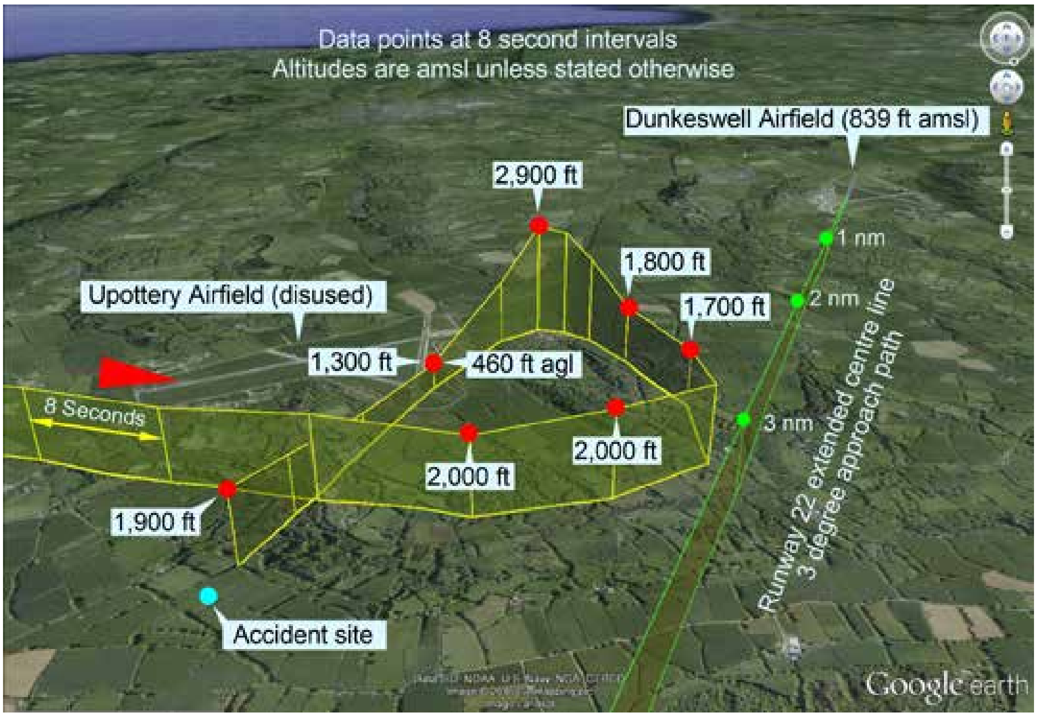

Figure 5

Approach to Dunkeswell (Burrington Comb radar) – view looking south

Aircraft information

General

The Piper PA-46-350P Malibu Mirage is a six-seat, pressurised aircraft of conventional aluminium construction powered by a Lycoming TIO-540-AE2A piston engine. N186CB was fitted with a two-bladed constant speed propeller[12]. The aircraft has a maximum takeoff weight of 4,300 lb and a cruise speed of 215 KTAS at 25,000 ft. The published power-off stall speed at maximum takeoff weight, with the flaps and gear retracted, is 69 KIAS. Usable fuel tank capacity is 120 US gallons. The flying controls are conventional, with the ailerons, elevator and rudder operated by cables and pulleys. The elevator trim tab is controlled by a trim wheel in the cockpit, which operates a screw-jack in the tail of the aircraft via cables. The elevator trim (pitch trim) can also be operated electrically, using trim switches mounted on each of the dual control wheels which power a pitch trim servo beneath the aft cabin. The aircraft had electrically-controlled flaps and an after-market SP9000 spoiler system fitted.

The aircraft's seating configuration consisted of three rows of two seats, with the centre row of seats facing aft.

Instruments

The aircraft was fitted with two vacuum-driven attitude indicators for redundancy. The attitude indicator on the left side of the instrument panel was a Bendix/King KI256 Flight Command Indicator with flight director bars (Figure 6). The pitch ladder on this instrument reads up to 25° nose-up and the movable face of the instrument meets a physical stop between about 50° and 60° nose-up[13].

For navigation the aircraft was fitted with a Bendix/King ED462 Electronic Horizontal Situation Indicator and a Garmin GTN 750 GPS with moving map display.

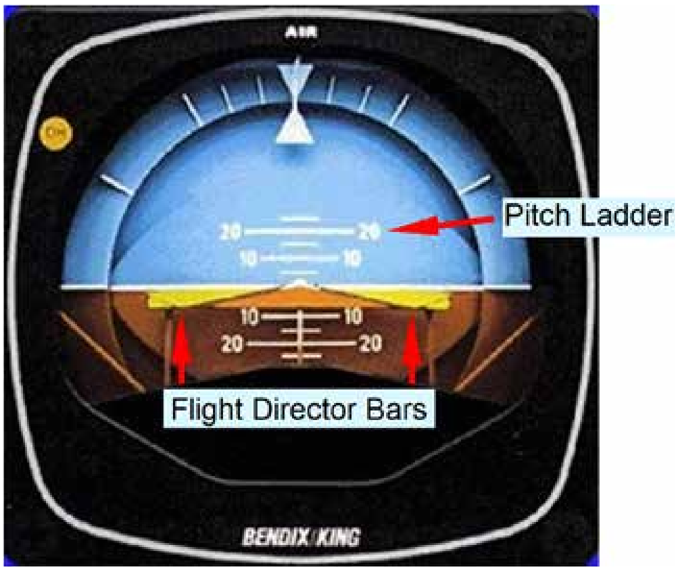

Figure 6

Bendix/King KI256 Flight Command Indicator (attitude indicator)

Footnote

12 The propeller rotates clockwise as viewed from the pilot's seat.

13 This instrument is designed to FAA Technical Standard Order TSO-C4c which requires the range of indication in pitch to be at least ±25°. The instrument must also be operable following manoeuvres of 360° in pitch. Above +25° the instrument must show blue sky but the pitch angle indication need not be accurate.

Autopilot

A Bendix/King KFC150 3-axis autopilot system was fitted. This system incorporated a KC192 Flight Computer (Figure 7) and four servos controlling the elevator, elevator trim, aileron and the rudder. The rudder servo provided a yaw damper function. The aircraft was also fitted with the optional KAS297B Altitude/Vertical Speed (VS) Selector. The autopilot was engaged by pressing the AP ENG button on the KC192 which engaged the autopilot in an attitude hold mode unless another mode button was also pressed. Selecting 'ALT' engaged the altitude hold mode and the autopilot maintained the selected altitude. Selecting 'HDG' engaged the heading mode and the autopilot turned the aircraft to the pilot's selected heading[14].

In HDG mode the autopilot will turn the aircraft to a newly selected heading with a maximum bank angle of about 22°. At an airspeed of 150 kt, a bank angle of 22° will result in a turn rate of 3.0º/sec. The maximum bank angle of 22° is commanded whenever the heading bug is moved more than about 15° away from the current heading. If a smaller heading change is selected a reduced bank angle is used, resulting in a reduced turn rate.

The separate KAS297B Altitude/VS Selector was used to select a climb or descent rate and could be set to capture a selected altitude. The maximum climb rate that could be selected was 3,000 fpm. The KAS297B received its barometric correction from the setting on the pilot's primary encoding altimeter. Another way of changing altitude with the autopilot engaged was to press the Vertical Trim UP/DN button on the KC192 (Figure 7) – a single press commands a 500 fpm change in altitude in the selected direction. The third way of changing altitude with the autopilot engaged was to press and hold the Control Wheel Steering (CWS) button on the control wheel and manoeuvre to a new altitude, then release the button.

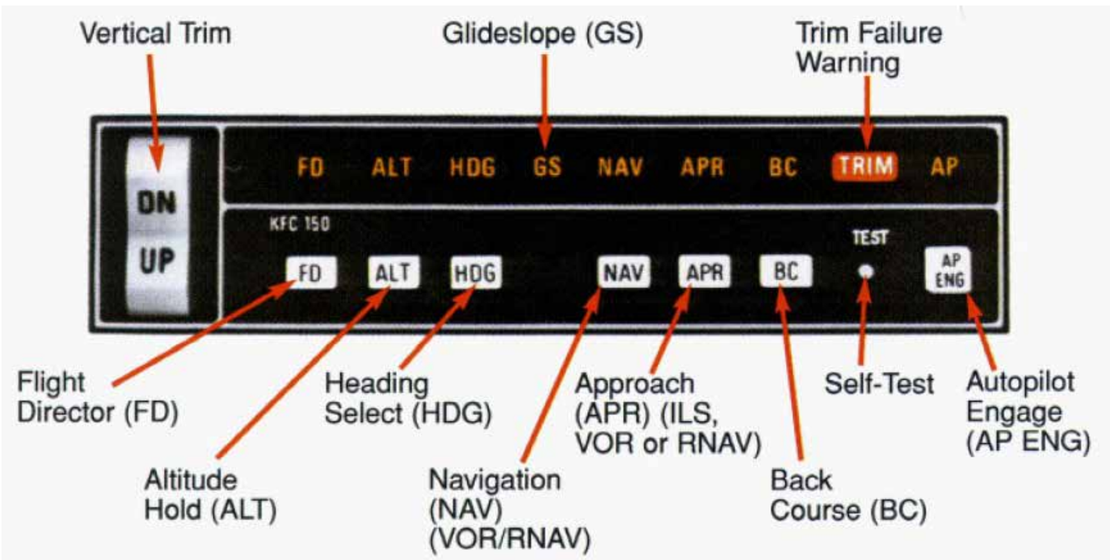

Figure 7

KC192 Flight Computer (autopilot control panel)
(YD yaw damper caption not shown but it was to the left of the FD caption)
(image copyright Honeywell)

Footnote

14 The heading was selected using a rotary knob in the centre of the instrument panel.

N186CB was fitted with an optional yaw damper switch to operate this system independently of the autopilot.

The primary means of disengaging the autopilot was by pressing the Autopilot/Yaw Damper (AP/YD) disengage button[15] on the control wheel (Figure 8). Pressing this button would disengage the autopilot, yaw damper and the flight director. Pressing the pitch trim switches on the control wheel or the 'AP ENG' button on the KC192 would also disengage the autopilot but would leave the flight director and yaw damper on, together with any associated modes (eg ALT, HDG, NAV). Pitch rates in excess of 8° per second (between pitch angles of ±15°) or roll rates in excess of 14° per second, for a period of 1 second, would also cause the autopilot to disengage and would leave the flight director and yaw damper engaged[16].

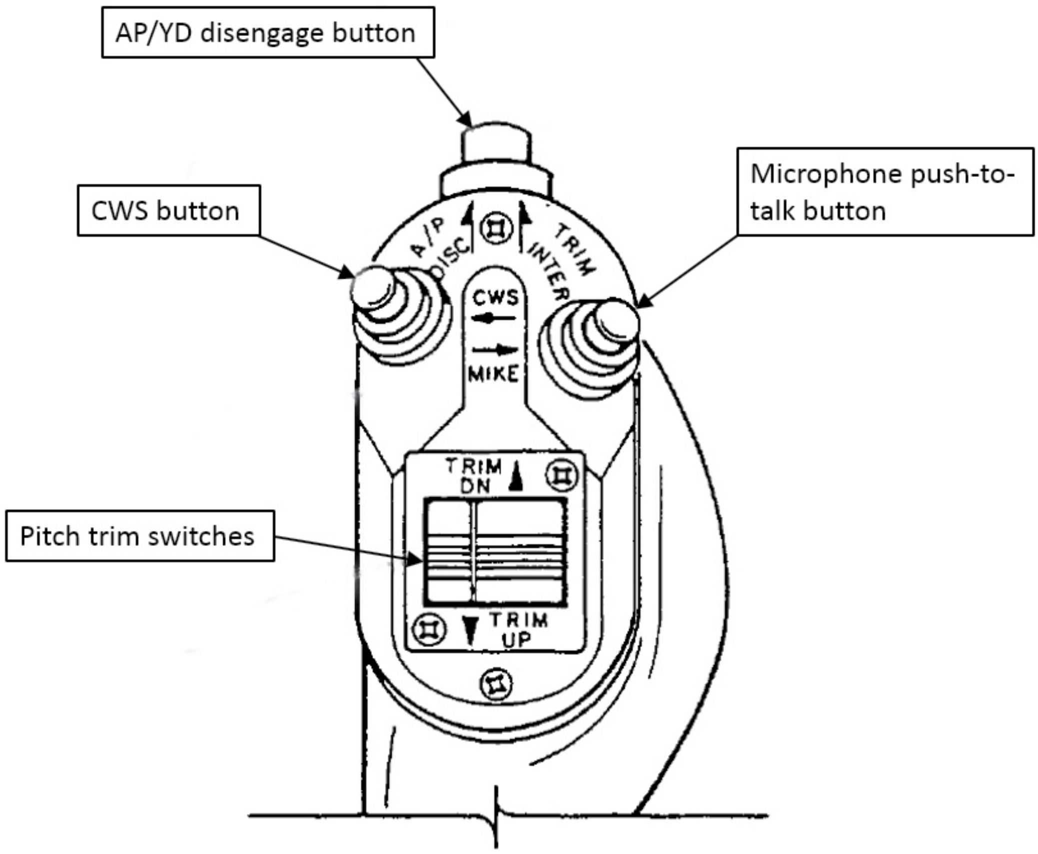

Figure 8

Control wheel switches
(image copyright Honeywell with AAIB annotations)

Footnote

15 This button is referred to in the flight manual as the 'A/P DISC/TRIM INTER switch' but the term Autopilot/Yaw Damper disengage button is used in this report because the button serves to disengage both the autopilot and the yaw damper.

16 If the CWS button is pressed while these pitch or roll rates are exceeded the autopilot will not disengage. If a pitch rate of 8°/s is exceeded above an angle of 15° the autopilot may not disengage because the pitch angle data sent by the KI256 attitude indicator to the KC192 flight computer is not sufficiently accurate above 15°.

The flight manual supplement for the KFC150 includes the following warning:

> *'Do not help the autopilot or hand-fly the airplane with the autopilot engaged as the autopilot will run the pitch trim to oppose your control wheel movement. A mistrim of the airplane, with accompanying large elevator control forces, may result if the pilot manipulates the control wheel manually while the autopilot is engaged.'*[17]

If, for example, the autopilot is engaged in ALT hold mode at 2,000 ft and the pilot pushes the control wheel forward to descend, the autopilot will command nose-up pitch trim in an attempt to regain 2,000 ft. This nose-up pitch trim will continue until either the autopilot is disengaged or 2,000 ft is reached.

The manual for the KFC150 states that the autopilot must be disengaged below 200 ft agl during approach operations and below 800 ft agl for all other phases of flight. The yaw damper must be disengaged before landing.

The KFC150 has a trim monitor which will emit an aural warning and cause the TRIM failure warning light to flash if it detects uncommanded pitch trim movement. The KFC150 manual contains a procedure for a TRIM failure which involves grasping the control wheel firmly while pressing and holding the autopilot disengage switch (which also interrupts power to the trim servo), and then locating and pulling the 'pitch trim' and 'autopilot' circuit breakers. The Radio Master switch can be used to remove power from the autopilot and trim servo while the circuit breakers are located.

Maintenance history

The aircraft was maintained by a Federal Aviation Administration (FAA) approved maintenance organisation in the UK, in accordance with FAA regulations. The aircraft had logged 1,751 hours and its last maintenance was an altitude encoder fault investigation on 11 November 2015. This investigation did not find any fault with the altitude encoding system after connectors and pins had been cleaned.

There were no deferred defects in the pilot's defect log found in the wreckage. The aircraft's last 100 hour inspection was on 24 August 2015 and included an altimeter calibration check. On 22 June 2015, the aircraft's lift transducer, part of the stall warning system, was replaced and was noted in the pilot's logbook as having been tested on 23 June 2015.

In 2007, the aircraft's fuselage was replaced due to a landing accident in Germany in 2003[18] that resulted in damage to the forward section of the fuselage assembly. The replacement

Footnote

[17] Explanation of 'mistrim': An aircraft is considered 'in-trim' in pitch if, when you release pressure on the controls, the aircraft does not pitch up or down. The elevator trim tab can be positioned manually by the pilot or automatically by the autopilot to cause the elevator to stay steady in the position that results in trimmed flight. An 'out-of-trim' or 'mistrim' condition exists when releasing pressure on the controls results in a pitch up or down.

[18] German Federal Bureau of Aircraft Accident Investigation (BFU) report 3X001-01/03, aircraft registration D-EXCC.

fuselage, from aircraft serial number 46-36196, had also been involved in an accident, although according to the accident report there was no damage to the fuselage[19]. This fuselage had originally been fitted with a KFC225 autopilot system, but it was supplied without avionics. The original fuselage's avionics, including the KFC150 autopilot system, were refitted during the replacement.

Accident site and initial wreckage examination

The aircraft wreckage was found in a field, 175 m north-east of the aircraft's last radar position. The aircraft had struck the ground at an elevation of 820 ft amsl, in a nose-down attitude, with a high rate of descent and at low forward speed (Figure 9). The orientation of the fuselage was in the direction 123°(M) and the fractured forward fuselage was resting at a nose-down attitude of about 25°. Damage to the undersides of the wing was consistent with the aircraft's flight path having been steeper than its nose-down attitude, suggesting that the wing was at a high-angle-of-attack, probably stalled, on impact. The aircraft had missed 6.5 m high power lines, which were 2.1 m aft of the aircraft's tail, and the left wing had travelled forward about 1 m from its initial impact point. The right wing had failed at the rear attachment and was angled forward. The tail section had failed in downward bending and the vertical tail had failed in forward and sideways bending. All external components of the aircraft were accounted for.

Figure 9
Accident site

The propeller hub had fractured and its mounting flange had failed at the engine crankshaft attachment due to impact forces. One blade, which had detached from the failed hub, had suffered significant damage and was buried in the ground underneath the nose of the aircraft. The remaining blade, still attached to the hub, had suffered minimal damage with some chordwise scoring. The flaps and landing gear were in the retracted position.

Footnote

19 Accident Investigation Board Denmark report HCL16/02, aircraft registration OY-JAM.

Both fuel tanks had ruptured and were empty but there was a distinct smell of fuel at the site. A ground survey found that about 20 tonnes of soil was contaminated with fuel, but an accurate fuel quantity could not be determined from this.

Weight and balance

The pilot occupied the front left seat and the three passengers were sitting in one of the centre seats and both of the aft row seats. The exact fuel state of the aircraft at the time of the accident was not known, so a probable fuel load was calculated based on estimated fuel burn and previous fuel uplift records. Combining this with the weight of the passengers and the recovered baggage, the minimum weight was estimated at 3,951 lb with a CG of 146.3 inches (aft of datum) and the maximum weight was estimated at 4,383 lb with a CG of 146.7 inches. The maximum takeoff weight, as indicated in the Pilot's Operating Handbook (POH), was 4,300 lb with a CG range of 143.3 to 147.1 inches.

Detailed wreckage examination

Flying controls examination

An examination of the pitch, roll and yaw flying control systems revealed a few breaks but these were all consistent with overload failures associated with impact. There were no obvious control restrictions and there were no pre-impact failures in the elevator or elevator trim tab systems. The elevator trim actuator was found set to 19 mm (full nose-up trim was 40.6 mm, neutral was 24.1 mm and full nose-down trim was 5.8 mm).

Powerplant examination

The throttle, mixture and propeller control runs were examined and there were no disconnections, apart from some overload failures caused by impact.

A complete strip examination of the engine did not reveal any pre-impact mechanical failures or evidence of heat distress. The left magneto was bench-tested and operated normally. The right magneto was destroyed in the impact but an internal visual inspection did not reveal any defects. The fuel servo, the engine-driven fuel pump, fuel flow divider and injector nozzles were all tested and were within limits. The propeller governor was tested and was found to be slightly outside the specification for a new or overhauled unit but within the normal range for a used unit.

The propeller hub was also strip examined and the propeller manufacturer assisted in the analysis of the propeller blade damage and hub witness marks.

Blade 1 had remained attached to the hub and had suffered limited damage compared to blade 2, which had detached from the hub. Blade 1 had tip chordwise scoring on its forward face, which indicated rotation at impact, and no scoring on its aft face which indicated that the blade struck the surface at a negative angle of attack, indicating no or low power. The tip also showed slight twisting, leading edge down, and aft bending which also supported a negative angle of attack.

Blade 2 had suffered significant bending, twisting and leading edge damage, in a manner that was indicative of high rotational energy and a negative angle of attack at impact. It also had distinct chordwise scoring from mid-blade to the tip and it showed some tip tearing and fractures which, according to the propeller manufacturer, is almost always indicative of power. There was a witness mark on the pre-load plate of blade 1, which indicated that it was struck by the pitch change knob of blade 2 when blade 2 was at an angle of 17.5°, the angle of the low-pitch stop.

The difference in damage between blades 1 and 2 was probably due to blade 1 striking the ground first and coming to a stop in less than one full revolution. According to the propeller manufacturer sudden stoppage, even at moderate power, was not uncommon in soil.

With the propeller blade on the low-pitch stop, power could be estimated from the altitude, airspeed and propeller rpm. Only the altitude at impact was accurately known; however, the engine tachometer was found stuck at 2,100 rpm. From the manufacturer's performance tables, if the rpm had been 2,000 rpm and the airspeed 100 KTAS, then power would have been 24%. At 2,000 rpm and 80 KTAS the power would have been 32%. In both cases, the tip angle of attack would have been negative. At 60 KTAS and 2,000 rpm the tip angle of attack would have been positive, which was not seen in the damage.

Instrument examinations

The cockpit was fitted with a Caution and Warning Panel (CWP) which contained caption lights for 18 different cautions and warnings. These included Alternator 1 Inop, Alternator 2 Inop, Fuel Pressure, Oil Pressure, Low Vacuum, Low Bus Voltage and Stall Warner Fail. Each caption contained two filament light bulbs. Microscope analysis of these bulbs revealed a number of broken filaments but none of the filaments had been stretched. A stretched filament would have indicated that it was probably hot at impact and, therefore, that the light was on[20]. The fact that some of the filaments had broken and that some of the filaments in light bulbs from the Flight Computer had stretched (see next section) indicated that the g-forces at impact were sufficient to stretch a hot filament. Therefore, it was concluded that it was unlikely any of the CWP bulbs were illuminated at impact.

The KI256 Flight Command Indicator (Attitude Indicator) was too badly damaged to test so it was strip-examined by the manufacturer under the AAIB's supervision. The rotor inside the gyroscope did not exhibit any rotational scoring, which would have been indicative of rotation at impact, nor did it exhibit any static witness marks which would be indicative of a stationary rotor at impact. No anomalies inside the instrument were noted and the as-found indication of the instrument was 30° nose-down and 2° left wing low, which was similar to the forward fuselage's final resting attitude. Both engine-driven vacuum pumps driving the KI256 instrument were strip examined and neither had any indications of a pre-impact failure.

Footnote

[20] Hot filaments are more ductile than cold filaments which makes them more likely to stretch than break. Cold filaments are brittle and are likely to break without any stretch.

The primary altimeter examination is described in the 'Transponder altitude data validity' section earlier in this report. The altimeter pressure setting was found at 994 hPa, which was the QFE setting for Dunkeswell at the time of the accident.

Many of the switches in the instrument panel, including the radio master switch, were destroyed and their pre-impact position could not be determined.

Autopilot system examination

The following components of the autopilot system were removed from the aircraft and examined by the manufacturer under the supervision of the AAIB: KC192 Flight Computer, KS271A Roll Servo, KS271A Yaw Servo, KS270A Pitch Servo, KS272A Pitch Trim Servo, KAS297B Altitude/VS Selector, KG102A Directional Gyro, KRG331 Rate Gyro, KC296 yaw computer, and the left control-wheel-mounted trim switches and autopilot disengage button. The KI256 Flight Command Indicator (examination previously described) also formed part of the autopilot system, providing the pitch and roll reference.

The KC192 Flight Computer was too badly damaged to test. The circuit boards were examined and no anomalies were detected that could not be attributed to impact damage. The bulbs which provide the YD, FD, ALT, HDG, GS, NAV, APR, BC, TRIM and AP captions were examined under the microscope. The YD and FD bulbs had filaments which were significantly stretched and the ALT bulb had a filament with three areas of stretch. The HDG bulb filament exhibited some crossover and some minor stretch. All the remaining bulb filaments had no indications of stretch and all had broken, except for the TRIM bulb. It was concluded that the YD, FD, ALT and HDG bulbs were likely all illuminated at impact and the other bulbs, including the AP, were extinguished.

The KAS297B Altitude/VS Selector contained a memory chip with non-volatile memory which revealed that the last selected vertical speed was 0 fpm and the last selected altitude was 2,000 ft.

The pitch trim servo had seized due to a bent servo mount, the bending of which was impact-related. When the servo was removed from its mount and bench-tested, it passed all tests. There were no faults detected within the pitch trim servo that would have caused a pitch-trim runaway.

The pitch servo was bench-tested and passed all tests except for the torque switch test, revealing that the torque switches were set slightly outside the specification on the low torque side. These switches serve to detect the servo load required to deflect the elevator. The effect of the low torque setting would have been to cause the autopilot to command pitch trim movement earlier than necessary. It would not have caused the pitch trim to move to an out-of-trim position.

The roll servo had suffered impact damage and some internal repairs were required before it passed bench tests. The yaw servo could not be tested because the internal motor had seized as a result of impact damage. A donor motor was installed but could not be powered due to impact-related damage of two circuit board components.

The slip clutches on the servo mounts for the roll and pitch servos were within specification. The force required to slip the clutches of the pitch trim and yaw servos were slightly above specification.

The directional and yaw rate gyros and yaw computer passed their functional tests.

The left control-wheel-mounted autopilot disengage button and pitch trim switches were tested and functioned correctly. The autopilot disengage button is a simple open/close circuit switch to ground, which, when pressed, provides power to an autopilot disconnect relay. This relay, when powered, removes power to the pitch trim servo and provides an electrical signal to the flight computer, causing the autopilot and yaw damper to disengage. This relay had a large dent in its side and did not function correctly when powered. The internal contacts which enable autopilot disengagement were stuck in the 'autopilot disengage' position. The relay connects to six wires, five of which had separated at the soldered pins on the relay and one had separated mid-wire. The wire separations were consistent with the large impact force that had caused the dent in the side of the relay.

The autopilot and pitch trim systems obtain power via a 10-amp autopilot circuit breaker and a 5-amp pitch trim circuit breaker respectively. These circuit breakers were incorrectly labelled in N186CB[21]. The 10-amp autopilot circuit breaker was labelled 'A/P Servos' and the 5-amp pitch trim circuit breaker was labelled 'Autopilot'. N186CB's fuselage, which was previously fitted with a KFC225 autopilot system, would have had circuit breakers labelled 'A/P Servos' and 'Autopilot' and no separate pitch trim circuit breaker.

The pitch trim circuit breaker (labelled 'Autopilot') located on the cockpit's right side panel was found tripped. In total, 10 out of 23 circuit breakers on this panel had tripped. On the cockpit's left side panel 17 out of 44 circuit breakers had tripped. Circuit breakers tripping during impact is not uncommon, particularly when there is significant disruption to wiring, as found in N186CB. The wire from the pitch trim circuit breaker to the autopilot disconnect relay had failed mid-wire. Contact between this wire and the aircraft structure could have caused the pitch trim circuit breaker to trip at impact.

Evaluation flights

The AAIB organised a series of three evaluation flights in another Piper PA-46-350P fitted with a KFC150 autopilot. One of the flights was conducted with a qualified test pilot. The purpose of the flights was to:

- gain a better understanding of the use of the KFC150 autopilot in the PA-46-350P
- experience and appreciate the handling and stall characteristics of the aircraft
- determine the speed at which the aircraft would be 'in trim' with the elevator trim actuator positioned at 19 mm (as found at impact)
- establish the required pitch attitude to achieve the rate of climb indicated by the recorded radar data

Footnote

[21] The circuit breakers were identified by tracing the routing of their wires.

- establish engine power settings required to achieve the 1,200 ft height gain, and corresponding rate of climb, recorded after the aircraft turned away from the final approach
- establish the effect of over-riding the autopilot in pitch
- establish if the Upottery disused airfield could be mistaken for Dunkeswell Aerodrome
- establish the base of radar cover near the town of Crewkerne

The aircraft used for the evaluation flights was fitted with an Attitude and Heading Reference System (AHRS) sensor, to record pitch attitude and pitch rate, and three GPS units which recorded track and altitude. The aircraft was ballasted so that the weight and CG was similar to that estimated for the accident flight.

Elevator trim

In order to determine the corresponding trim position relative to the aircraft's airspeed, the trim wheel in the cockpit was graduated with five positions, evenly distributed across the range of trim movement available. Position 0 was full forward (nose-down) trim and position 5 was full aft (nose-up) trim (Figure 10). It was found that 19 mm extension of the elevator trim actuator equated to a position of 1.7 on the trim wheel scale. The flight evaluation revealed that, with an aft CG, in level flight, at a stabilised airspeed of 150 KIAS (which was the estimated airspeed of N186CB shortly before it climbed rapidly) and the aircraft 'in trim', the trim wheel position was about 0.9.

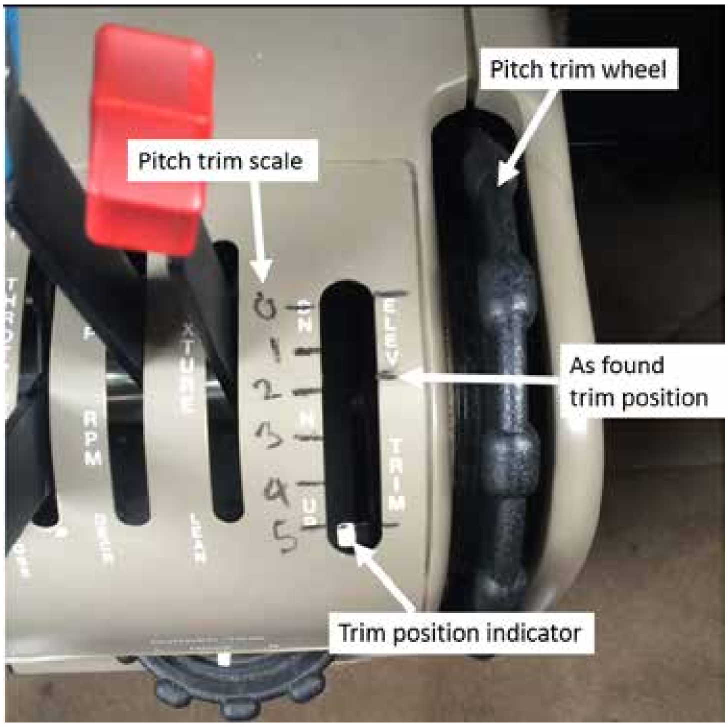

Figure 10

Pitch trim wheel and scale used on the PA-46-350P aircraft for the flight evaluation

In straight and level flight, it was found that 19 mm extension of the elevator trim actuator equated to a trimmed airspeed of about 115 KIAS. At an airspeed of 150 KIAS, this extension of the elevator trim actuator caused the aircraft to enter a steep nose-up climb when the pressure on the control column was released.

Autopilot disengaged evaluation

The aircraft was flown manually, in trim at 150 KIAS, and the recorded vertical profile of the accident aircraft was followed. The test pilot noted that as the airspeed reduced, an increasing pull force was required on the control column to maintain the aircraft's nose-high attitude (indicative of the aircraft's stable longitudinal static stability). A relaxation of the pull force allowed the aircraft's pitch attitude to reduce and the airspeed to increase. To stall the aircraft in this configuration required the increasing pull force on the control column to be maintained deliberately for a sustained period. The test pilot concluded that the aircraft did not have a tendency to stall when initiating a pull up with the autopilot disengaged and the aircraft in trim. It was observed that, to achieve an average rate of climb of about 3,700 fpm and an altitude gain of 1,200 ft, as recorded during the accident flight, required a nose-up attitude of about 35º and an increase in engine power to above the normal approach power setting (Figure 11).

The stalling characteristics of the aircraft were then explored. The POH for the Malibu states:

> *'The stall characteristics of the Malibu are conventional. An approaching stall is indicated by a stall warning horn which is activated between five and ten knots above stall speed. Mild airframe buffeting and pitching may also precede the stall.'*

Despite testing normally[22], the aural stall warning did not sound during the evaluation flight as the aircraft approached the stall. The other stall characteristics described in the POH were found to be accurate, with stalls flown in a variety of configurations described by the test pilot as 'generally benign and controllable'.

Autopilot engaged evaluation

From level flight, with the autopilot engaged, the aircraft was placed into a descent by manually overriding the altitude hold mode. As the aircraft descended, the control column forces increased as the autopilot automatically applied nose-up pitch trim to return the aircraft to the set altitude. When the forward pressure on the control column was released, the aircraft pitched rapidly to a high nose-up attitude. The test was repeated a number of times, with similar results. During several of these tests, the pitch rate exceeded 8° per second, but the autopilot did not disengage[23].

Footnote

[22] The stall warner was successfully tested immediately before the manoeuvre but had not tested normally on the ground.

[23] According to the autopilot manufacturer this was due to the pitch rate exceeding 8° per second (for at least 1 second) above 15° where the pitch-rate monitor is not designed to work.

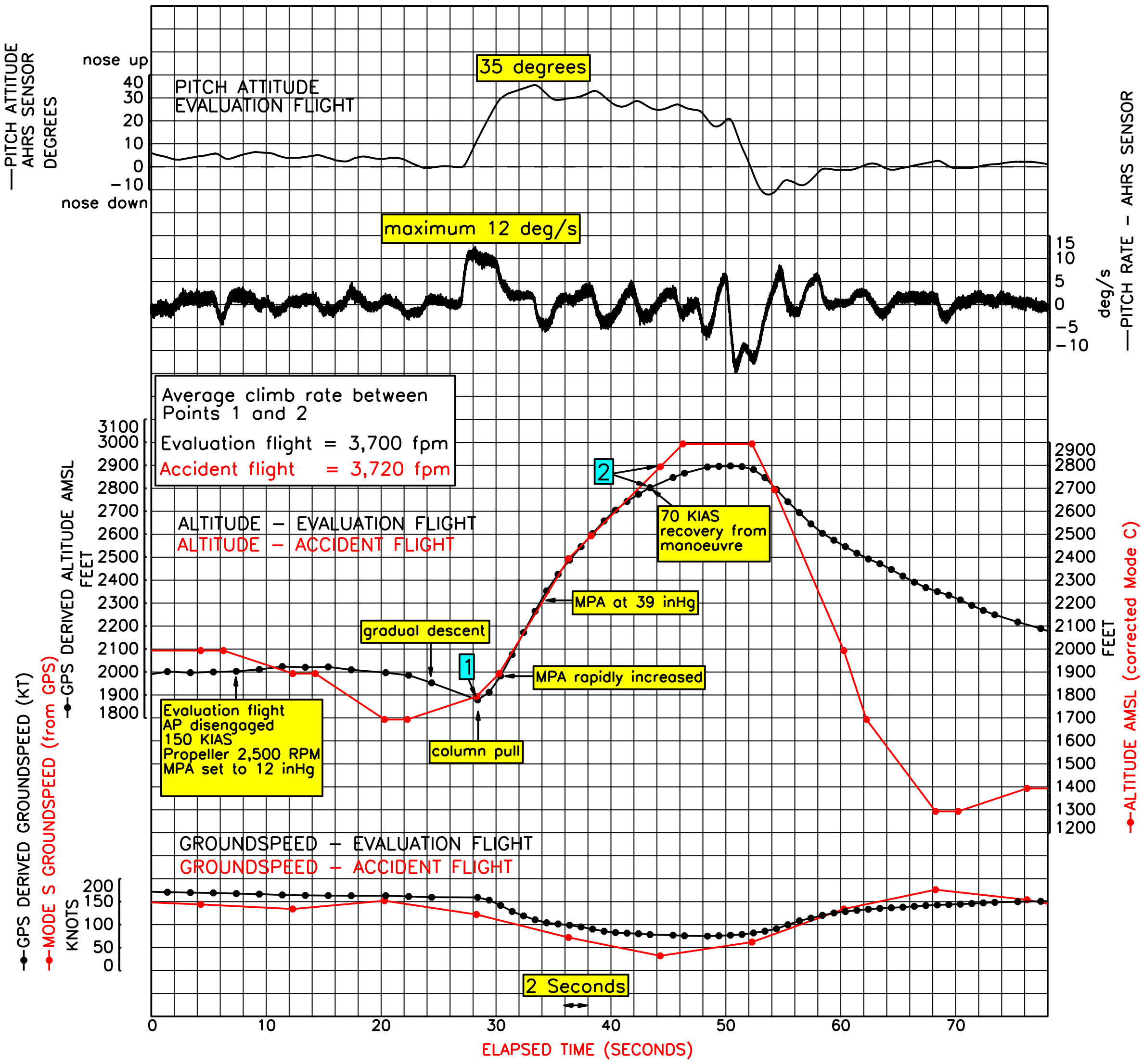

Figure 11

Comparison of accident and evaluation flight
(autopilot disengaged then climb at same rate as accident flight)

The test pilot considered that the high nose-up attitudes and pitch rates achieved during these manoeuvres would be extremely disorientating for a pilot, especially in IMC conditions. He also considered that the control column forces required to override the autopilot quickly became so large, that it was unlikely a pilot would continue to oppose them without re-trimming.

On subsequent tests, the test pilot pressed the pitch trim switches, disengaging the autopilot, when he considered the control column force was excessive. This occurred at approximately 300 ft below the set altitude. It was noted that the pitch trim had reached a setting of 3.5, which equated to a significant nose-up trim position for the weight and CG.

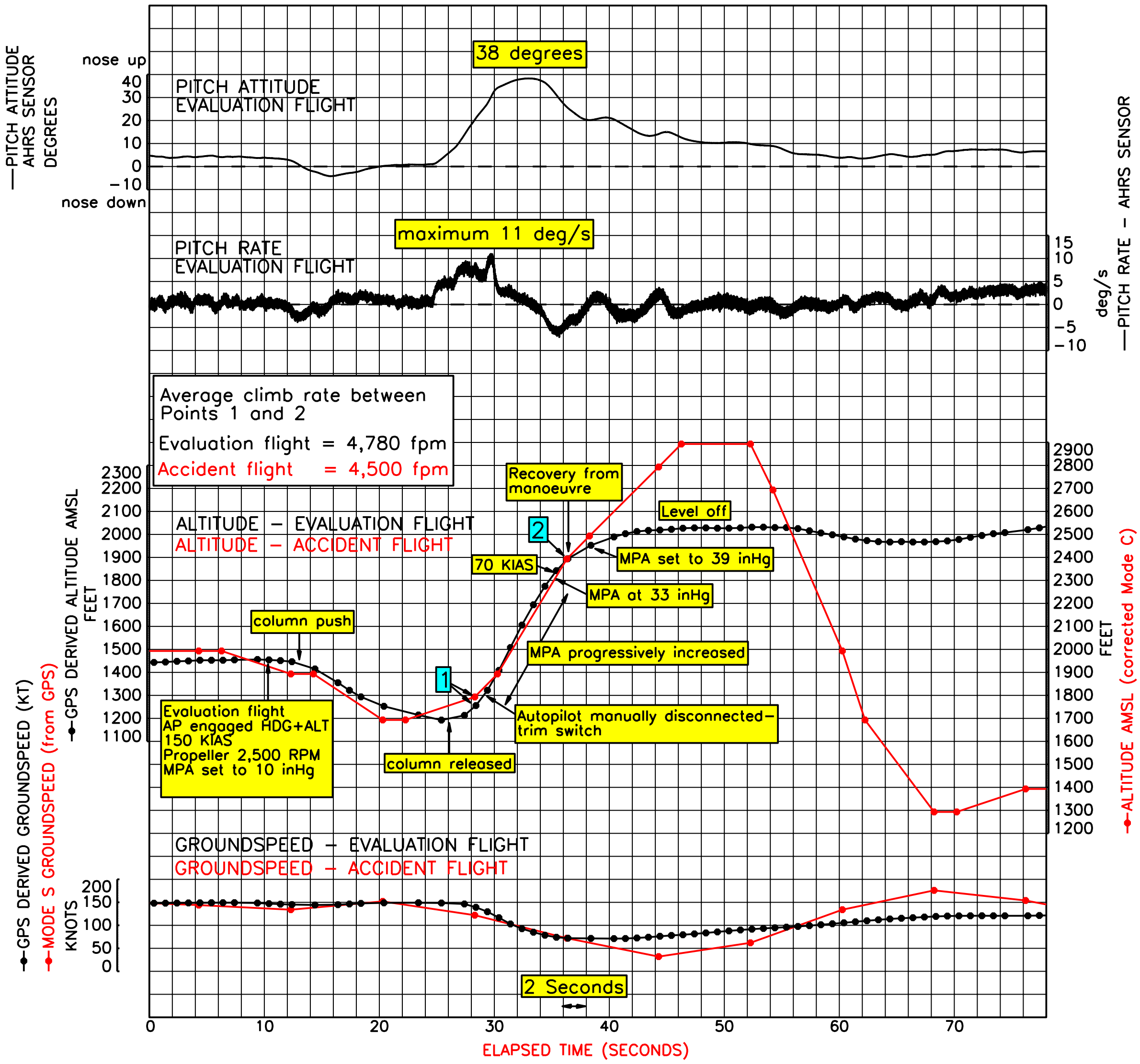

Figure 12

Comparison of accident and evaluation flight (autopilot engaged in heading and altitude hold, with control column pushed and then released)

Figure 12 provides a plot of salient parameters, showing the effect of the pitch trim during one of the autopilot engaged ‘push-and-release’ tests. Parameters from the accident flight are overlaid for comparison. Following the initial pitch-up, engine power was progressively increased as the aircraft climbed. The rate of climb closely matched the accident flight, with a nose-up attitude of 38° recorded during the evaluation. Having climbed about 800 ft, the aircraft was levelled off to prevent it from stalling. The test pilot considered that, had the engine power been applied more rapidly as the aircraft started to climb, and the airspeed been allowed to reduce further, the 1,200 ft gain recorded during the accident flight would have been achieved.

During the evaluation flight, the aircraft overflew the disused airfield at Upottery. It appeared to be in such a state of disrepair that it was considered unlikely to have been mistaken for Dunkeswell Aerodrome.

Radar coverage near Crewkerne

The radar recordings corroborated the evidence that N186CB had overflown a witness near Crewkerne (location 1 in Figure 1) at a time close to that reported. However, the aircraft's altitude, recorded from its transponder, indicated that it was at 2,000 ft amsl (+/- 50 ft) when observed, which was 1,100 ft higher than the witness's estimate.

To ascertain if a PA-46-350P could be recorded on radar when overflying the witness's location at a height of about 500 ft agl, as reported, a series of overhead passes were carried out at different altitudes. The lowest altitude at which the radar detected the aircraft was 1,335 ft amsl, about 950 ft agl.

Medical and pathological information

A post-mortem examination revealed evidence that the pilot had severe coronary artery disease and that his medical history included a recent bout of dizziness, which was believed to have been caused by a temporary blockage in one of his Eustachian tubes. Although it was not possible to rule out either medical condition as being causal or contributory to the accident, the pathologist concluded that the pilot was alive at the time of the accident and, from the pattern of his injuries, his hands were in contact with the flying controls. Toxicological results indicated he was not under the influence of alcohol or drugs at the time of the accident and there was no evidence of carbon monoxide poisoning. The pathologist concluded that the pilot died as a result of multiple injuries.

Pilot's history

The pilot commenced his flying training in early 2012 and shortly afterwards purchased a Cessna 172 aircraft. He passed his PPL(Aeroplanes) skills test in June 2012 and passed the skills test for an IMC rating in October 2012. He continued flying regularly in his Cessna 172 until he purchased N186CB in the Summer of 2013. His logbook indicated that he flew N186CB frequently, visiting Dunkeswell at least 25 times between September 2013 and October 2015 and flying 60 instrument approaches in the aircraft during the same period. In March 2015, he commenced training for an FAA Instrument Rating (IR)[24] and was due to take the test for this rating the week after the accident. The pilot had logged over 120 hours of instrument flying, including 55 hours in N186CB.

Other pilots and instructors who flew with him regularly recalled that his normal way of operating the aircraft, when en-route, was to use the autopilot. He would use the 'ALT' mode to maintain his selected altitude and the 'HDG' mode, which he would manipulate as required to ensure the desired track. For instrument approaches, the pilot had been taught to intercept the final approach path at 120 kt and configure the aircraft with the landing gear extended and a single stage of flap. He would then select more flap once he was visual with the required landing references. The pilot's normal method of disengaging the autopilot was to use the AP/YD disengage button on the control wheel.

Footnote

[24] The FAA IR is a full Instrument rating without any of the restrictions of the IMC rating.

The autopilot manufacturer commented that “a typical small airplane autopilot user” would, during a visual landing, disengage the autopilot at 800 ft agl using the manual electric trim switch, leaving the yaw damper engaged, especially during poor weather conditions including turbulence. They would then use the AP/YD disengage button, just prior to landing, to disengage the yaw damper. However, examiners in the UK advised the AAIB that, in their experience, pilots they flew with in the PA-46, including the accident pilot, disconnected the autopilot using the AP/YD disengage button on the control wheel. They had not seen any instances where the accident pilot had disengaged the autopilot with the trim switch, leaving the yaw damper engaged.

The pilot was described by his instructors as being quite good at “doing things by numbers” but he was considered to be less able than average pilots at multi-tasking and poor at prioritising, especially when under pressure. One of his instructors stated that “he would often have difficulty in dealing with an unusual or unexpected condition”.

The FAA examiner who had been due to conduct the IR test in the week following the accident, had flown with the pilot twice in May 2015 in simulated IMC conditions. At that time, he considered the pilot was not ready for test and on two occasions during these flights the examiner reported that he had had to intervene to prevent an unsafe condition from worsening. Since then, the pilot had flown over 48 hours, including over 12 hours of instrument flying training, and his instructor considered that he was ready for his planned test.

On 10 October 2015, N186CB, piloted by the owner, landed on Runway 22 at Dunkeswell, having flown from Fairoaks. The pilot had gone around from his first approach, as he was unable to see the airfield, and landed after his second approach. Witnesses at the time reported that they were surprised to see an aircraft arrive in such poor weather. An observation from the Dunkeswell SYNOP showed the visibility at the time to have been 2,700 m, with an overcast cloudbase at 300 ft aal.

Analysis

Aircraft examination

The accident site revealed that the aircraft had struck the ground in a steep nose-down attitude and at a high angle of attack, consistent with an aerodynamic stall. The aircraft’s final trajectory was probably about 60° to 70° below the horizon, as indicated by it missing the nearby power lines, its negligible forward movement after impact and the accident site’s close proximity to the final radar point. The evidence suggested that the aircraft was probably in a spin when it struck the ground, although there were insufficient indications in the ground marks and fuselage damage to identify the spin direction.

The investigation found no evidence of any pre-impact structural or flight control failures in the aircraft and the powerplant examination did not reveal any faults. The damage to the propeller indicated that the engine was probably producing low power at impact.

In addition, no evidence was found of any fault with the KI256 Flight Command Indicator or the primary altimeter. The encoded altitude information from this altimeter, as recorded by the Mode C radar, appeared to be higher than that estimated by some witnesses. However, confirmation of the base of radar cover at the location of the Crewkerne witness supported the validity of the Mode C altitude data. Furthermore, there was no evidence of any pre-impact fault within the altimeter or its encoder.

With this in mind, the engineering investigation focussed on the autopilot and the pitch trim systems as possible causes for the sudden and prolonged pitch-up during the approach.

Analysis of the radar data

The radar data was analysed to determine if the pilot was using the autopilot to control the aircraft's flightpath during the latter stages of the flight. The evidence showed that the aircraft's track varied throughout the flight and analysis of the rates of turn, after the aircraft had descended to an altitude of 2,000 ft amsl in the latter stages of the flight, indicated that the heading changes could have been achieved with the autopilot engaged, using the HDG mode, or by flying manually with the autopilot disengaged. The aircraft maintained an altitude of about 2,000 ft amsl until shortly before turning towards the extended centreline for Runway 22 at Dunkeswell, which was consistent with the last selected altitude set in the KAS297B Altitude/VS Selector. It was also known that the pilot's normal practice was to use the autopilot ALT mode in combination with the HDG mode.

As the aircraft turned towards the extended centreline, the derived rate of turn progressively increased. For the first 24 seconds of the turn, the maximum calculated rate was 1.8º/sec. This turn rate was within the capability of the autopilot but may have been flown manually, with the autopilot disengaged. With the autopilot engaged and HDG mode selected, this could have been achieved by progressively altering the selected heading less than 15° at a time. Had the pilot made just one adjustment on the heading selector, to establish the aircraft on the runway centreline, the turn rate should have been more constant, at about 3º/sec. Therefore, the turn may have been flown manually, with the autopilot disengaged, or with the autopilot engaged and the ALT and HDG modes selected.

As the aircraft turned away from the extended centreline, the rate of turn increased beyond 3º/sec, indicating that the pilot was either overpowering the autopilot or flying the aircraft manually, with the autopilot disengaged. This increase in turn rate beyond 3º/sec occurred as the aircraft was also descending, and shortly before it climbed rapidly.

Autopilot and pitch trim system evidence

A pitch trim runaway was considered as a possible cause of the aircraft pitching up. The trim actuator was found in a nose-up trim position for the aircraft's estimated CG and airspeed of about 150 KIAS. However, this pitch trim position was not significantly nose-up, with 44% nose-up travel remaining (1.7 units on the trim wheel scale used in the evaluation flight). Furthermore, the pitch trim servo passed all functional tests, with the clutch disengaging cleanly when the power was removed. Although not conclusive in itself, the un-stretched bulb filament in the TRIM warning caption was also consistent with a normal functioning trim system. In addition, it was noted that the aircraft manufacturer was not aware of any previous occurrences of un-commanded pitch trim runaways on this aircraft type. For all these reasons, an un-commanded pitch trim runaway was considered unlikely.

An un-commanded pitch servo movement was also considered as a cause of the pitch-up but this servo passed its functional tests. In addition, the pitch rate monitor is designed to disengage the autopilot following an un-commanded pitch servo movement because it is likely that such a condition would exceed the 8° per second pitch rate threshold.

The KC192 flight computer could not be tested due to its impact damage, so an internal fault could not be ruled out. However, the component manufacturer reported that it was not aware of any pitch trim runaways being caused by this unit.

An examination of the KC192 flight computer's control panel revealed that the bulbs associated with the YD, FD, ALT and HDG captions were likely to have been illuminated at impact and the AP caption was likely to have been off. This meant it was probable that the autopilot had disengaged prior to impact but that the yaw damper and flight director had remained engaged.

The evidence suggested that the pilot had been operating the aircraft with the autopilot engaged and with the ALT and HDG modes selected, as was his usual practice. In this configuration, the YD, FD, ALT, HDG and AP captions would most likely have been illuminated as the aircraft approached Dunkeswell (the yaw damper and flight director are automatically engaged when the autopilot is on).

Prior to landing, the autopilot and yaw damper *'must'* be disengaged and the normal and simplest way to achieve this is by pressing the AP/YD disengage button on the control wheel. However, this also results in all captions on the flight computer control panel being extinguished. Therefore, for the YD, FD, ALT and HDG captions to have remained illuminated at impact, it was possible that either:

- the AP ENG button on the KC192 control panel was pressed[25]
- the pilot had pressed the trim switches
- the pitch or roll rate monitors had caused the autopilot to disengage

According to the pilot's instructors, the pilot disengaged the autopilot using the AP/YD disengage button on the control wheel. They did not think he was aware of the technique using the trim switches, leaving the yaw damper engaged. Therefore, it was considered unlikely that the pilot had intentionally used the trim switches to disengage the autopilot. Similarly, it was considered unlikely that the pilot had disengaged the autopilot by pressing the AP ENG button, which would have involved reaching across to the KC192 control panel.

Footnote

[25] Pressing the AP ENG button on the KC192 engages the autopilot when it is off and will disengage the autopilot when it is on.

It was possible that the pilot intended to take manual control but, unknowingly, tried to override the autopilot with it still engaged. He might then have pressed the trim switches to reduce the control forces that would have started to increase as the aircraft's flightpath changed, thereby disengaging only the autopilot. Alternatively, the pitch rate monitor may have disengaged the autopilot during one of the pitch-up or pitch-down manoeuvres.

For the above reasons, the investigation considered that the pilot may have initiated a descent manually from 2,000 ft, without first pressing the AP/YD disengage button on the control wheel (or he pressed it and it did not function), and started to overpower the autopilot, causing it to trim in the opposite direction. The Altitude/VS selector showed 2,000 ft and 0 fpm as its final settings, so there were only two other ways to descend below 2,000 ft without disengaging the autopilot. One method would have been to press the Vertical Trim DN button on the KC192 (Figure 7), which would have targeted a 500 fpm descent. However, the actual descent rate was about 1,100 fpm, so this was unlikely. Alternatively, the pilot could have pressed and held the CWS button to initiate a descent but, according to his instructor, he did not use this feature.

It was possible that the pilot pressed the AP/YD disengage button on the control wheel, before initiating his descent, but that the button did not operate correctly. The button was tested and functioned normally. However, the AP disconnect relay could not be tested due to impact damage, so a pre-impact fault preventing AP disengagement could not be ruled out.

Circuit breaker anomaly

The 'Autopilot' and 'Pitch Trim' circuit breakers were incorrectly labelled. This probably occurred when the fuselage was replaced in 2007, when all the circuit breakers would have been removed from the old fuselage and installed in the new one. The new fuselage was originally fitted with a different KFC225 autopilot system and would have had holes in the circuit breaker panel for an 'Autopilot' and an 'AP Servos' circuit breaker. These labels should have been changed but were not. The FAA's Designated Airworthiness Representative who signed off the fuselage replacement work has been made aware of this anomaly, as has the maintenance organisation. It was considered unlikely to have been a factor in the accident.

Operation of the aircraft

The pilot was flying an aircraft, with which he was familiar, on a route he had flown at least 14 times before. The flight proceeded uneventfully until the aircraft turned left to establish on the final approach for Dunkeswell at three miles. This would normally have involved a relatively high workload, with the pilot manoeuvring the aircraft on to the runway extended centre line, slowing it down and extending the flaps and landing gear.

The evidence indicated that the aircraft started its descent, turned through the inbound heading and then suddenly pitched up. At this stage, the aircraft was flying into deteriorating weather and may have flown into cloud as it turned onto the final approach (the cloudbase at Dunkeswell before and after the accident was 300 ft aal). Having entered cloud, the pilot may have attempted to climb to a safe altitude and inadvertently pulled the control wheel back too much, causing the aircraft to pitch up excessively. However, this seemed unlikely, given the benign handling characteristics of the aircraft and the pilot's recent currency of flying on instruments, including time in actual IMC conditions.

The evidence from the autopilot system examination suggested that, as the pilot turned onto the final approach and started to descend, the autopilot may not have been disengaged due to a mental lapse, incorrect button selection or a technical fault. With the pilot manually overriding the autopilot, to turn and descend, the control forces required to prevent the aircraft pitching up would have become excessive, as the autopilot trimmed nose-up to regain the 2,000 ft set in the Altitude/VS Selector. The pilot may then have pressed the trim switches to reduce this force. However, if he had not trimmed sufficiently nose-down, which would have taken some time, the remaining nose–up trim could still have been sufficient to pitch the aircraft excessively nose-up, achieving a rate of climb similar to that seen in the recorded data.

The aircraft was found with 1.7 units of trim on the trim wheel but it is possible that the initial pitch-up event was caused by a pitch trim of up to 3.5 units and, in the subsequent manoeuvres prior to the impact with the ground, the trim was reduced to the position in which it was found.

Evaluation flights during the investigation established that a pitch attitude of about +35° nose-up would have been required to achieve the rate of climb seen in the data. This would have been disorientating for the pilot, especially in IMC with the pitch attitude in excess of the pitch ladder on the attitude indicator, which only extended to +25° nose-up. The altitude achieved at the top of this climb suggested that additional power had been applied at some point during the manoeuvre, possibly to achieve a safe altitude. The aircraft's calculated airspeed of 33 KIAS at the top of this climb was consistent with the aircraft having stalled, and the change in direction to the left was consistent with a left-wing drop, which is more likely in a power-on stall due to the clockwise rotation of the propeller (as viewed from the pilot's seat).

Following this manoeuvre, the aircraft maintained a generally constant track during its rapid descent, before aggressively pitching up again. It appeared that the engine power was subsequently reduced prior to impact.

The investigation considered whether either of the medical conditions detected by the pathologist may have contributed to the accident. It was concluded that, whilst the possible effects of the medical conditions could not be excluded entirely, the aircraft's final manoeuvres and the changes of engine power were unlikely to have occurred without control inputs from a conscious pilot. Therefore, it was probable that the pilot was manipulating both the control wheel and the power lever.

The investigation determined that, in the circumstances, recovery from the unusual aircraft attitude required to replicate the accident flight's initial rapid pitch-up and climb may have been beyond the training, experience and, whilst in IMC, the capabilities of the pilot.

Conclusion

Whilst positioning for an approach to Dunkeswell Airfield, the aircraft suddenly pitched nose-up and entered cloud. This rapid change in attitude would have been disorientating for the pilot, especially in IMC, and, whilst the aircraft was probably still controllable, recovery from this unusual attitude may have been beyond his capabilities. The aircraft appears to have stalled, turned left and descended steeply out of cloud, before climbing rapidly back into cloud. It probably then stalled again and entered a spin from which it did not recover. All four occupants were fatally injured when the aircraft struck the ground.

The investigation was unable to determine with certainty the reason for the initial rapid climb. However, it was considered possible that the pilot had initiated the preceding descent by overriding the autopilot. This would have caused the autopilot to trim nose-up, increasing the force against the pilot's manual input. Such an out-of-trim condition combined with entry into cloud could have contributed to an unintentional and disorientating pitch-up manoeuvre.