Accident

Aircraft Type and Registration:	Piper PA-23-250, G-BKJW
No & Type of Engines:	2 Lycoming IO-540-C4B5 piston engines
Year of Manufacture:	1971 (Serial no: 27-4716)
Date & Time (UTC):	6 July 2023 at 1845 hrs
Location:	1 nm south-west of Bagby Airfield, North Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed and burnt
Commander's Licence:	Private Pilot's Licence
Commander's Age:	21 years
Commander's Flying Experience:	440 total hours (3 hours on type) to 2 June 2023[1] Last 90 days – 46 hours to 2 June 2023[1] Last 28 days – not known[1]
Information Source:	AAIB Field Investigation

Synopsis

The pilot had departed Bagby airfield in the morning and flown to Deauville in France where he collected five passengers and delivered them to Abbeyshrule in Ireland. The accident occurred at the end of the return flight to Bagby, with the pilot the sole occupant of the aircraft. After the pilot made a normal radio call to Bagby to say that he was four miles from the airfield, the aircraft was seen on radar and CCTV to join right base for Runway 06. The CCTV video showed the aircraft's descent angle start to steepen while it was on right base. There was then a slight reduction in descent angle before the descent angle steepened sharply and the aircraft struck trees and then the ground at an angle of about 35° to 40° nose-down, with no indication that the aircraft was starting to recover. The ground impact caused a fire, and the accident was not survivable.

The post-impact fire destroyed a significant amount of physical evidence, but that which remained contained no identifiable defects that could have caused or contributed to the nose-dive. The one anomaly found was the position of the pitch trim drum which was 3 mm from the full nose-down position. Evidence from a flight trial on the same type of aircraft revealed that this was more nose-down than would be expected for any flap configuration in the speed range determined from the CCTV. However, the possibility of the trim having

Footnote

[1] No logbook entries were recorded after 2 June 2023.

moved during the post-impact break-up could not be discounted, so other theories of what could have caused the final nose-dive were considered. Of all the causes reviewed, a pitch trim runaway was considered to be the most likely, but there was insufficient evidence to determine that it was the definitive cause of the accident.

In conducting the investigation, it was apparent that although occurrences of pitch trim runaway are rare, when they do occur the results can easily be catastrophic, particularly if it occurs at low altitude where there is limited time to respond. Irrespective of whether a pitch trim runaway was the cause of the accident to G-BKJW, the investigation identified ways to reduce the risk of such an event. Consequently, the CAA plan eight safety actions which concern:

1. Training for a pitch trim runaway.
2. Deactivating inoperative autopilots.
3. Making autopilot and electric trim circuit breakers more visible.
4. Providing clearer information regarding differences training requirements.

History of the flight

The pilot arrived at Bagby airfield at about 0800 hrs on the day of the accident. His first flight that day was to deliver a Cessna 310 aircraft to Leeds East Airport where the aircraft was to be part of a static display for an airshow the following day. The aircraft departed Bagby at 0910 hrs for the short flight, with the pilot being collected on arrival and driven back to Bagby airfield by car.

The pilot then prepared to fly G-BKJW to Deauville, France to collect five passengers to be flown to Abbeyshrule airfield, Ireland. From Abbeyshrule, the pilot planned to fly the short distance to Navan airfield to collect an aircraft spare part before returning to Bagby airfield the same day. A witness stated the aircraft had been refuelled to full tanks the evening before departure.

The pilot departed Bagby airfield, alone, in G-BKJW at 1050 hrs, arriving at Deauville Airport at 1259 hrs. A fuel receipt showed it was refuelled there with 205 litres. He picked up the five passengers and departed Deauville at 1348 hrs, landing at Abbeyshrule airfield at approximately 1630 hrs where the passengers disembarked. The pilot then flew on to Navan airfield, a distance of about 35 nm.

The owner of Navan airfield described the weather as being poor at the time G-BKJW arrived and that he was impressed the pilot had been able to land. He reported that he then helped the pilot refuel, adding 160 litres, so that the two inner tanks were full. A spare part for a light aircraft canopy rail was also loaded onto the aircraft for delivery to Bagby. The airfield owner knew the pilot and reported that there appeared to be nothing unusual about his demeanour. He stated that he had, however, told the pilot he was concerned about the poor weather conditions.

Having refuelled, the pilot departed Navan airfield for the flight back to Bagby airfield, with radar first picking up the aircraft about 8 nm east of Navan at 1743 hrs and later recording a cruising level of FL070. During the flight, the pilot sent a photo by text to the owner of Navan airfield of the weather conditions en route, with the aircraft appearing at the time to be flying in clear air between broken layers of cloud. The accompanying text described the weather conditions as ‘smooth as silk’.

The pilot received a flight information service for much of the flight from London Information ATC and, during the descent towards Bagby airfield, had made a blind call on the Leeming ATC frequency that he would be flying through their Combined Military Aerodrome Traffic Zone (CMATZ). The aircraft entered the CMATZ 8 nm west-southwest of Bagby. There was no other contact with the aircraft until at about 1842 hrs when the pilot called the Bagby Air/Ground station, reporting he was four miles from the airfield and would be joining on a right base for Runway 06. The Air/Ground operator replied, providing the airfield QFE and weather conditions. He reported that there was nothing unusual in the pilot’s transmission. The operator looked out of the radio room window for the aircraft and could see it in the distance. He reported that, soon after seeing the aircraft, he saw it suddenly enter a steep, wings-level, nose-down descent, from an altitude of about 1,000 ft while on base leg. The aircraft continued to descend until it disappeared behind some trees and a plume of black smoke could be seen to rise.

At the same time, the aircraft was seen by another witness who was out walking near the airfield. They reported seeing the aircraft suddenly pitch nose-down from a low height, wings-level and diving to the ground.

Some people at the airfield, realising the aircraft had crashed, quickly drove to the accident site which was in a field about 1 nm south-west of the airfield. They found the aircraft badly damaged and on fire. The emergency services were quickly in attendance, putting out the fire and finding that the pilot had been fatally injured.

Recorded information

A tablet and two smartphones were found in the wreckage, but they were too severely damaged by fire to recover any data.

Surveillance data

Position data and timings for the majority of the route flown by G-BKJW during the day were obtained by the AAIB. The data was sourced from en route NATS radar heads and the PilotAware network. The data covered most of the journey within UK airspace, apart from on the short flight between Abbeyshrule and Navan airfields, and on descent and climb out from these airfields when G-BKJW was not in range of any ground stations. Figure 1 shows this data and salient flightpath timings.

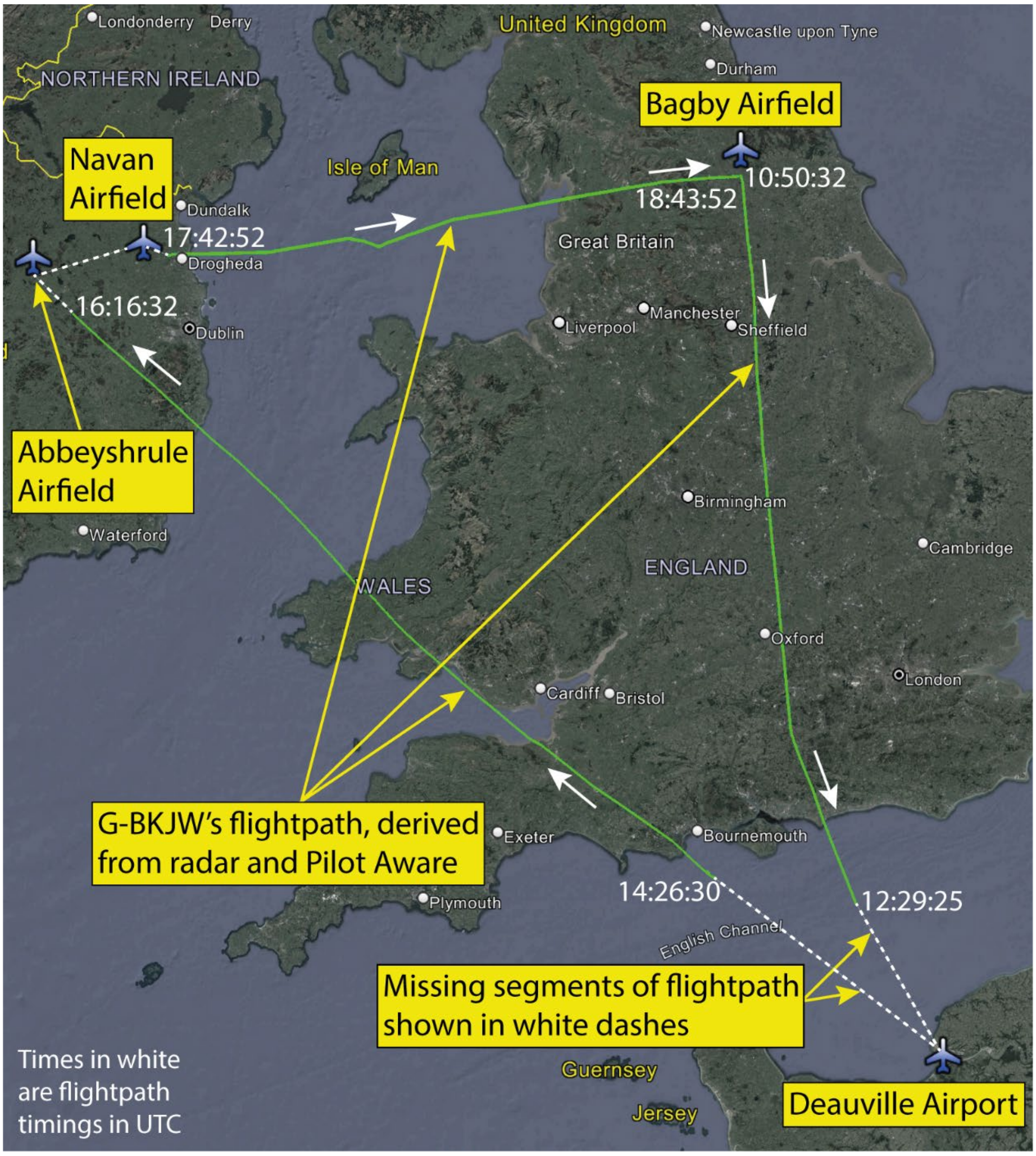

Figure 1

G-BKJW's flightpath on the day of the accident
Map data: SIO, NOAA, US Navy, GEBCO / Image: Landsat/Copernicus

Two of the en route NATS radar heads, at Claxby and Great Dunn Fell, tracked G-BKJW until radar coverage was lost just prior to the accident. Altitude data from these radar sites, as well as the descent rate calculated using both sets of radar data, are shown in Figure 2. The last radar return for G-BKJW at 18:43:52 was 875 m south-southeast of the accident site and the reported altitude was 740 ft amsl. The descent rate data shows that 70 seconds prior to the last radar return, G-BKJW's descent rate increased markedly reaching 1,800 ft/min (point 1 on Figure 2), before briefly reducing toward 1,000 ft/min (point 2), and then increasing again until radar coverage was lost (point 3). The average groundspeed during the rapid descent prior to the turn on to base was about 168 kt. An overview of the final radar ground track from Claxby is shown in Figure 3.

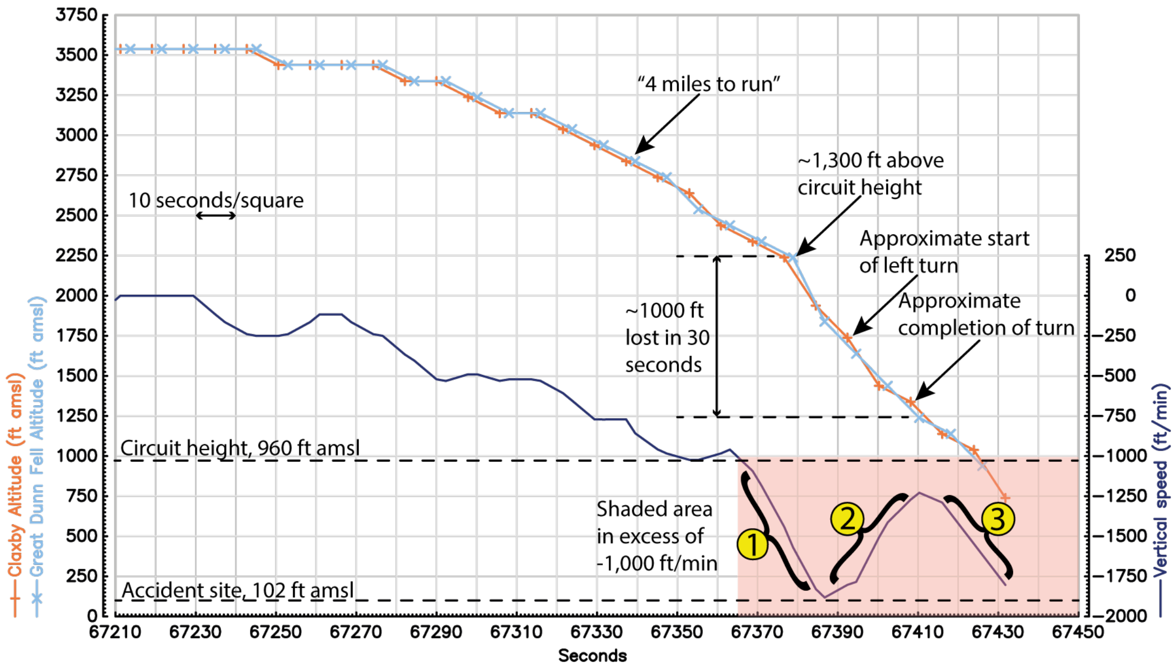

Figure 2

Altitude data and calculated descent rate derived from radar for G-BKJW

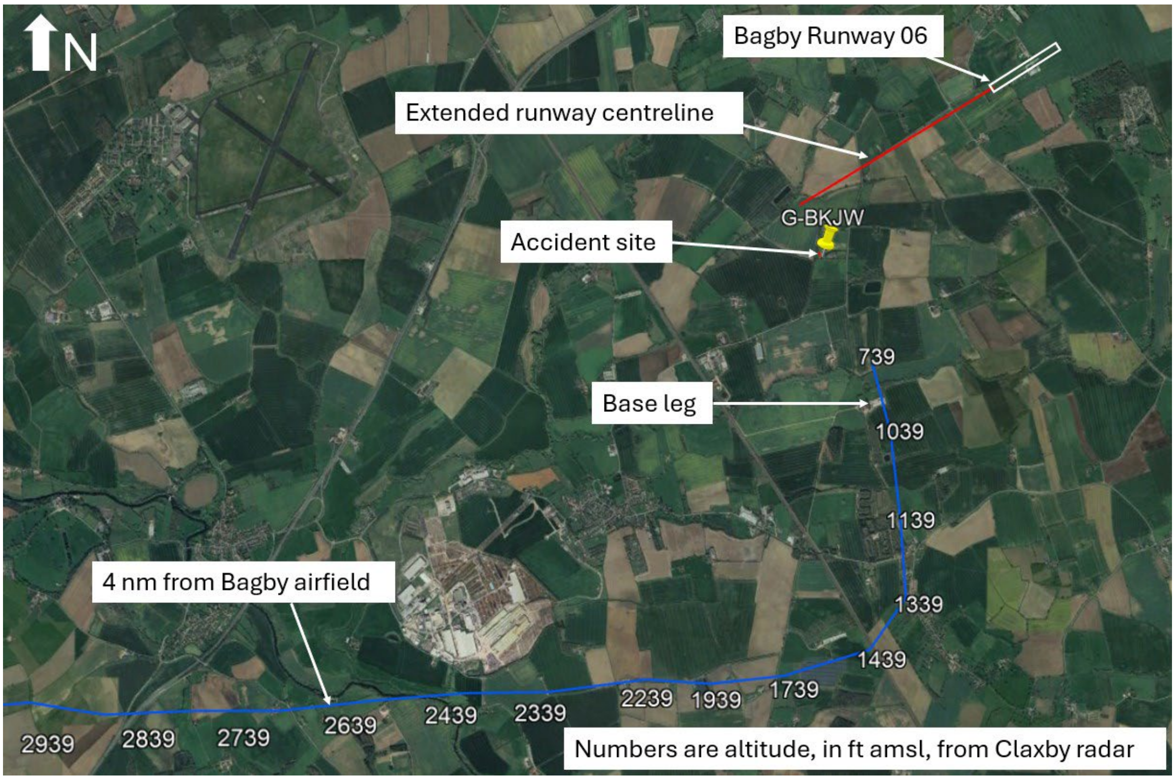

Figure 3

Final radar ground track, accident site and Bagby runway
© Google Earth, Image © Airbus

Closed-circuit television (CCTV) video

CCTV video obtained from Bagby airfield showed G-BKJW joining the visual circuit at Bagby and then descending into terrain. A composite image, made up of individual frames of this CCTV is shown in Figure 4. The approximate position of the last radar return is also shown.

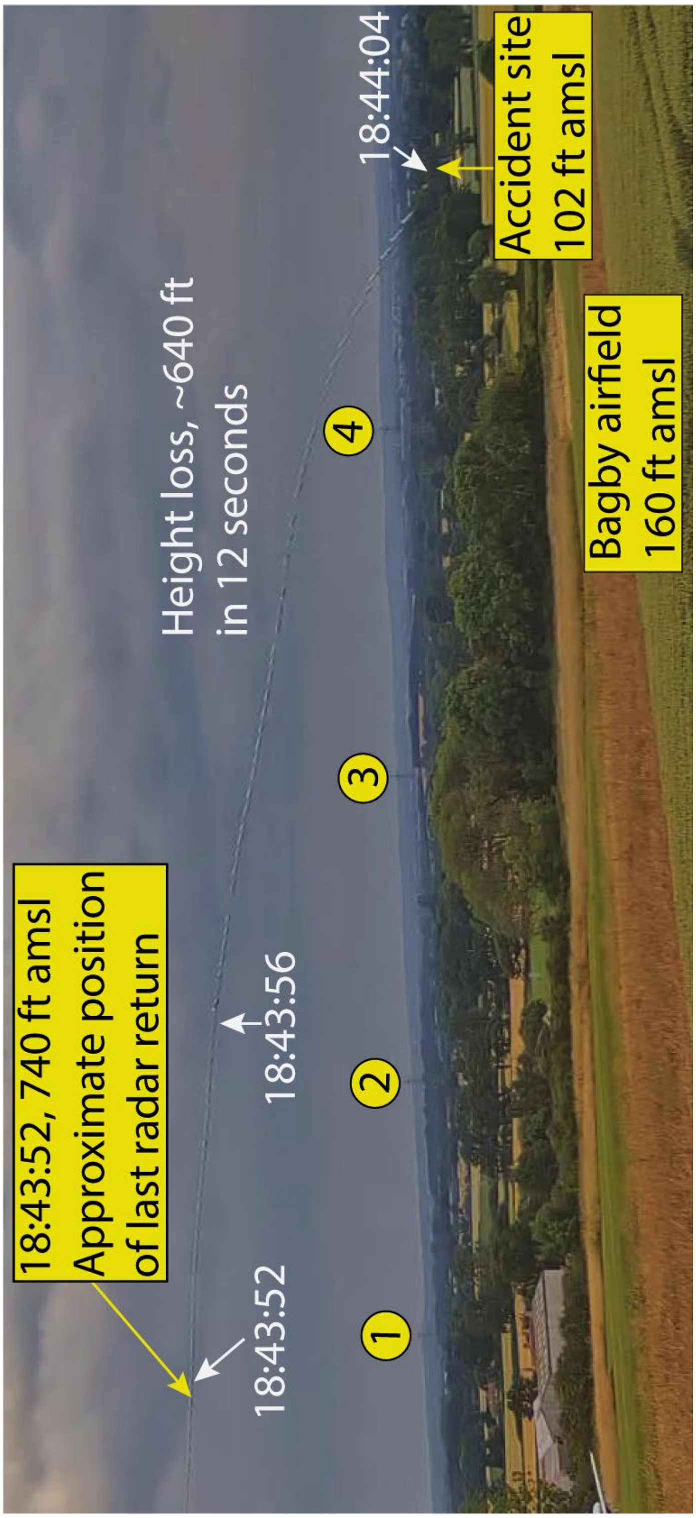

Figure 4

Composite CCTV image of G-BKJW descent into terrain

Several electricity pylons are visible in this image, numbered 1 through 4, and G-BKJW's groundspeed was calculated by timing the passage of the aircraft between these points, using an assumed ground path for G-BKJW between the position of the last radar return and the accident site. These calculations resulted in an estimate for G-BKJW groundspeed of approximately 122 kt, although the associated error in these calculations may be as much as ± 18 kt. With the reported 10 kt wind from the south, G-BKJW's airspeed would have been approximately 112 kt ±18 kt. A close-up of the aircraft's final descent is shown in Figure 5.

Figure 5

Close-up of final descent from composite CCTV image

Accident site

The accident site was located 1.0 nm south-west of the Runway 06 threshold at Bagby airfield (Figure 6). The site revealed that the aircraft had struck trees in a steep nose-down attitude before hitting the ground and catching fire, consistent with the CCTV video. The direction of travel from the trees to the ground and the aircraft fuselage remains was in a line of about 335°(T) (Figure 7). There was no indication of aircraft roll or yaw at impact. Both engines had created similar impact craters, and their location indicated a flight path of about 35° to 40° nose-down from tree impact to ground impact. The wreckage spread was about 47 m and the pilot's body was found 34 m beyond the remains of the fuselage. The wreckage was extensively damaged by fire, but the aircraft's tail section was relatively intact (Figure 8). The horizontal stabilator was free to move and its control cables were connected. The stabilator pitch trim drum was found in a nearly full nose-down trim position. The pre-impact flap and landing gear positions could not be determined.

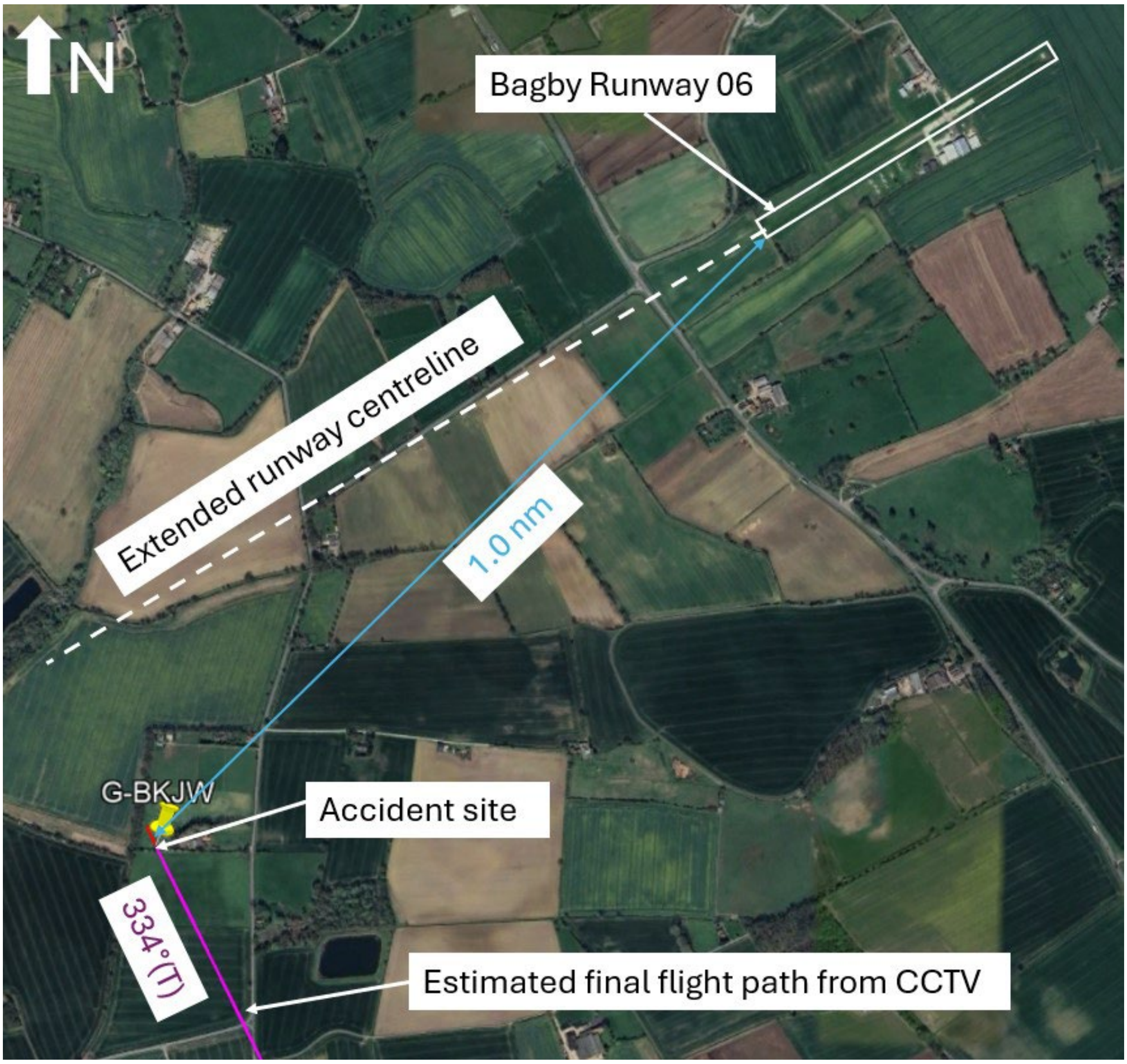

Figure 6

Accident site location relative to runway at Bagby airfield

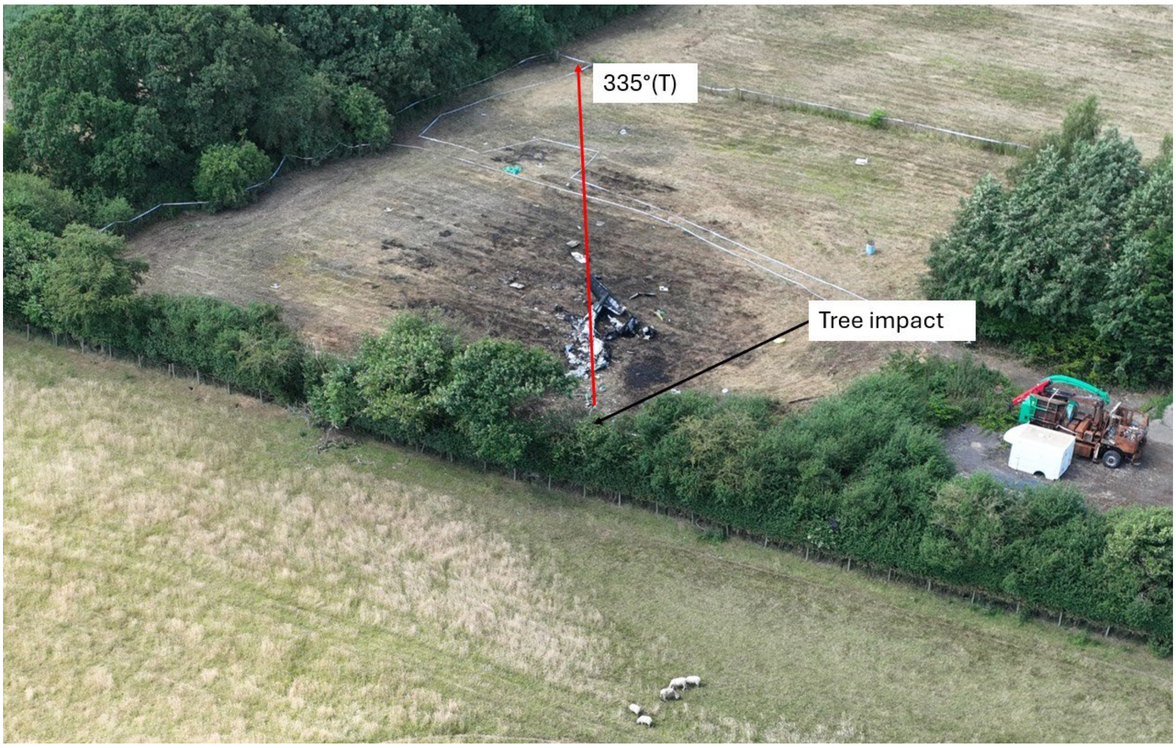

Figure 7

Aerial view of accident site

Figure 8

Wreckage extensively damaged by fire

Aircraft information

Background

The Piper PA-23-250 Aztec is a six-seat twin-engined light aircraft that was first certified in 1959. The accident aircraft, G-BKJW, was an 'E' model Aztec manufactured in 1971 (Figure 9). G-BKJW had sat unused at Sandtoft airfield between the end of 2020 and the beginning of 2023. During this period, it had been parked outside under a cover and the engines were occasionally run. The aircraft was bought and taken to Bagby airfield on a Permit to Fly (ferry permit) on 9 February 2023 and then underwent an annual inspection over the subsequent three months. The aircraft's technical log was not found in the wreckage, but the maintenance organisation estimated that the aircraft had flown about 30 hours since the annual inspection with no reported issues apart from a rough running engine which was resolved by cleaning the injectors. The total airframe hours were about 6,340 hours. The left and right engines had accumulated about 280 hours and 450 hours respectively since last overhaul.

Figure 9

Accident aircraft, G-BKJW

Flight controls

The aircraft was fitted with conventional mechanical flight controls. The aircraft had an all-moving horizontal stabilator for pitch control which was connected to the control yoke via cables. It had an anti-servo trim tab on its trailing edge which had two functions. It deflected in the opposite direction of the stabilator in order to provide an aerodynamic stabilising force. It also acted as a trim tab, controlled by the pilot or autopilot, to remove control forces. The trim tab was actuated by a rod connected to a pitch trim drum, which was in turn actuated by cables connected to a trim handle in the roof of the cockpit (Figure 10).

Figure 10

Pitch trim handle in the roof of the cockpit of a PA-23-250

Flaps

The aircraft had a hydraulic system that actuated the landing gear and the flaps. The flaps were commanded by moving a flap control lever in the cockpit up or down, holding it in that position and then moving it back to neutral to stop the flaps from moving. Moving the flap lever back to neutral trapped the hydraulic pressure in the hydraulic lines to the flap actuator. There was no mechanical lock in the actuator. When the flap lever was moved all the way down or up, the lever would lock in position, and when the flaps reached full travel the lever would automatically spring back to neutral. The flaps had the following four positions and maximum extension speeds:

Flap Position	Maximum Flap Speed
Up	N/A
Quarter	139 kt (160 mph)
Half	122 kt (140 mph)
Full	109 kt (125 mph)

Table 1

PA-23-250 Flap positions and extension speeds

The flap actuator moved a bellcrank that was welded to a torque tube and connected to a rod that actuated the right flap. The torque tube was also connected to a rod that actuated the left flap; the torque tube linked both flaps so that when the torque tube rotated both flaps extended or retracted together.

When the flaps were extended the aircraft pitched up. It is normal for light aircraft to pitch when flaps are extended, but the pitch up in the PA-23-250 was sufficiently significant that on later F models the aircraft manufacturer introduced a flap-to-trim-tab interconnect system which automatically moved the trim tab to counter the pitch effect of the flap. This was not fitted on G-BKJW which was an earlier E model.

Autopilot and electric trim systems

The aircraft was equipped with a Piper Altimatic IIIB autopilot system that was placarded inoperative but known to have some functionality. The build record for G-BKJW revealed that this system had been fitted at original manufacture. It was an analogue autopilot system that had three servos to control the ailerons, the stabilator and the pitch trim tab respectively. Its control console was fitted to the lower instrument panel on the pilot's left side (Figures 11 and 12). The autopilot was turned on by pressing the Autopilot/Roll engage switch. This would engage the autopilot in roll mode which could then maintain a selected bank angle or be used to track a heading after pressing the heading engage button. The pitch mode was engaged using a separate Pitch Engage button. Prior to engaging the pitch mode it was important to centre the trim indicator using the Pitch Command Disk. If this was not done the aircraft would pitch up or down upon pitch mode engagement. Once the pitch mode was engaged the Pitch Command Disk could be used to select a desired pitch angle up to 8° nose-up or 6° nose-down, or the Altitude Selector could be used to select a desired altitude. The autopilot was disengaged by either pressing the Autopilot/Roll Engage switch OFF, or by pressing the autopilot disconnect switch on the control yoke; however, the yoke mounted disconnect switch was not fitted on G-BKJW – there was an empty hole for it (Figure 12).

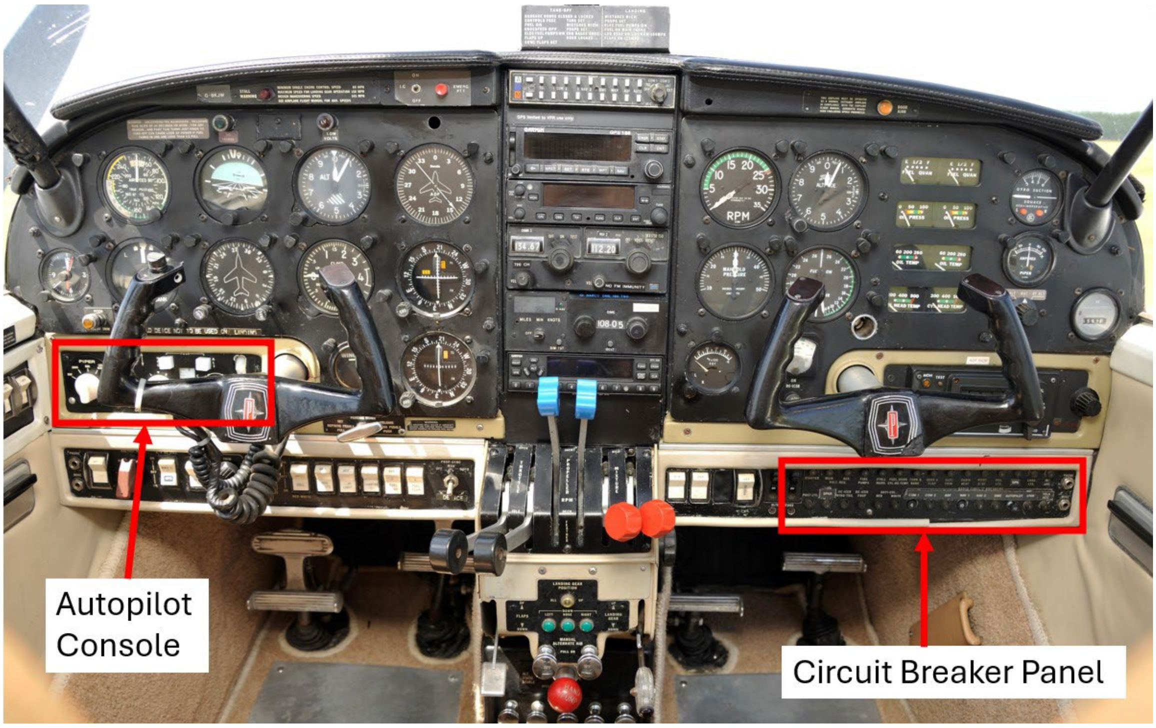

Figure 11

G-BKJW Instrument Panel (October 2020)
(Copyright Keith Wilson/SFB Photographic)

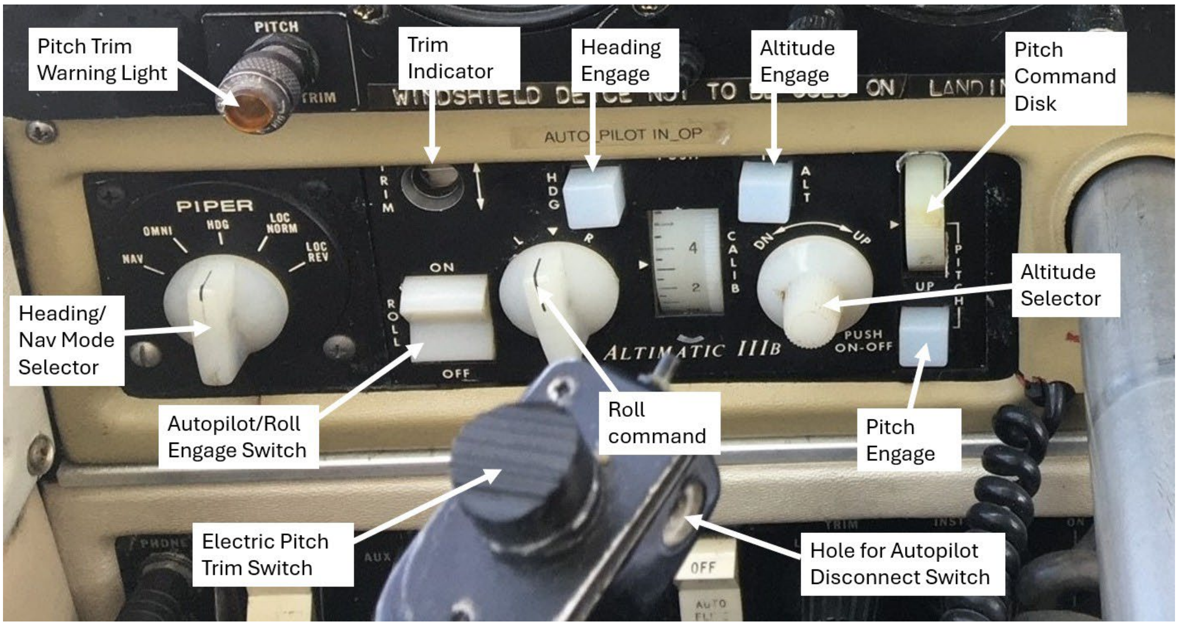

Figure 12

Altimatic IIIB Autopilot Console fitted to G-BKJW

Figure 13 depicts the autopilot disconnect switch fitted to a different PA-23-250 that also had an Altimatic IIIB autopilot. The electric pitch trim switch and the autopilot disconnect switch depicted in this figure are the same type as shown in the Piper Altimatic IIIB Operating Instructions[2]. There is a Piper approved kit[3] to replace the type of pitch trim switch in this figure with the type of pitch trim switch fitted to G-BKJW but it does not mention the autopilot disconnect switch. The trim switch in Figure 13 was subject to a Service Bulletin as it was known to stick. However, the aircraft manufacturer was not aware of issues with the newer type fitted to G-BKJW.

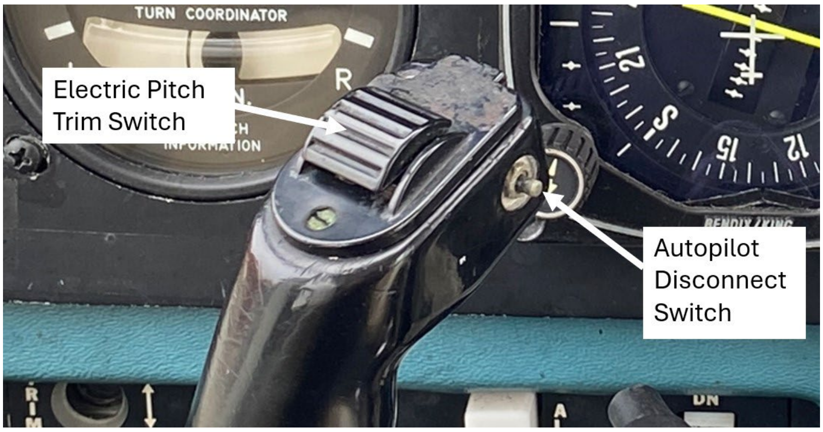

Figure 13

Pitch trim switch and Autopilot Disconnect Switch in another PA-23-250 aircraft fitted with an Altimatic IIIB autopilot

Footnote

2 Piper Altimatic IIIB Operating Instructions, part number 753 781, issued 1968.
3 Piper part number 761 039 KIT – Electric trim switch replacement.

In roll mode, only the roll servo is engaged, which operates the cables connected to the ailerons. In pitch mode both the pitch servo and pitch trim servo are engaged, which operate the cables connected to the stabilator and the pitch trim drum respectively. 'Engagement' means that a solenoid in the servo is receiving power and has engaged the motor to the servo capstan. The servos have internal clutches that allow the control cables to move if the servo were to jam, or if the pilot needed to oppose the autopilot's inputs. The Altimatic IIIB Operating Instructions state that '*approximately nine to fifteen pounds of pressure on the control wheel should override both the roll and pitch functions….[and] it should be checked prior to each flight.*'

Electric pitch trim operation

The electric pitch trim has two modes of operation: (1) manual via the switch on the control yoke when the autopilot is off and (2) automatic when the autopilot is on.

<u>Manual pitch trim mode</u>

In manual mode moving the pitch trim switch forward commands 'aircraft nose-down' pitch trim tab deflection, and moving it aft commands 'aircraft nose-up' pitch trim tab deflection. The switch contains movable and stationary contacts that are connected to four wires: red live, black earth, and a pair of white and green wires which are connected to the pitch trim servo motor and solenoid. When the switch is moved forwards the live wire is connected to the green wire and the earth is connected to the white wire, completing a circuit and causing the solenoid to engage and the motor to be driven in the nose-down direction. The opposite occurs when the switch is moved aft.

A pitch trim runaway is a situation where the electric trim runs nose-down or nose-up uncommanded. With the autopilot turned off, two independent short circuits would be required to cause a trim runaway: the green wire needs to short to live and the white wire needs to short to earth, or vice versa. A single short would not cause the trim to run uncommanded; if only a single wire were either shorted to live or earth then operation of the trim switch in one of the two directions would cause the live to be connected to earth which would trip the electric trim circuit breaker and stop trim movement.

If the autopilot is engaged in pitch mode, moving the pitch trim switch has no effect and does not disengage the autopilot.

<u>Automatic pitch trim mode</u>

When the autopilot is engaged in pitch mode, the pitch trim operates in automatic mode, automatically moving the pitch trim when it senses that the stabilator cables are under tension. This is to ensure that when the pilot disengages the autopilot the aircraft does not suddenly pitch up or down. The stabilator control cables run through a mechanical pitch trim sensor which senses differential cable tension (Figure 14). When there is more tension on one cable than the other, due to an out-of-trim condition, the trim sensor moves sideways and mechanically actuates a set of electrical contacts which send a signal to the pitch trim servo motor (via a trim amplifier) to operate the trim in the direction that will relieve the tension.

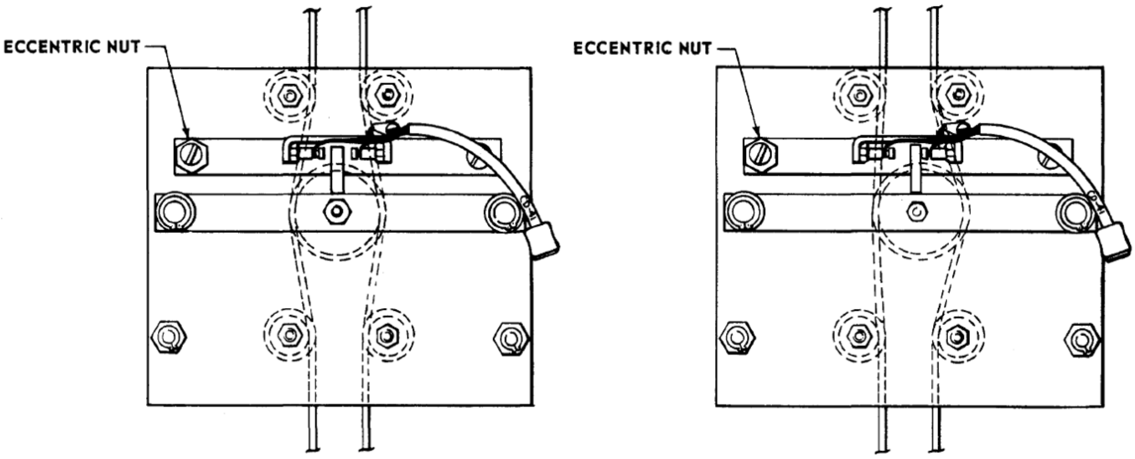

Figure 14
Pitch trim sensor (© Piper Aircraft)

A single fault in the pitch trim sensor, for example the sensor sticking to one side, could cause a pitch trim runaway.

A pitch trim warning system was fitted to G-BKJW. It is not known if it was functional, but the system is active when the autopilot is on in pitch mode. The system consists of an amber warning light on the instrument panel above the Autopilot Console and an electronic timing device that detects the duration of pitch trim servo operation. If the servo operates continuously for more than 3 to 4 seconds then the pitch trim warning light is illuminated. When the sensor contacts open, even momentarily, the electronic timer resets and the warning light goes out. There is no aural tone associated with the pitch trim warning. The system is tested by pressing and holding the light, and the light should illuminate after 3 to 4 seconds.

Electric trim malfunction checklist

The Aztec E Pilot's Operating Manual[4] contains the following Emergency Procedures for the Altimatic IIIB. For a malfunction of the Roll or Pitch modes it states to push the Roll engage switch OFF or push the Autopilot OFF button on the control wheel. It states that the '*Pitch Trim Section may be overpowered manually. In the event of a malfunction in the Pitch Trim Section, pull the Pitch Trim circuit breaker.*'

Footnote

4 The Piper Aztec E Pilot's Operating Manual, part number 761-455, revision 19 December 1990. This document includes the Airplane Flight Manual for Aztec E, serial numbers 27-4426, 27-4574 through 27-7554168.

The separate 'Altimatic IIIB Operating Instructions' document contains the following procedure for a malfunction of the Automatic Pitch Trim System:

a. *'Place the aircraft's trim indicator in approximately correct position by overriding Trim Servo through the use of trim crank or wheel.*

b. *Depress the control wheel button to disengage the Autopilot. Be sure to have manual control of the control wheel.*

c. *Correct trim by hand.*

d. *Pull out Trim Circuit Breaker, check to make certain correct breaker was opened by employing the trim switch on pilot's control wheel. If trim can be activated it would indicate incorrect breaker was opened.*

e. *With Trim Circuit Breaker opened, Altimatic IIIB can be reengaged, however, it will now be necessary to set trim by hand for any altitude changes.'*

The document does not contain a procedure for a malfunction of the manual electric pitch trim system.

Circuit breaker panel

The circuit breaker panel was located on the lower right side of the instrument panel, beneath the right control yoke. Figure 15 shows a pre-accident photo of the circuit breaker panel on G-BKJW, with the location of the electric trim and autopilot circuit breakers highlighted. The maintenance organisation stated that the circuit breakers had been re-labelled during the aircraft's annual inspection with black text on yellow tape to make them clearer, but no photos of this change were available. The circuit breakers automatically open when an overload occurs on the electrical circuit it protects. The circuit breakers can also be manually pulled out to isolate a circuit and manually pushed in to reset it.

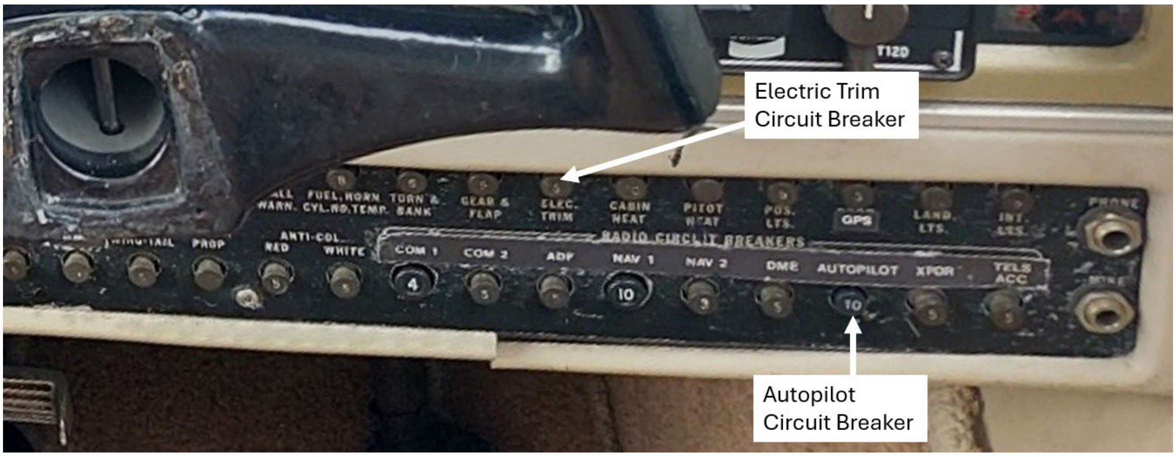

Figure 15

Location of electric trim and autopilot circuit breakers (G-BKJW pre-accident photo)

The autopilot circuit breaker is labelled '10' meaning 10 Amp. According to the circuit load chart in the PA-23-250 Service Manual[5] the Altimatic IIIB should have a 5 Amp circuit breaker. This difference indicates that other equipment may have been added to the circuit since original manufacture.

Seat belts

Each seat was equipped with standard aircraft lap straps secured to either side of the seat – one strap with a metal buckle and one strap with a metal tongue. The strap is fastened by slotting the tongue into the buckle which is held in place by a spring and metal tab within the buckle. The strap is unfastened by lifting the buckle lever which twists the spring and disengages the metal tab from the tongue. The force required to lift the buckle lever and unfasten the strap in normal use is considerably less than when the straps are under load, such as during an impact. The front two seats were also each supplied with an inertial reel shoulder strap. Once the lap strap was secured, the shoulder strap could be pulled out from the reel and attached to a circular hook on the base of the metal tongue from the lap strap.

Fuel

The aircraft had four fuel tanks, two in each wing. Each tank had a capacity of 36 USG with a total capacity of 144 USG (545 Litres), of which 4 USG was unusable. There was a fuel selector for each wing in the cockpit with selections for inner tank, outer tank and off. For flight planning, a fuel consumption of 100 litres/hour was reportedly used. Using this fuel burn rate, fuel uplifts and estimated flight times, the fuel remaining at the time of the accident was estimated to be about 290 litres.

Stall speed

The aircraft's calibrated stall speed at maximum takeoff weight was 64 kt (74 mph) with gear and flaps up, and 59 kt (68 mph) with gear and flaps down. At the aircraft's estimated accident weight of about 3,900 lb (see section Weight and balance) the stall speed was 56 kt (65 mph) with gear and flaps up, and 52 kt (60 mph) with gear and flaps down.

Maintenance history

The last recorded maintenance on the aircraft was an annual inspection which was carried out at Bagby between 7 February 2023 and 26 May 2023. The work involved routine maintenance as well as replacing flexible hoses, repairing both exhaust systems, overhauling all four magnetos, fuel bowl upgrades, replacing all tyres, and other rectification work. No maintenance on the autopilot or electric trim system was recorded.

The licensed aircraft engineer responsible for the annual inspection stated that the inspections would have included running the electric trim to check it worked and would have included examining all the control cables and pulleys. He also thought that the electric trim would have been tested during the post maintenance 'air test'. He did not know why

Footnote

5 Piper Aztec Service Manual PA-23-250, part number 753-564, 31 July 2021.

the autopilot was placarded INOP and said that it was already placarded when the aircraft was bought. He said that the autopilot circuit breaker was not pulled and isolated because he thought it was needed either to run the electric trim or to power the intercom or a radio.

The CAA had conducted an audit of the maintenance organisation nine days before the accident resulting in two non-conformance level 2 findings[6]. Following the accident to G-BKJW the CAA carried out a survey of the maintenance organisation. They found discrepancies in the maintenance of three aircraft by the maintenance organisation, which included G-BKJW. The findings included evidence that some Airworthiness Directives (AD's) had not been complied with on G-BKJW. The survey findings resulted in the CAA provisionally suspending the maintenance organisation's approvals. The CAA investigation is ongoing.

Maintenance by previous organisations

The aircraft had been maintained by a different maintenance organisation from the late 1980s until January 2020. Worksheets from this organisation were available dating back to 1993. No autopilot or electric trim rectification work was detailed in the worksheets apart from a replacement of the attitude indicator in 2000 which was part of the autopilot system. The last time the autopilot was recorded as operating satisfactorily was in December 2011. In a worksheet from January 2012 the autopilot was recorded as being inoperative and placarded as such. A worksheet from March 2019 stated of the autopilot: '*Roll servo not engaging. Radio couple extremely stiff. Autopilot placarded INOP at customer's request.*'

The previous two co-owners of the aircraft had intended to use a different maintenance organisation to carry out an annual inspection of G-BKJW at the end of 2020. One of the co-owners had sent this maintenance organisation a list of defects which included '*Autopilot ALT dial sticks below 4000 ft*', but he told the AAIB that the autopilot was not used. The other co-owner stated that the autopilot did not work well and that it had issues with height hold. He stated that he might use it for a couple of minutes, but it was "not good". He also stated that he had had issues using the electric trim so had stopped using it. He recalled one occasion when trying to troubleshoot the autopilot height function that the trim moved further than would be normal. He could not recall if the autopilot was on or off when this happened. He said it was easily controlled, and he did not consider grounding the aircraft for rectification, but that he intended to have it checked at the next annual inspection.

The engineer who had been approached to carry out the annual inspection informed the AAIB that he had been told by one of the co-owners, as part of the pre-maintenance discussions, that the aircraft had had a trim runaway. As a result, the engineer had been intending to strip and inspect the complete trim tab system; however, this work was never started, because it was decided to sell the aircraft due to the high estimated cost of the annual inspection. The engineer added that, after the accident to G-BKJW, he had spoken to the same person again, who said that his earlier comments had been misinterpreted and

Footnote

6 A level 2 finding is any non-compliance with Part-CAO requirements which may lower the safety standards and possibly hazard flight safety. Part-CAO is a combined Maintenance and Airworthiness Management Organisation Approval for General Aviation Aircraft.

that he had experienced a ‘trim overrun’ rather than a ‘trim runaway’. This information was not recorded in the aircraft paperwork and the engineer working on behalf of the purchasers preparing the aircraft to obtain a Permit to Fly for the ferry flight to Bagby stated that he was not made aware of it.

Information about G-BKJW after the annual inspection in May 2023

One of the owners of the maintenance organisation at Bagby that carried out the last annual inspection said that while the autopilot was placarded INOP he believed the heading function still worked, but that if altitude hold was engaged the aircraft would pitch up or down.

The AAIB interviewed the pilot who flew G-BKJW when it came out from the annual inspection. He had not flown a PA-23 before and had not undertaken differences training with an instructor, as he was not aware of the requirement and did not consider it necessary. He instead self-briefed by reading the Pilot’s Operating Manual and speaking to another pilot who had flown the type. He said he used the electric pitch trim and had no issues with it. He tried using the autopilot and got it to follow heading and hold altitude, but he did not use it much. In terms of a pre-flight check he recalled checking the autopilot and seeing the yoke move, but as the autopilot was INOP “it wasn’t really part of a pre-flight check”. He recalled there being a circuit breaker to pull if there was an issue, but he could not recall if there were separate autopilot and electric trim circuit breakers.

The AAIB also spoke to another pilot who had flown G-BKJW four or five times after the annual inspection. He said that he always used the electric trim in flight and did not experience any issues with it, and that he only used the manual trim wheel on the ground. He used the autopilot in heading mode, but when he tried the altitude hold mode the aircraft started climbing so he did not use the vertical modes. As part of his pre-flight checks he actuated the electric trim and checked the trim had moved by looking on the overhead trim indicator. He did not carry out any pre-flight checks on the autopilot. He was aware of an autopilot circuit breaker but not an electric trim circuit breaker.

Maintenance requirements

The aircraft’s maintenance programme stated that it was being maintained in accordance with a Minimum Inspection Programme (MIP) complying with Part-ML.A.302(d)[7]. The programme did not list any autopilot related maintenance. For the annual inspection there was an operational check under *‘Flying controls’* for ‘*primary/secondary flight controls and trim systems for full and free movement in the correct sense’*, a check of control cables for correct tension, and inspections for push-pull rods, bell cranks, control cables and pulleys, and an inspection item called *‘pitch trim motors’*. The CAA stated that the maintenance programme should have included a number of additional inspections that are detailed in the Piper PA-23-250 Service Manual[8]. These included a 100-hour inspection of the Piper Altimatic III Autopilot which involved checks of servo bridle cables and servo clutch override tests.

Footnote

[7] CAA Part-ML details the airworthiness requirements for ‘Light Aircraft’.
[8] Piper Aztec Service Manual PA-23-250, part number 753-564, 31 July 2021.

The PA-23-250 Service Manual also lists an inspection to be carried out at every 50 and 100 hour check which states:

> *'If installed, check operation of Autopilot, including automatic pitch trim, and manual electric trim (See Note 13).' Where 'Note 13' states: 'Refer to Airplane Flight Manual or Pilot's Operating Handbook for pre-flight and flight check lists.'*

The Airplane Flight Manual, in its supplement for the Altimatic IIIB, includes operational ground checks of the autopilot and checking that the autopilot can be disengaged. It refers to actuating the electric pitch trim and doing a press-to-test of the pitch trim warning light. It does not refer to checking the servo clutch override, but this is referred to in the previously mentioned *'Piper Altimatic IIIB Operating Instructions'* which state that the ability to override the autopilot's control should be checked prior to each flight[9].

Aircraft wreckage examination

The aircraft wreckage was recovered to the AAIB's facility at Farnborough for a detailed examination. The fuselage and cockpit were severely damaged from the impact and the post-impact fire, both of which resulted in a significant loss of evidence.

Engines and propellers

The right propeller had detached from its engine and was embedded in the right engine impact crater, while the left propeller had remained attached to its engine. Both propellers had suffered similar levels of bending and leading-edge damage consistent with rotation at impact. The wings-level steep nose-down trajectory seen in the CCTV video was not consistent with a single or dual engine power loss, so engine teardown inspections were not carried out. However, there were no external indications of mechanical failure and the oil filters on both engines were clear of debris.

Flight controls

The control cables between the control yoke assembly in the cockpit and the stabilator control arm (balance arm) were intact and attached. The stabilator moved up and down freely when the cables were actuated. There were no foreign objects in the tail assembly, or any obvious damage in the tail area to indicate a control jam of the stabilator.

The pitch trim tab moved freely and in the correct direction (opposite to the direction of the stabilator) when the stabilator was moved up and down, in its function as an anti-servo tab. The pitch trim tab actuating arm was connected to a rod that was actuated by the cable-operated pitch trim drum. The pitch drum translates up or down when the cable is pulled one way or the other. The drum was found to be in position 3 mm from full drum up, which corresponded to 3 mm from full nose-down trim position (Figure 16). The full range of travel was 13 mm and so it was 10 mm away from full nose-up position. The drum moved freely when the cable was pulled in either direction. It was possible that post-impact break-up forces applied some unequal pressure to the cable causing the pitch trim drum to move.

Footnote

9 The aircraft manufacturer was not aware as to why the clutch override pre-flight check was in the *'Piper Altimatic IIIB Operating Instructions'* but not in the Airplane Flight Manual.

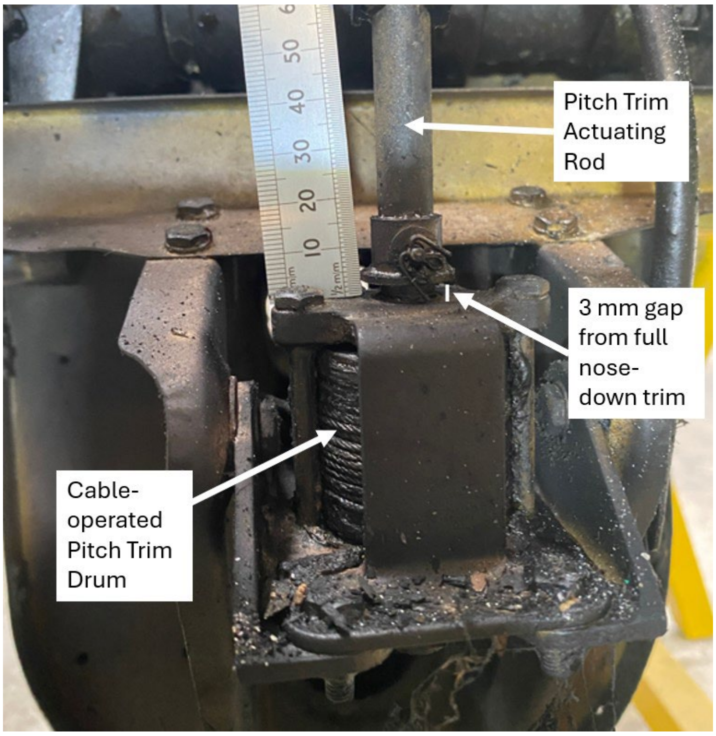

Figure 16
Position of pitch trim drum post-accident

The pitch trim cable was found to be continuous between the pitch trim drum and the trim handle in the cockpit. Attempts were made to check the rigging of the trim tab, with the stabilator in the neutral position, but the tab was warped from the fire and no longer had a flat surface for accurate angular measurement.

Flaps

The flap actuator ram had separated from the flap actuator cylinder due to impact forces and fire damage (Figure 17). Once the ram is detached the flaps are free to move and so it was not possible to determine the flap position at impact. The flap actuating components, including the bell crank, flap push-pull rods, torque tube and the torque tube supporting bearing blocks, had suffered multiple failures. These components, including the actuator ram, were sent to a metallurgical lab for detailed forensic examination. The forensic organisation concluded that all the fractures were the result of overload, and that there was no evidence of any progressive crack growth such as fatigue. They also concluded that:

> *'The overload failure and deformation observed in the flap actuator ram and flap actuator ram rod end is not considered to be consistent with overload which may have occurred if the flaps had been extended while the aircraft was above the maximum permissible speed for flap deployment. If this had occurred, it would be expected that the flap actuator ram would have been in tension, which is not consistent with the degree of deformation/bending observed. This suggests that the failure of the flap actuator ram and rod end was the result of the aircraft impacting the ground.'*

Figure 17

Remains of flap actuator cylinder (left) and flap actuator ram (right)

The bell crank was found to have separated from the torque tube due to overload, but the weld joining these two parts exhibited some degree of lack of fusion between the weld and the tube. It was considered that the lack of fusion was most likely due to poor welding technique, but the forensic organisation concluded that:

> *'Even though the weld was not particularly good on the outboard edge, it may still have been sufficient for the expected in service loads. There was no evidence of any fatigue cracking present in the weld, which would suggest that at the time of the accident, the lack of fusion had not resulted in any problems with normal in-service loading for the life of the aircraft.'*

In addition, deformation of the bellcrank and witness marks on its inboard and outboard faces were considered to be most likely caused when the aircraft struck the ground.

The aluminium flap torque tube had burnt through its centre, so it could not be determined if it was intact prior to impact, but an in-flight failure of the torque tube with flaps extended would have caused the left flap to retract while the right flap remained extended; this would have caused the aircraft to roll left which was not seen in the CCTV video.

Autopilot and electric trim

The autopilot and electric trim components were examined with the assistance of an avionics engineer familiar with the autopilot system. The Autopilot Console had suffered significant impact and fire damage (Figure 18). As the Roll ON/OFF switch was a magnetically-held-on switch, the loss of electrical power at impact would have released it so it was not possible to determine if the autopilot was turned on at the time of impact. There were no tungsten filament remains from the lights inside the HDG, ALT or Pitch ON/OFF buttons, so it could not be determined if these lights had been on at impact. The circuit breaker panel was destroyed with multiple loose circuit breakers so it could not be determined if the autopilot or electric pitch trim circuit breakers were in or out.

The left horn of the left control yoke had detached (Figure 19) and the electric pitch trim wires were broken, and their insulation had vapourised in the fire. The hole for the autopilot disengage switch was empty and an internal examination of the horn did not reveal a switch (this switch was also missing in the instrument panel photo that was taken in October 2020 – Figure 11). A detailed examination of the electric pitch trim switch did not reveal any anomalies. Some of the contact arms were bent but there was no evidence of contact welding.

Figure 18
Remains of Autopilot Console (lower image)

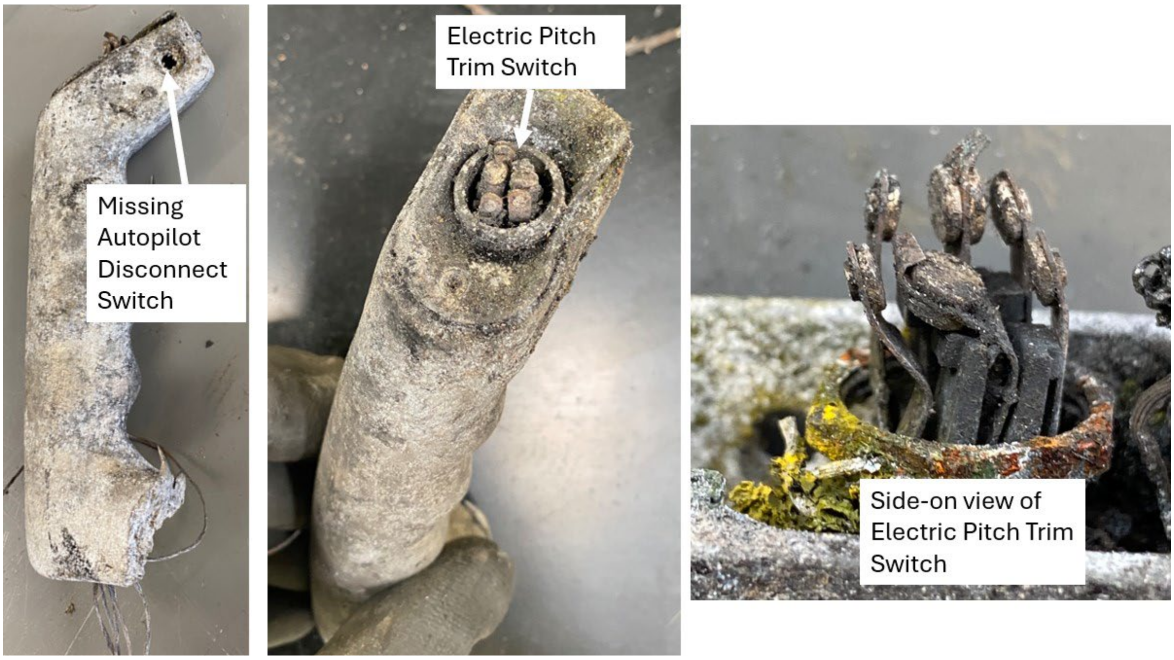

Figure 19

Detached left horn of left control yoke with exposed electric pitch trim switch

The section of instrument panel containing the pitch trim warning light had separated from the cockpit. Most of the instruments had detached from it as had the pitch trim warning light bulb.

The pitch trim servo was destroyed with just molten globules remaining of its casing. The motor and gears had separated, but the pitch trim servo cables were securely connected to the pitch trim cables. The capstan and gear part of the pitch servo was intact with some deformation of components, but the motor and solenoid had detached; the heat that it had been exposed to meant that any measurements of clutch friction would not be reliable. The part number and serial number of the pitch servo were visible and corresponded to the numbers in the aircraft manufacturer's build record, which meant that it was the same servo that was installed in the aircraft when it was new in 1971. The pitch servo cables were connected to the stabilator control cables.

The stabilator control cables had separated from the pitch trim sensor (Figure 20). The central pulley could be moved sideways and contact could be made with each of the electrical contacts on its reverse side. There was some resistance to movement when moving it side to side, but this could have been the result of fire and impact damage, with the panel being slightly bent. The damage meant that it was not possible to determine if the sensor may have stuck in one position.

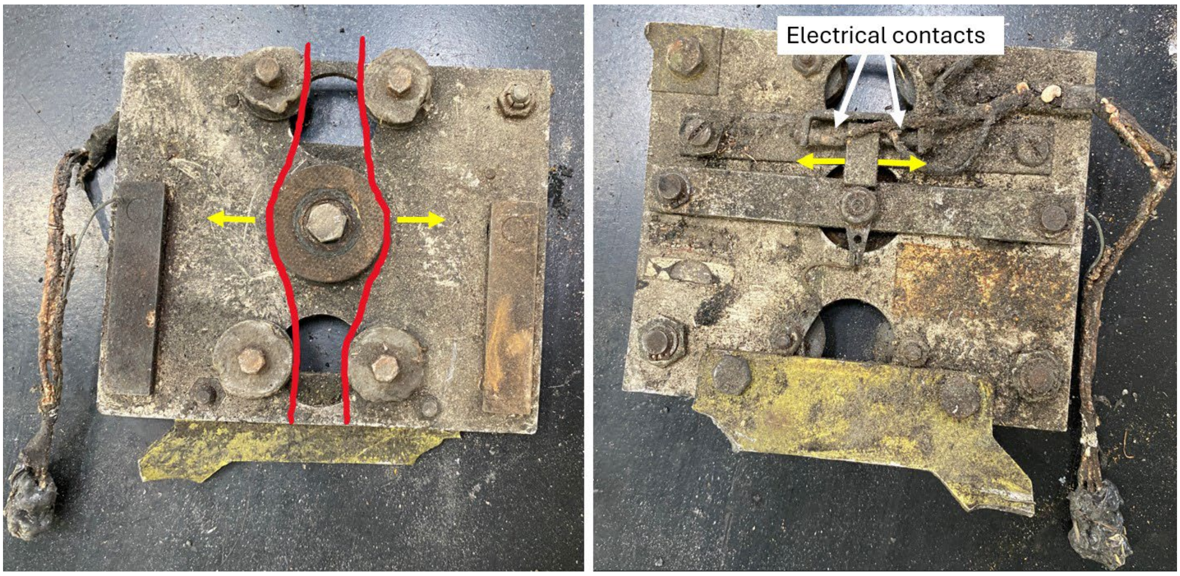

Figure 20

Pitch trim sensor (red lines show path of stabilator control cables)

The autopilot amplifier[10] was destroyed and could not be tested. Some transistors were loose while others were still attached to the heatsink. A short circuit in a transistor can cause a trim runaway but tests of the transistors were inconclusive due to the fire and impact damage.

Seat belts

All the seats had separated from the floor structure, and some were thrown clear of the main wreckage, including the front left pilot seat, which was identified by matching the damage at its base with the damage of the left front seat support structure. The left lap strap, with its buckle, was still securely attached to the left side of this seat. The right lap strap was also securely attached to the right side of the seat, but the strap had burnt through and was missing the part of the strap with the tongue that would be inserted into the buckle (Figure 21). A detached right lap strap was found with a tongue that had a circular hook designed to attach a front seat shoulder harness; however, it could not be determined if this was from the front left or front right seat. Both front seat shoulder harnesses and inertial reels were severely fire damaged.

The lap strap remains shown in Figure 21 were taken to a forensic investigation organisation for detailed examination to determine if there was any evidence that they may have been in use at the time of impact but subsequently came undone. They concluded, based on visual and microscope examinations, that it was likely that the left pilot's seat buckle and the strap with tongue were not in use at the time of impact.

Footnote

[10] The amplifier is an analogue computer that interfaces between the controls, sensors and servos.

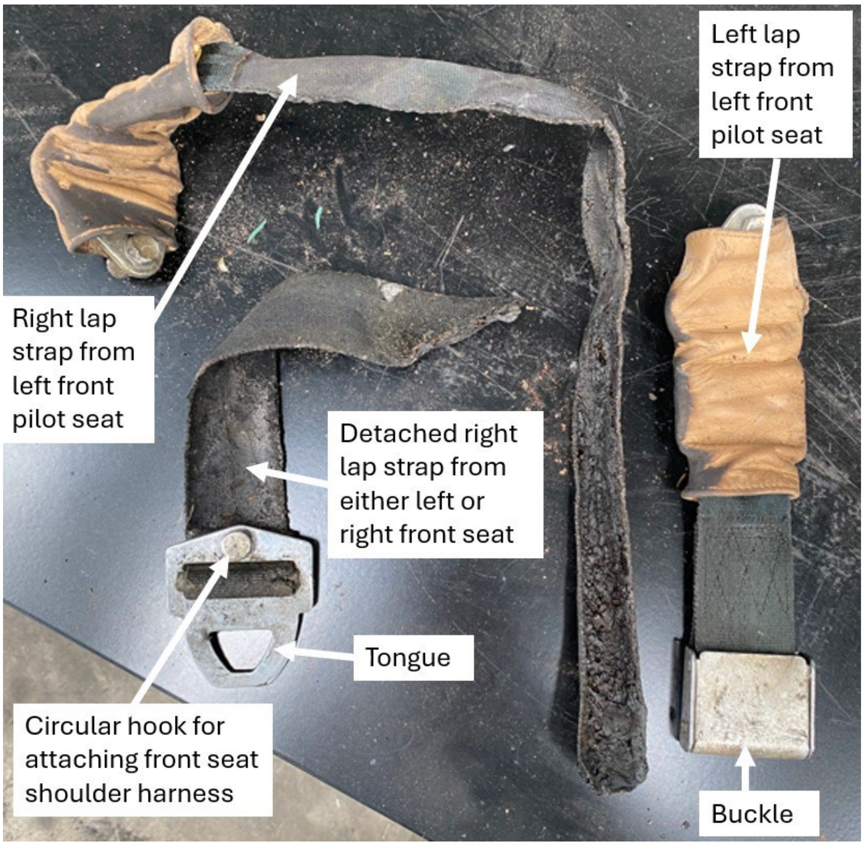

Figure 21

Lap strap remains from left front pilot seat (after removing the bolts attaching them to the seat) and tongue strap from either the left or right front seat

Aircraft documents in the wreckage

Aircraft documents were found at the accident site that were unaffected or only minimally affected by fire. These included the aircraft's Certificate of Airworthiness, Airworthiness Review Certificate, and the aircraft's Flight Manual with the aircraft's registration and CAA stamp. There was also a loose-leaf A4 print-out of the Piper Altimatic IIIB-1 Operating Instructions which had some differences to the Piper Altimatic IIIB Operating Instructions (a IIIB was fitted to G-BKJW). No technical log or paper checklist was found.

Weight and balance

The aircraft's basic weight was 3,317 lb and the pilot's weight was 160 lb. The cabin contents were sufficiently lightweight and their pre-impact locations unknown so they were not included in estimating the weight and balance. The usable fuel remaining at the time of the accident was estimated to be about 290 litres, weighing 460 lb. This gave a total weight of 3,937 lb (under the maximum takeoff weight of 5,200 lb) and a centre of gravity (CG) location of 93.1 inches, placing it slightly forward of a mid CG range.

Meteorology

On the day of the accident, there was an area of low pressure centred to the west of Ireland, extending a south-westerly flow across the UK with a slack pressure pattern over northern France. Frontal systems associated with the low pressure were affecting the west of Ireland and moving across Ireland during the afternoon.

Forecast conditions issued prior to the pilot's departure from Bagby were for good flying conditions for the flight from Bagby to Deauville, ahead of the frontal activity, with good visibility and high cloud bases. The forecast indicated the aircraft would start to enter the frontal zone with thickening and lowering cloud bases and outbreaks of light rain as it progressed west across south-west Wales. As the flight progressed further west towards Abbeyshrule the forecast included occasional visibility reductions to 6 km in rain becoming increasingly widespread near the warm front, with broken or overcast cloud between 1,500 to 3,000 ft. Additionally, the low-level significant weather chart forecast a risk of isolated heavy rain or thunderstorms, reducing visibility to 3,000 m and embedded cumulonimbus cloud with bases around 1,500 to 2,500 ft. Occasional or widespread low-level cloud between 600 to 1,200 ft was also forecast near coasts, lowering to 300 ft within the warm sector. The forecast for the onward flight to Navan airfield would have taken place under similar forecast conditions.

Recorded actual weather conditions were not available for either Abbeyshrule or Navan. Reports were obtained from an automatic weather station at Mulingar, located approximately 5 nm east-southeast of Abbeyshrule. During the period of 1500 to 1900 hrs the wind was reported as being generally southerly at 5 to 8 kt, with broken or overcast cloud initially at 1,000 to 1,200 ft, lowering to 500 ft by 1900 hrs. A witness at Navan described the weather while G-BKJW had been there as being 'not great' with overcast cloud, rain and a visibility of 8km.

Reports for Dublin, approximately 22 nm south-east of Navan, were obtained. During the time that the aircraft was at Navan, Dublin was reporting moderate south-easterly winds of between 12 to 17 kt, greater than 10 km visibility in light rain, with a cloud base initially broken at 2,200 ft, which then lowered to between 1,300 to 1,400 ft with a few patches at 700 ft.

An aftercast obtained from the Meteorological Office stated that the aircraft's final leg from Navan back to Bagby would have been mainly within the frontal zone, with thick layered cloud and a risk of embedded cumulonimbus activity. The photograph sent by the pilot shows the aircraft flying between two layers of broken cloud, although it is not known at what point on the route it was taken.

The flight would have cleared the frontal activity over the North Yorkshire Moors with observations from RAF Topcliffe (located 3 nm west of Bagby airfield) at 1850 hrs, just after the accident occurred, indicating that, even though light rain was present, visibility remained above 10 km, with southerly winds at 10 kt, and a broken cloud base of 5,100 ft. The reported temperature was 19°C with a forecast freezing level of between 6,000 to 8,000 ft.

Visual Flight Rules (VFR)

The flight was conducted under VFR. While flying below FL100 this is defined as requiring a minimum of 5 km flight visibility, 1,500 m horizontal separation from cloud and 1,000 ft vertical separation from cloud. Outside controlled airspace for fixed wing aircraft when flying at or below 3,000 ft and below 140 kt, this is reduced to 1,500 m visibility, remaining clear of cloud and in sight of the surface.

Airfield information

Bagby is an unlicensed airfield with a 690 m long grass runway (06/24). The airfield elevation is 160 ft amsl. It has an Air/Ground radio operator for passing airfield information to arriving and departing aircraft.

Organisational information

The aircraft was owned by an Irish business, specifically set up to purchase and operate the aircraft on behalf of its four directors, and was based at Abbeyshrule airfield, Ireland. The purchase was organised by a brokerage company, based in Ireland, one of the two directors of which was also a director of the maintenance company at Bagby which had conducted the post-purchase maintenance work on the aircraft.

The aircraft owners were involved in the horse racing industry and had no knowledge of operating aircraft. It has not been possible to confirm the exact arrangements under which the aircraft was operated, but a commercial pilot had advised and assisted in the insurance, hangarage and refuelling arrangements. Other authorities are investigating the financial arrangements in place for the provision of pilots to operate the aircraft. Evidence exists that the flights conducted by the pilot of G-BKJW on 6 July 2023 had already been offered to another private pilot with little twin-engine experience, and no experience on a PA-23, in return for payment. This pilot had turned the offer down.

None of the passengers on board the aircraft from Deauville to Abbeyshrule had paid for the flight. As such, it was considered a private flight, although any pilot being paid to conduct the flight would have needed to hold a commercial pilot's licence to receive payment.

Ongoing maintenance of G-BKJW was intended to be carried out by the same maintenance organisation that had conducted the annual maintenance inspection at Bagby airfield.

Pilot background

The pilot had started flying gliders in 2014 at the age of 12. He commenced training for a Private Pilot's Licence (PPL) in 2018, later being awarded a flying training scholarship and gaining his licence in October 2019. The pilot had then begun building his flying hours, mainly on the single-engined Piper PA-38 Tomahawk, which included buying blocks of hours from a company based at Bagby airfield, as well as some time flying in Ireland.

From 31 July 2021 onwards, the pilot's logbook listed a significant number of flights being flown, some of which were recorded as being on behalf of the maintenance organisation at Bagby and the aircraft brokerage company in Ireland involved with the purchase of G-BKJW. These flights included delivery flights, including one to Poland, and flights recorded in his logbook as demonstration flights. During this time the pilot had been working as a contractor for the maintenance company in various roles, including IT, technical and secretarial work, although the company stated that they never paid contractors or staff for flying services. They added that the pilot was able to fly aircraft in a flying group, that they provided maintenance for, at a discounted rate as a "perk of his position". They also stated he was able to fly aircraft, owned by the brokerage company that were based at Bagby for sale, paying only for the fuel used.

In December 2022, the pilot completed a multi engine piston (MEP) rating. His logbook recorded this took seven flying hours, flown on a Cessna 310. Two months later, in February 2023, he started a CPL flying course, but before he was able to complete it the flying school went into administration. His last flight with the school was on 22 April 2023, at which time he had completed approximately 23 hours flying, including seven hours dual and one hour solo on the twin-engined Diamond DA42. He had needed to complete two further training flights and a successful test flight in order to have gained his CPL qualification. His training reports reflected he was a competent pilot.

The pilot returned to flying a variety of single engine aircraft based out of Bagby airfield while making arrangements to complete his CPL at a different flying school. At the time of the accident, he did not hold either a CPL or an instrument rating. He had a total of 4 hours 50 minutes instrument flying on a DA42 simulator and 6 hours 50 minutes instrument flying on single engine aircraft.

The two flying schools involved in the multi engine and CPL training reported that students were taught the basic functions of any autopilot fitted to the aircraft, but that the autopilots were not used during flight. They could not provide details on specific training given to students on what to do in the event of a trim runaway or autopilot malfunction.

The pilot's logbook first records a flight on G-BKJW on 25 May 2023. This recorded a 15-minute flight from Bagby airfield as pilot in command. Three further flights on G-BKJW were recorded from Bagby on 26 May totalling 2 hours 20 minutes, again, with the pilot recorded as being the pilot in command. There was no record of what the purpose of the flights was.

Another pilot stated he had flown with the accident pilot on the flight in G-BKJW on 25 May and the first two flights on 26 May. He too had recorded that he was the pilot in command for the flights and added that he was in the left seat (as normally occupied by the pilot in command). His recorded total flight time for the three flights was 25 minutes less than that recorded by the accident pilot for the same flights.

None of the flights by the accident pilot in G-BKJW were recorded as training flights and there was no evidence of the pilot having received instruction from a qualified flying instructor on the PA-23.

The last entry in the logbook was on 2 June 2023, recording a flight on a Cessna 172. It is known from information provided by others that the pilot had, however, conducted other flights on G-BKJW after this date. This included a flight on 3 July 2023, three days before the accident, when the pilot flew the same five passengers from Abbeyshrule, where G-BKJW was based, to Deauville. He had then continued in the aircraft to Bagby airfield where it remained parked until the day of the accident.

Pathology

The pilot's medical history and post-mortem examination did not reveal any evidence of a natural disease or medical factor which may have caused a medical collapse or physical debilitation. This included a toxicology test which showed that the pilot had not been exposed to carbon monoxide.

There were no injuries associated with wearing a lap strap or shoulder harness, but these might have been obscured by other injuries. Therefore, the pathologist could not exclude the possibility of the straps having been worn. A passenger onboard for the flight from Deauville to Abbeyshrule reported that the pilot had been wearing a seat belt for that flight. However, the physical evidence from the pilot's lap strap examination indicated that it had probably not been worn at the time of the accident.

Survivability

The damage to the aircraft from the steep, high-energy, impact meant that surviving the accident was considered unlikely, irrespective of the lap strap and harness having been worn.

Tests and research

Flight trial

A flight trial was carried out using a PA-23-250 'E' model aircraft to obtain information about the pitch control forces that can be experienced in an out-of-trim situation, the ability to reach and pull the electric trim circuit breaker, and the aircraft's response to a sudden flap retraction. A qualified test pilot was used to fly the aircraft from the left seat and an experienced instructor on the type assisted from the right seat. After an initial familiarisation flight, the flight trial was carried out using two cameras strapped to the pilots' chests to record the control inputs, instruments and intercom audio. A portable g-meter and a data logger that recorded GPS position and attitude data were also installed. The aircraft was ballasted such that, during the mid portion of the flight, it was representative of G-BKJW's estimated final CG. The pilot used a portable stick force gauge to measure the control forces which had a maximum range of 30 daN[11] (67 lb).

Footnote

[11] Newton (N) is a measurement of force. daN is the unit of dekaNewton. 1daN = 10 N. 1daN is a force equivalent to that applied by a weight of mass 1.02 kg, or 2.25 lb.

The test aircraft was fitted with a different autopilot to the autopilot fitted to G-BKJW so no autopilot tests were carried out. However, the time to move the electric pitch trim full travel was measured at 38.4 seconds which compared with 38.5 seconds measured on a different PA-23-250 that was fitted with the same Altimatic IIIB autopilot as G-BKJW, so the trim movement timings used during the test were representative.

Control forces with ‘as found’ pitch trim position

The pitch trim drum was set on the ground to the same 3 mm position as found at the accident site. A mark was then placed alongside the pitch trim indicator in the cockpit – this position was called the ‘as found’ trim position. The aircraft was then flown at the minimum and maximum airspeeds that were determined from the CCTV video, 93 KIAS[12] and 130 KIAS, and also at a midrange speed of 112 KIAS, in the flaps up and ¼ flap configurations, and at lower maximum speeds at ½ flap and full flap so as not to exceed the flap limiting speeds (Table 1). During the test pilot’s familiarisation flight he had established that the landing gear position had little effect on pitch trim position, except during gear transition, so all test points were flown landing gear up.

At each speed and flap configuration shown in Table 2 the electric trim was used to set the aircraft ‘in trim’. When ‘in trim’ the pilot can release their hands from the control yoke and the aircraft will not pitch up or down in smooth air. The electric trim was then actuated in the nose-down direction until the trim indicator reached the marked ‘as found’ trim position. During this period the pilot held the control force required to maintain pitch attitude and altitude. The stick force gauge was then applied to the control yoke to measure the out-of-trim push force at the ‘as found’ trim position – these figures are recorded in daN and lb in Table 2. The electric trim was then actuated in the nose-up direction and the time to return to ‘in trim’ was measured. Ground tests had revealed that the trim operated at the same speed in both directions, so these figures are entered in Table 2 as the ‘Time to ‘as found’ nose-down trim position’ in seconds.

Footnote

[12] KIAS is ‘Knot Indicated Airspeed’. The aircraft’s indicated airspeed was in mph and these were converted post-flight to kt.

Flap	Speed (KIAS)	Time to 'as found' nose-down trim position (sec)	Out-of-trim force (daN)	Out-of-trim force (lb)
UP	93	22	29	65
	112	22	30	67
	130	17	30+	67+
1/4 Flap	93	20	25	56
	112	15	28	63
	130	12	30	67
1/2 Flap	93	11	14	31
	112	8	16	36
Full Flap	93	10	11	25
	109	10	10	22

Table 2

Using electric trim, the time from in-trim to the 'as found' trim position and the resultant out-of-trim force at the yoke for different airspeeds and flap configurations with power for level flight (the '+' symbol indicates that the force exceeded the gauge limit of 30 daN)

It was noted during ground tests that the trim indicator only moved through part of the indicated range from full nose-up to full nose-down. As the range of movement was limited the trim could not be said to have been set precisely to the 'as found' trim position each time.

As well as revealing the high control forces that could be expected following a trim runaway, the results also showed that in none of the flap configurations or airspeeds, was the 'as found' trim position an 'in-trim' position. It was closest to in-trim at ½ flap and 112 KIAS, with 8 seconds of trim travel.

Aircraft response to sudden release of controls when out-of-trim

Tests were also carried out to look at the aircraft's response when a small amount of nose-down trim was applied, while holding the controls, and then suddenly releasing the controls. This simulates the situation where a trim runaway has started while the autopilot is engaged which initially masks the runaway by compensating with the pitch servo, until the pitch servo clutch slips. The duration of the trim inputs were limited so as not to risk exceeding aircraft limits. In the flaps up configuration at 130 KIAS after applying a 5 second nose-down trim input and releasing the controls the minimum g reached was 0.5 g and the nose dropped 5 degrees. At 87 KIAS with full flap, after applying a 10 second nose-down trim input and releasing the controls, the minimum g reached was 0.2 g and the nose dropped to -12° nose-down.

Visibility of, and ease of reach to, the electric trim circuit breaker

The electric trim circuit breaker was in the same location on the test aircraft as on G-BKJW. The test pilot, who was 1.68 m tall, stated that the circuit breaker was difficult to identify, because it was not visible from a normal seating position (Figure 22); he had to lean to see it and reach it. He found that it was not possible to hold any control force on the control yoke while simultaneously reaching for and pulling the electric trim circuit breaker. Another pilot, 1.88 m tall, sat in the left seat, also had to lean to reach the electric trim circuit breaker. The height of the accident pilot was 1.83 m.

Figure 22

View of location of Electric Trim Circuit Breaker from the left pilot's seat head position in test aircraft – same location as on G-BKJW. Control yoke is being held in a normal in-flight position.

The test pilot considered that it was very unlikely that a pilot in a trim runaway event, under the circumstances described in this accident, would have sufficient time or capacity to find and pull the electric trim circuit breaker. And combined with the high control forces that can be experienced he did not think the aircraft would meet the current requirements for trim runaway in CS 23.677 (see next section on certification requirements).

Effect of lapstrap being undone

The test pilot assessed whether having the lap strap undone would have affected his ability to pull high control forces. He reported that all the force he was pulling on the yoke was reacted through his feet on the rudder pedals and that there was no load on his lap strap. He stated, however, that having the lap strap undone could have had an impact on the pilot's ability to control the aircraft if the aircraft had gone to zero g or negative g.

Flap retraction tests

Extending the flaps causes the PA-23 aircraft to pitch nose-up and requires the pilot to trim nose-down to remain in trimmed level flight. If a failure were to cause the flaps to retract suddenly, then the aircraft would pitch nose-down and the pilot would need to pull on the yoke and trim nose-up to recover.

The AAIB spoke to an experienced instructor on the PA-23. He reported that during a handling exercise at 5,000 ft, with full flap set, with the aircraft in-trim, at about 100 KIAS, he selected the flap up, which retracted in about 4 seconds. He reported that without input on the controls, within 3 seconds the aircraft had reached a nose-down attitude of -50° and lost 500 ft of altitude. He had then initiated a gentle recovery resulting in a total height loss of about 2,000 feet. A similar exercise conducted with ½ flap was less severe but still with a nose-down attitude of about -30°.

The test flight aimed to repeat these findings, but also by simulating a more rapid flap retraction that might occur if there was a structural failure of the flap mechanism or if the flaps lost hydraulics. To simulate this, the test pilot maintained altitude (the plan had been to maintain attitude) while the right seat pilot retracted the flaps. Then the controls were released to see the aircraft response. The first test was conducted with ½ flap at 104 KIAS. After flap retraction the controls were released while the aircraft was pitched up to +5°. The aircraft pitched down to -5° within 2 seconds, and a minimum of 0.3 g was recorded, before recovery was initiated. There was negligible height loss. The plan was to repeat the test with full flap, but after setting up the condition and feeling the high control forces of 14 daN necessary to hold altitude, the test was aborted due to concerns that the aircraft might go negative g.

6° nose-down test

The autopilot fitted to G-BKJW had a 6° nose-down pitch limit. A test was conducted at 172 kt and 6° nose-down pitch to determine the rate of descent that could be achieved (168 kt was the approximate average descent speed of G-BKJW prior to the turn on to base). The test, with slightly more than idle power, produced a descent rate of between 1,200 and 1,300 ft/min.

Flight control force and trim runaway certification requirements

The Piper PA-23-250 was certified to the US Civil Air Regulations (CAR) 3, dated 1 November 1949, including amendments 3-1 to 3-9, dated 15 December 1952. These requirements did not include a controllability requirement following a pitch trim runaway. However, there was a general controllability requirement (3.106) which stated that control forces in pitch shall not exceed:

- 10 lb (4.45 daN) for prolonged control application on a stick or control wheel
- 60 lb (26.7 daN) for temporary application on a stick
- 75 lb (33.4 daN) for temporary application on a control wheel

These control force requirements still apply in EASA Certification Specification 23.143 (Amendment 4)[13], with a change in that the 75 lb force requirement is with two hands on the control wheel, and that for one hand on the control wheel the requirement is reduced to 50 lb (22.2 daN) temporary force application.

In 1991 the US introduced Federal Aviation Regulation[14] (FAR) 23.677(d) (Amendment 23-42) which introduced a requirement on trim runaway which stated:

> *'It must be demonstrated that the aeroplane is safely controllable and that the pilot can perform all the manoeuvres and operations necessary to effect a safe landing following any probable powered trim system runaway that reasonably might be expected in service, allowing for appropriate time delay after pilot recognition of the trim system runaway. The demonstration must be conducted at the critical aeroplane weights and centre of gravity positions.'*

This text was subsequently incorporated into the EASA Certification Specifications for Part 23 when they were first introduced in 2003 and is in CS 23.677 (Amendment 4).

CS 23 (Amendment 4) contains a Flight Test Guide which is referred to as Acceptable Means of Compliance in CS 23 (Amendment 6). The Flight Test Guide contains the following information on 'Temporary Control Forces':

> *'Temporary application, as specified in the table, may be defined as the period of time necessary to perform the necessary pilot motions to relieve the forces, such as trimming or reducing power. The values in the table under 23.143 of CS 23 are maximums. There may be circumstances where a lower force is required for safety.'*

Footnote

13 EASA Certification Specification (CS) 23 (Amendment 4) was issued on 15 July 2015 and applied to Normal, Utility, Aerobatic and Commuter Category Aeroplanes. The current CS 23 (Amendment 6) was issued on 27 February 2023 and contains CS 23.2135 on Controllability which cross refers to CS 23.143 (Amendment 4) as Acceptable Means of Compliance. The UK CAA adopted all the EASA Certification Specifications on EU Exit Day and CS 23 (Amendment 6) was adopted on 20 December 2023.

14 The full regulation title is Title 14 CFR Part 23 – Airworthiness Standards: Normal Category Airplanes.

Part 139 of the Flight Test Guide states that '*For a system in which the fault analysis indicates a single failure will cause a runaway, flight test should be conducted*.' It states that appropriate pilot recognition times are 1 second for takeoff, approach and landing, and 3 seconds for climb, cruise, and descent. It states that a '*Disconnect Switch*' is:

> *'A switch which is located within immediate reach and readily accessible to the pilot, which has the primary purpose of stopping all movement of the electric trim system. A circuit breaker is not considered to be a disconnect switch.'*

It states that the reaction times previously mentioned should be applied prior to corrective action with the primary flight controls, and that an additional appropriate reaction time should be added to disconnect the system. And that when there are other switches in the vicinity, a time increment should also be added for identifying the switch. Appropriate reaction times for these are not provided in the Flight Test Guide.

Muscular force that can be applied to flight controls

In 2019 a report was published on '*Evaluation of Muscular Forces that can be Applied to Flight Controls*'.[15] The study involved 300 participants, including males and females, pilots and non-pilots and different age ranges. A cockpit seating mockup was constructed (Figure 23) to measure the control forces that could be applied to a control yoke, stick and rudder pedals. Both prolonged and temporary application of control forces were measured. For temporary application a time period of 3 seconds was used. The results were then compared to the certification requirements.

The results showed that 68% of participants could not pull and hold 50 lb (22.2 daN) for 3 seconds with one hand on the control yoke. And 56% of participants could not pull and hold 75 lb (33.4 daN) for 3 seconds with both hands on the control yoke. There was a small difference between pilots and non-pilots and a large difference between male and female participants. More than 90% of female participants could not hold 50 lb (22.2 daN) for 3 seconds with one hand, and more than 70% of female participants could not hold 75 lb (33.4 daN) for 3 seconds with both hands. For male pilot participants 34% could not hold 50 lb (22.2 daN) for 3 seconds with one hand, and 25% of male pilot participants could not hold 75 lb (33.4 daN) with both hands.

Footnote

[15] Beringer, D.B. and Joslin R.E. (2019) 'Evaluation of Muscular Forces that can be Applied to Flight Controls'. *Proceedings of the Human Factors and Ergonomics Society 2019 Annual Meeting*. Abstract at https://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2010s/2019/201905 [accessed 13 June 2025].

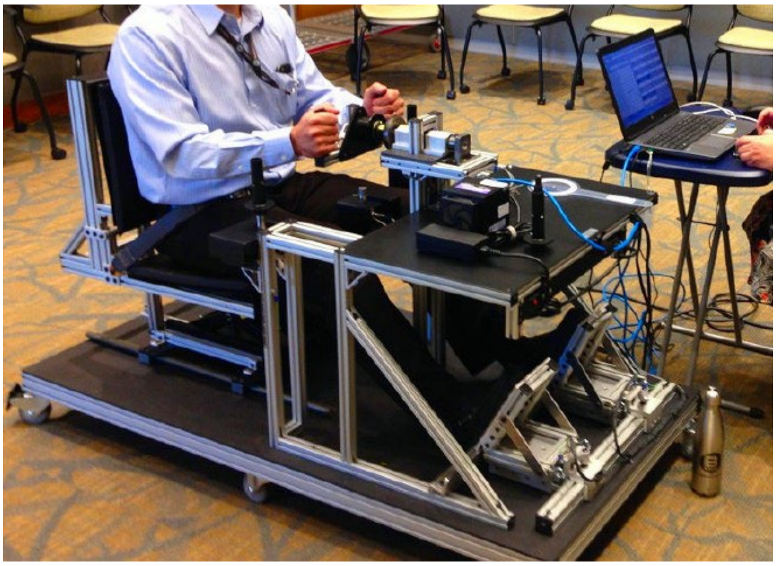

Figure 23

Muscular force measurement apparatus
(Copyright Beringer, D.B. and Joslin R.E.)

The report recommends that the force values in the regulations and in advisory guidance are re-evaluated in light of the study findings and other studies with similar findings. It states that: '*A prudent approach would be to adopt lower values that are both consistent with measured human performance and with policy determining what percentage of the pilot population should be accommodated by the subsequently determined revised reference values.*'

According to the Federal Aviation Administration (FAA), the pilot force work is being progressed as part of a series of changes called TACAM (Transport Airplane Certification Modernization).

Other information

Tests carried out on a PA-23-250 fitted with an Altimatic IIIB autopilot

Some ground tests were carried out on a PA-23-250 that was fitted with an Altimatic IIIB autopilot. The electric trim switch operated the trim and pulling the electric trim circuit breaker caused the trim to stop moving. Pulling the autopilot circuit breaker did not prevent the trim switch from operating the trim. When the autopilot was engaged pressing the trim switch did not cause it to disengage.

Pitch servo clutch forces

The type of pitch servo fitted to G-BKJW (p/n 1C508-4-184P) was required to have a clutch setting of 17 ±3 lb when installed in a Piper PA-23 (equivalent to a torque of 17 ±3 in-lb). This is the force that the pilot must apply at the capstan to override the autopilot's commands to the pitch servo; once this force is exceeded the clutch inside the capstan slips and the pilot has full control of the stabilator.

An autopilot repair organisation in the US that services these type of servos stated that their repair records for the previous two years showed that 25 servos out of 107 servos had a breakaway torque in excess of 20 in-lb which (equivalent to a force of 20 lb). And six servos had a breakaway torque in excess of 100 in-lb. The organisation stated that it was doubtful a pilot could override a servo with that type of torque. They stated that factors that can cause the clutch to bind are: age, corrosion, contamination from oil and dirt, and when the clutch has not been over-ridden in a long time. The Altimatic IIIB Operating Instructions state that the ability to override the clutch should be checked prior to each flight[16].

Trim disconnect switch on the control yoke

The Operating Instructions for the later model Altimatic IIIB-1 show an electric trim ON/OFF switch fitted to the control yoke on the Piper PA-31-350 model aircraft (Figure 24). It also shows a different type of electric trim switch fitted to the PA-23-250 that incorporates an autopilot disengage switch that must be pressed before the trim switch operates.

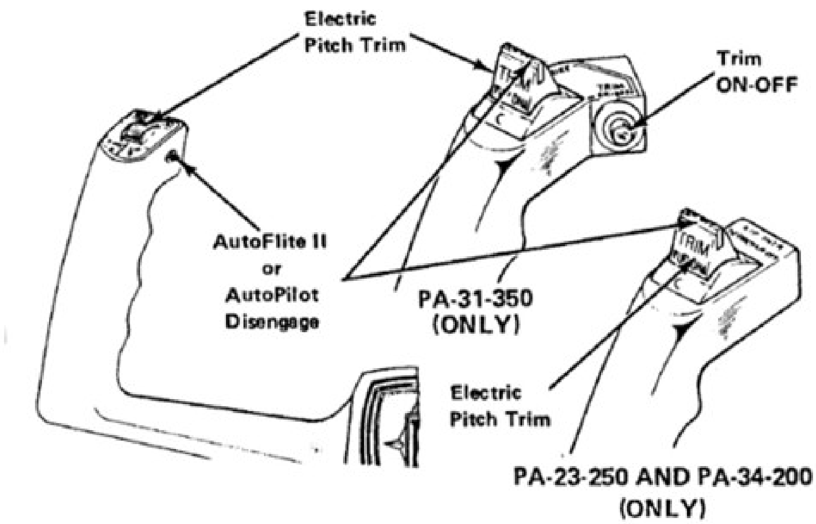

Figure 24

Electric trim ON/OFF switch fitted to Piper PA-31-350

The PA-31-350 (Navajo Chieftain) was first certified in 1972. The aircraft manufacturer could not find records to reveal the reason why an electric trim switch was added to the control yoke on this aircraft type. The PA-31 also had the circuit breaker panel located on the pilot's left side.

A PA-23-250 with an Altimatic IIIC autopilot system was found that had an electric trim disconnect switch below the autopilot console, next to the battery master switch.

Footnote

[16] A paper copy of the Operating Instructions for the later model Altimatic IIIB-1 autopilot was found within the G-BKJW wreckage. It contained the same statement that 'The override should be checked prior to each flight'.

Study on automation failures including pitch trim runaway

In 1997 the FAA published a research paper on *'Automation in General Aviation: Two Studies of Pilot Responses to Autopilot Malfunctions'*[17]. In this study the responses of general aviation pilots to a number of different autopilot malfunctions were examined. The FAA's Advanced General Aviation Research Simulator, configured as a Piper PA-46 Malibu, was used with a Bendix/King KFC-150 autopilot. The study involved 24 pilots who were instrument rated, had experience with complex aircraft and autopilot systems, and all had more than 300 hours flight experience. One of the malfunctions evaluated was a pitch trim runaway in the nose-down direction with the autopilot engaged. Only pulling the pitch trim circuit breaker would correct the problem. The time to detect a malfunction and initiate an initial action, such as using autopilot disconnect, control wheel steering, panel-mounted autopilot engage switch or circuit breaker was measured, as was the time between the initial action and pulling the pitch trim circuit breaker. The average time to initial action was 12.2 seconds (median of 6.14 seconds). The subsequent time to pulling the pitch trim circuit breaker averaged 36.4 seconds (median 16.1 seconds). 13 of the 24 pilots encountered 'flight-terminating circumstances', where the simulator was deliberately frozen. This was done when high descent rates persisted within 100 feet of the ground or overspeed conditions were reached.

In the *'Post-test Questionnaire/Interview'* section, the paper stated:

> *'When asked to report on the difficulty or ease of diagnosing and recovering from autopilot failures experienced during their experimental session, our subjects unanimously agreed that runaway pitch trim was the most difficult from which to recover.'*

The paper cited two accidents where the elevator trim was found in the full nose-down position and a pitch trim runaway was implicated, one involving a twin-engined aircraft and one involving a Beechcraft Bonanza. In the case of the Bonanza it was determined that 45 lb (20 daN) of force would have been required to maintain level flight.

Other accidents and incidents involving pitch trim runaway

In 2019 the AAIB published a report on an accident to a Piper PA-31 Navajo (N250AC)[18], where fire damage and limited recorded information made it difficult to determine the cause of the accident, but a possible scenario was a pitch trim runaway. The aircraft struck the runway at Caernarfon Airport with landing gear and flaps retracted, at high speed, and with no noticeable flare manoeuvre. The pilot had reported over the radio having pitch control problems and the elevator trim was found close to the full nose-down trim position.

Footnote

17 Beringer, D.B. and Howard H.C. (1997) 'Automation in General Aviation: Two Studies of Pilot Responses to Autopilot Malfunctions'. Civil Aeromedical Institute, Federal Aviation Administration. DOT/FAA/AM-97/24. https://www.faa.gov/sites/faa.gov/files/data_research/research/med_humanfacs/oamtechreports/AM97-24.pdf [accessed 13 June 2025].

18 AAIB Bulletin: 3/2019 on accident to Piper PA-31, N250AC, on 6 September 2017. https://www.gov.uk/aaib-reports/aaib-investigation-to-piper-pa-31-n250ac [accessed 13 June 2025].

In another case, the AAIB spoke to an instructor who had experienced a pitch trim runaway on a PA-23-250 Aztec many years ago. He could not recall many details but he reported that the aircraft started pitching up during departure. He recalled that the control loads to push and bring it back under control were very heavy. On this model he recalled there being a disconnect switch on the control yoke that he used to stop the trim. He stated that an alternative would have been to turn off the electrical master switch which is within close reach.

In addition, the AAIB spoke to an aircraft engineer, who was also a pilot, who had experienced a pitch trim runaway in a PA-23-250 Aztec about 20 years ago. He was conducting an air test following maintenance work when at about 3,000 ft he engaged the autopilot and the aircraft "suddenly went into a nose-dive". He noticed the trim handle going round and instantly pulled back on the controls. He had an observer in the right seat who assisted with pulling on the control yoke. There was no trim disconnect switch on the control yoke and he could not recall if there was an autopilot disconnect switch on the yoke. His observer was trying to locate the electric trim circuit breaker, but in the meantime the pilot decided to switch off the electrical master switch. This stopped the trim runaway and he was able to re-trim and regain control. They levelled out at about 2,200 ft after having lost about 800 ft. They then pulled the electric trim circuit breaker and turned the master switch back on. He could not recall the cause of the fault, but thought it was an Altimatic III autopilot that was fitted.

There are more PA-23-250 aircraft operating in the US than in the UK, so the National Transportation Safety Board's (NTSB) accident database was searched to try and identify any pitch trim runaway accidents. One report[19] detailed a fatal accident involving a rapid descent which destroyed the aircraft. The pitch trim was found in the full nose-down position, but the cables were fractured. It had an Altimatic IIIB autopilot but no autopilot system components were recovered. The aircraft owner had reported that the electric pitch trim switch was either inoperative or intermittent. The probable cause was stated as '*in-flight loss of control for undetermined reasons resulting in the in-flight collision with terrain*.'

Another NTSB report[20] about a fatal PA-23-250 accident describes the pilot requesting a return to land after takeoff. On downwind the aircraft was seen to descend below surrounding terrain in a wings-level attitude. The pitch trim was found in the full nose-down position. No further details on what might have caused the pitch trim to be found in that position are in the report, but the probable cause was stated as '*The pilot's inability to maintain aircraft control due to a full nose-down trim condition, which resulted in a loss of control and collision with terrain*.'

Footnote

[19] NTSB Aviation Investigation Report. Accident Number: MIA02FA079. https://data.ntsb.gov/carol-repgen/api/Aviation/ReportMain/GenerateNewestReport/54467/pdf [accessed 16 June 2025].

[20] NTSB Aviation Investigation Report. Accident Number: NYC96FA073. https://data.ntsb.gov/carol-repgen/api/Aviation/ReportMain/GenerateNewestReport/39082/pdf [accessed 16 June 2025].

Incidents involving flap retraction

The NTSB's accident database was also searched for any incidents or accidents involving the PA-23-250 with an uncommanded symmetric flap retraction, but none were found. The FAA's Service Difficulty Reporting System database was also searched and there was one report of an event involving a PA-23-250 where the '*actuator rod end fell off during approach causing the flaps to retract*', but it stated that the landing was completed without incident. The extent to which the flaps had been extended was not reported and no details on the failure cause were provided.

Circuit breaker identification

Some aircraft owners fit coloured caps or collars to autopilot and trim circuit breakers to make them easier and quicker to identify in an emergency (Figure 25). A coloured circuit breaker cap can be purchased from aviation suppliers for less than £4.

Figure 25

Coloured circuit breakers caps/collars on a Cirrus SR20 (left) and a Cessna 210 (right)

When the AAIB examined a PA-23-250 that was fitted with an Altimatic IIIB autopilot, it was noticed that the electric trim circuit breaker was fitted with a cloth lanyard (Figure 26). This would have enabled the circuit breaker to be easier to identify and easier to pull. This aircraft had not flown since a change of ownership, and despite a few attempts to contact the previous owner, no contact could be made so the reason they decided to install the lanyard could not be established.

Figure 26

Lanyard found installed on the electric trim circuit breaker of a PA-23-250

There are no requirements to fit such devices to general aviation aircraft.

Coloured circuit breaker caps are required to be installed on the stick shaker circuit breakers of Boeing 737 MAX aircraft following two fatal accidents involving the aircraft type and its Manoeuvring Characteristics Augmentation System (MCAS)[21].

Requirements to deactivate defective equipment

The autopilot on G-BKJW was placarded INOP, but the autopilot circuit breaker had not been pulled or locked out. Pulling a circuit breaker on inoperative or malfunctioning equipment can prevent its inadvertent use, while locking the circuit breaker can help prevent deliberate use. An inexpensive method of locking a circuit breaker is to pull it out and fit a plastic tie wrap around its narrowest part. Discussions with some UK-based avionics shops revealed that some might pull and lock the circuit breaker but that there was no requirement to do so. Discussions with a US-based avionics shop revealed that they considered it a requirement to pull and lock a circuit breaker on inoperative equipment. They cited US Federal Aviation Regulation 91.213[22] on *'Inoperative instruments and equipment'* which states:

> *'(3) The inoperative instruments and equipment are-*
>
> *(i) Removed from the aircraft, the cockpit control placarded, and the maintenance recorded in accordance with § 43.9 of this chapter; or*
>
> *(ii) Deactivated and placarded "Inoperative". If deactivation of the inoperative instrument or equipment involves maintenance, it must be accomplished and recorded in accordance with part 43 of this chapter;'*

Footnote

[21] CAA Airworthiness Directive G-2021-0001 R1 on Boeing 737-8 and 737-9 aeroplanes. G-2021-0001 R1: Boeing 737-8 MAX and 737-9 MAX: Return to Service | Civil Aviation Authority [accessed 13 June 2025].

[22] Title 14 CFR Part 91 – General Operating and Flight Rules. https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-91#91.213 [accessed 13 June 2025].

They interpreted deactivating to include pulling and locking a circuit breaker – placarding alone was not sufficient to meet the requirement. No similar requirement for light aircraft maintenance could be found in any CAA or EASA regulation. However, the CAA's regulation for light aircraft maintenance Part-ML[23] states the following in relation to aircraft defects (section ML.A.403):

> *'(a) Any aircraft defect that seriously endangers the flight safety shall be rectified before further flight.*
>
> *(c) Any aircraft defect that does not seriously hazard flight safety shall be rectified as soon as practicable from the date on which the defect was first identified and within the limits specified in the maintenance data.'*

Trim runaway safety information

Following the AAIB's investigation into the accident involving the Piper PA-31 Navajo (N250AC) that may have been caused by a pitch trim runaway, the CAA published some information on the topic.

In the Summer 2019 edition of *'Clued Up'*, the CAA included an article on *'Trim Runaway*[24]'. It describes a nose-up trim malfunction in a light aircraft after takeoff where the pilot stated that '*the amount of forward pressure needed to maintain control, inconsequential at first, had become exhausting by midfield on the downwind leg*.' He stated that he was lucky he had someone in the right seat who handled the throttles, radio and landing gear, and then also helped on the control yoke.

The article states that the '*problem with electric trim malfunctions is that, as more and more weight suddenly and progressively comes onto the yoke, some pilots will initially be confused while trying to understand what's happening. As the situation quickly worsens, coping with the problem becomes harder by the second – it's an issue that needs immediate action*.'

To see how a pilot would cope they gave a trainee commercial pilot, who was flying straight and level in a simulator, a runaway trim in the nose-up sense. The pilot reacted instinctively by pushing the yoke forwards and then tried to use the trim switch on the yoke to trim nose-down but realised this was having no effect. The pilot then pressed the red 'electric trim disconnect' button on the control yoke. This solved the immediate issue before they then pressed the 'electric trim off' button on the panel and manually retrimmed. The article stated that the event took the '*best part of a minute' to resolve and there was 'a clear 15-20 seconds of "what's going?" confusion*'. It stated that it was a relatively quick response by a pilot undergoing training who had already learned about this type of malfunction.

Footnote

[23] UK Regulation (EU) No 1321/2014 Annex Vb Part-ML Airworthiness requirements for 'Light Aircraft'. https://regulatorylibrary.caa.co.uk/1321-2014/Content/map2/03700_Annex_Vb_Part-ML.htm [accessed 13 June 2025]. 'Light Aircraft' includes aeroplanes of 2,730 kg maximum take-off mass or less that are not in the air operator certificate of an air carrier.

[24] CAA 'Clued Up' Summer 2019. https://www.caa.co.uk/media/xy1off0x/cluedupsummer19.pdf [accessed 13 June 2025].

The article recommends that pilots: '*Prepare for a trim malfunction by thinking through the actions you'd take and practising them for each type you fly*.'

Some of the same information was published in the CAA's CAP1774 *'In Focus Special: Handling a trim runaway'*[25]. It states that: '*In some types it can be essential to know from memory which circuit-breaker to pull to stop the trim motor before the loads become too high. Some owners make the relevant circuit breaker identifiable, to ensure it is easy to locate*.'

The CAA also published a video on their website on 'Handling a trim runaway'[26]. This video and CAP1774 can be found under the 'Safety Topic' 'Trim runaways' on the CAA's website.

Differences training requirements

An MEP rating does not immediately give a pilot the privilege to fly any MEP aircraft. Apart from some exceptions, differences training is required before a pilot can fly another variant of an MEP aircraft. The requirements on differences training are published in the *'UK Aircrew Regulation*[27]*'* parts FCL.700 and FCL.710. It states that '*Pilots shall complete differences training or familiarisation in order to extend their privileges to another variant of aircraft within one class or type rating.*' It also states that the differences training '*shall be entered in the pilots' logbook or equivalent record and signed by the instructor or examiner as appropriate*.'

To work out which MEP variants require differences training requires referring to the *'UK Class & Type Rating Endorsement List – Aeroplanes'*[28]. On page 2 under MEP (land) it states: '*Aircraft within the class rating MEP (land) are not listed individually in this table, unless specific provisions have been established. All aircraft within the same class rating MEP require differences training, unless indicated otherwise in the list*.' The Piper PA-23-250 is not listed in the table which means that differences training is required before you can command it.

The above requirements have not changed since the UK exited the European Union and are the same as those published in EASA Part-FCL[29].

Footnote

[25] CAA CAP1774 'In Focus Special: Handling a trim runaway', published 14 March 2019. https://www.caa.co.uk/publication/download/17249 [accessed 13 June 2025].

[26] CAA Safety Topics, Trim runaways, videos on 'Handling a trim runaway'. https://www.caa.co.uk/general-aviation/safety-topics/trim-runaways/ [accessed 13 June 2025].

[27] UK Aircrew Regulation. UK Regulation (EU) No. 1178/2011, first published 2023, 2nd edition Amendment 1 December 2024. Aircrew UK Reg (EU) No. 1178/2011 [accessed 13 June 2025].

[28] CAA website, UK class and type rating lists. https://www.caa.co.uk/general-aviation/pilot-licences/uk-class-and-type-rating-lists/ and https://www.caa.co.uk/Documents/Download/10032/a1b19b0e-eff0-4762-b689-bb310ce7c99c/12 (Version 3) [accessed 13 June 2025].

[29] European Union Aviation Safety Agency (EASA) Part-FCL 'Easy Access Rules' (August 2020). https://www.easa.europa.eu/sites/default/files/dfu/Easy_Access_Rules_for_Part-FCL-Aug20.pdf [accessed 13 June 2025].

The CAA's website has two pages titled 'Multi engine piston rating for aeroplanes' which both existed prior to the accident. One of them is under the 'Commercial Industry' section of the website[30] and is more detailed and states that '*In order to extend the privileges to another variant of aeroplane within one class or type rating, the pilot must undertake differences or familiarisation training*.' It does not reference the Class & Type Rating Endorsement list. The other page is under the 'General Aviation' section of the website[31] and makes no reference to differences training requirements.

In June 2024 the CAA published a page on their website titled 'Differences Training in Single Pilot Piston Engine Aeroplanes'[32], which included the following sentence: '*For Multi Engine Piston (MEP) Class aeroplanes, differences training with a FI or CRI is always required when converting to another type or variant within the class.*' The page does not refer to the Class & Type Rating Endorsement list which provides for some exceptions.

The AAIB talked to a number of pilots with MEP ratings, of whom some were not aware of the differences training requirement. One MEP examiner thought it was a recommendation rather than a requirement. An MEP pilot who had flown in G-BKJW with the accident pilot was also not aware of the requirement.

Analysis

Background to the flight

The pilot was focussed on gaining a commercial pilot's licence and embarking on a professional flying career. He was self-motivated and his CPL training records suggested he was a competent pilot. In the process of building hours, the pilot had worked with others who provided him with opportunities to fly, although they stated he had not been paid for conducting flights on their behalf. The fact that he had almost completed his CPL training, which included some instrument flying, might have instilled in him the belief that he had the skills required to fly commercially and under IFR conditions, despite not holding the actual licence and ratings required.

From the evidence that is available it is known that the pilot had little experience flying twin-engine aircraft in general, and specifically the PA-23. No records can be found of him receiving any formal instruction on the PA-23, despite differences training being required. It is possible that he was not aware of this requirement, as was found to be the case with other MEP pilots interviewed by the AAIB, including an examiner, and an MEP pilot who had flown with the accident pilot. The information about these requirements could have been clearer on the CAA's website (see safety action 5). In addition, there were no records

Footnote

30 CAA website. 'Multi engine piston rating for aeroplanes'. https://www.caa.co.uk/commercial-industry/pilot-licences/aeroplanes/multi-engine-piston-rating-for-aeroplanes/ [accessed 13 June 2025].

31 CAA website. 'Multi engine piston rating for aeroplanes'. https://www.caa.co.uk/general-aviation/pilot-licences/part-fcl-requirements/ratings/multi-engine-piston-rating-for-aeroplanes/ [accessed 13 June 2025]

32 CAA website. 'Differences Training in Single Pilot Piston Engine Aeroplanes'. https://www.caa.co.uk/general-aviation/pilot-licences/part-fcl-requirements/ratings/differences-training-in-single-pilot-piston-engine-aeroplanes/#:~:text=For%20Multi%20Engine%20Piston%20%28MEP%29%20Class%20aeroplanes%2C%20differences,new%20MEP%20type%20to%20those%20already%20being%20flown [accessed 13 June 2025].

available to identify the extent of any training the pilot might have received, if any, during either his twin-engine rating or CPL training, on managing autopilot or trim failures (see safety actions 4 and 6).

The weather conditions for the flights to and from Ireland, were accurately forecast and it should have been obvious, prior to the pilot's departure from Bagby, that they would have been challenging to operate under VFR. It is considered that the pilot involved did not have the necessary experience or qualifications to be flying under such conditions. This is borne out by the comments of the owner of the airfield at Navan who had been impressed that the pilot had been able to land there in the prevailing conditions. The owner had also been sufficiently concerned that the pilot thought it necessary to text him during the flight back to Bagby to provide reassurance of the weather conditions en route.

Flight profile

During the cruise portion of the final flight the altitude and ground track were steady which could either indicate that the autopilot was being used, or that the pilot was flying accurately. His radio call to Bagby when he had "4 miles to run" was reportedly normal and he stated his plan to join right base for Runway 06. When the aircraft was 4 nm from Bagby, the aircraft was passing through an altitude of about 2,800 ft, and descending at a moderate rate of about 750 ft/min. At this rate of descent, the aircraft would have been left above the circuit altitude of 960 ft. The aircraft's subsequent increase in descent rate reaching 2,000 ft/min over a 30 second period could have been due to the pilot trying to rectify the fact he was too high, but the high rate at such a relatively low altitude could also be indicative of a control problem. Part way through this rapid descent the aircraft started its left turn to join base and passed through the circuit altitude of 960 ft, at a reduced rate of descent, about 17 seconds after completing the turn onto base.

After radar coverage of the aircraft was lost, after it descended below an altitude of about 740 ft, the aircraft was seen in the CCTV video flying in a shallow descent. At this stage the aircraft appeared to be flying under control. The descent subsequently started to steepen as seen in the CCTV at about 18:43:56 hrs (Figure 4). There was then a slight reduction in descent angle starting about 3 seconds later (above pylon 3 in Figure 4), before the descent angle steepened sharply about 2 seconds after that. The descent angle then appeared to steepen almost continuously until ground impact at 18:44:04 hrs. The fact the angle was steepening was evidence that the aircraft was not starting to recover.

The aircraft was wings-level throughout the descent which made issues with roll control or an engine failure very unlikely. The aircraft's airspeed was determined from the CCTV and the reported wind to have been between 94 kt and 130 kt, which was significantly higher than the aircraft's 56 kt stall speed with flaps up for the estimated weight. It could also be seen in the close-up image of the CCTV (Figure 5), that the aircraft's angle of attack[33] was

Footnote

[33] The aircraft angle of attack is the difference between the aircraft's pitch angle and flight path angle. The pitch angle is the angle of the aircraft's longitudinal axis relative to the horizon, while the flight path angle is the angle that the aircraft's centre of gravity is tracking through the air relative to the horizon. When the pitch angle is greater than the flight path angle, the angle of attack is positive. At high angles of attack the wing stalls and in most aircraft types this causes the nose to drop.

low or negative, far away from a stalling angle of attack. No large objects could be seen separating from the aircraft in the CCTV and all major aircraft components were accounted for at the accident site.

Wreckage evidence

The post-impact fire destroyed a significant amount of physical evidence, but that which remained contained no identifiable defects that could have caused or contributed to the nose-dive. The aircraft was intact at impact and there were no control cable failures in the pitch system. The flap component failures were considered to be most likely caused when the aircraft struck the ground.

The one anomaly found was the position of the pitch trim drum which was 3 mm from the full nose-down position. The flight trial evidence revealed that this was more nose-down than would be expected for any flap configuration in the speed range determined from the CCTV video. This would indicate that the aircraft had probably had a pitch trim runaway, but the possibility of the trim having moved during the post-impact break-up could not be discounted, therefore other potential theories that could have caused the final nose-dive were also considered.

Possible reasons for the nose-dive

1. Aircraft stalled

A stall was considered but discounted for the aforementioned reasons.

2. Ice on the stabilator

If ice had formed on the stabilator during the cruise this could have led to an aerodynamic stall of the stabilator causing the aircraft to pitch nose-down. The forecast freezing level was between 6,000 ft and 8,000 ft and the aircraft had been flown across the Irish Sea at 7,000 ft, possibly entering cloud where ice could have formed. However, the temperature at Bagby was 19°C and the aircraft had already spent a significant amount of time below the freezing level so ice being present at the time of the nose-dive was considered to be unlikely.

3. Shift in the aircraft's centre of gravity

If cargo moves forwards in an aircraft this can cause the aircraft to pitch nose-down. However, negligible contents were found within the wreckage and the items that the aircraft had reportedly been carrying were of negligible mass, so this theory was considered to be unlikely.

4. Flight control restriction

The cable connecting the stabilator to the pilot's control yoke was intact and the stabilator was free to move up and down. There were no foreign objects found in the tail assembly, or any obvious damage in the tail area to indicate a control jam of the stabilator. This possibility is, however, difficult to discount from physical evidence alone as most of the structure between the tail and the cockpit was destroyed. However, a control restriction would not have caused the aircraft to pitch nose-down, only prevent a recovery, and therefore this theory would not explain the initial nose-dive itself.

5. Pilot incapacitation

The pilot's medical history and post-mortem examination did not reveal any evidence of a natural disease or medical factor which may have caused a medical collapse or physical debilitation, and there was no evidence of carbon monoxide exposure. However, if the pilot had become incapacitated, he could have slumped against the control yoke, causing the aircraft to pitch nose-down. If this had happened, it is likely that this would have introduced a roll input as well, but the CCTV video shows the aircraft descending wings-level. In addition, the slight reduction in the aircraft's descent angle, just prior to the final descent before impact, is considered likely to be the result of an active input on the controls.

6. Deliberate act by the pilot

The AAIB has reported on accidents where there was evidence that the pilot had intentionally flown the aircraft into the ground. There was nothing to suggest it in the pilot's medical history or background. The pilot made a reportedly normal radio call. Therefore, a deliberate act by the pilot causing the nose-dive was considered unlikely.

7. Pilot distraction

The pilot might have been distracted and unintentionally pushed against the control yoke, causing the steep nose-down pitch. The pilot's lap strap was found undone which raised the possibility that he might have been reaching for something. To create the sustained nose-down pitch seen, the yoke would have needed to have been pushed and held forwards, which is unlikely to occur in a distraction event. And as in an incapacitation scenario it is also likely to introduce a roll input which was not seen. Therefore, a distraction leading to an inadvertent flight control input causing the nose-dive was considered unlikely.

8. Sudden uncommanded flap retraction

If a failure had caused the flaps to retract suddenly, then the aircraft would have pitched nose-down. The instructor who had flown this scenario reported that the aircraft pitched nose-down to -50° and rapidly lost 500 ft when the flaps were retracted from full. It also reportedly reached -30° nose-down pitch when the flaps were retracted from half. The flight trial had aimed to replicate these findings, but it did not see such steep nose-down attitudes; however, the aircraft was not configured or flown in the same manner, and the test with a retraction from full flap was aborted due to concerns about reaching negative g.

The examination of the flap components indicated that all the failures were probably the result of the aircraft striking the ground. Another mechanism by which the flaps could have retracted uncommanded was if there had been a hydraulic leak at the flap actuator or in the hose to the actuator. As these components had suffered fire damage, a hydraulic leak could not be ruled out. Following an uncommanded flap retraction the aircraft would still have been controllable, but the degree of height loss would have been dependent on how quickly the pilot reacted to the upset. The slight reduction in descent angle seen in the CCTV video prior to the final descent suggested that the pilot may have already reacted to something, but since the aircraft descent angle did not continue to reduce, the lack of recovery suggests that it was not due to an uncommanded flap retraction.

9. Inadvertent autopilot engagement

If the pilot had inadvertently pressed or knocked the Autopilot/Roll engage switch then this could have caused an unexpected nose-down pitch. For this to occur the Pitch Engage switch would have needed to have been left on from a previous engagement. Pitch excursions are known to occur when the pilot has not centred the autopilot trim indicator prior to engaging the Pitch mode. Such a pitch change could be startling, but the pilot should be able to override the pitch servo input and regain control. However, if the pitch servo clutch had not been checked in a long time, then the force to override the clutch could have been significantly greater than the 9 to 15 lb force specified at the control yoke, making it more difficult to stop the nose-down pitch. The clutch had not been checked during the annual inspection because the autopilot was placarded INOP, and although some pilots were known to have used the autopilot anyway, they were doing so without conducting a pre-flight clutch override check.

As the Autopilot/Roll engage switch is located behind the control wheel, it would seem unlikely that it would be knocked inadvertently. It is similarly unlikely that it would have been selected accidentally as the adjacent switches were also related to the autopilot and there would have been no reason to select them during the approach if flying without the autopilot. In addition, the autopilot nose-down pitch limit is -6° so would not explain the steep nose-down attitude seen in the CCTV video, unless there was a fault with the autopilot which caused it to exceed this limit.

10. A pitch trim runaway event

A pitch trim runaway event, causing the stabilator to move in the aircraft nose-down direction and increasing the control forces required to recover, with either the autopilot on or off, could have been the cause of the nose-down pitch and this theory is discussed in detail in the next section of the report.

Pitch trim runaway

A pitch trim runaway is a situation where the electric trim runs uncommanded, nose-down or nose-up. The pitch trim drum was found to be 3 mm from the full nose-down position, out of a full range travel of 13 mm. Although there might have been some movement of the drum during the post-impact break-up sequence, the finding raised the possibility that a pitch trim runaway had caused or contributed to the nose-dive.

The flight trial evidence revealed that the trim position as-found was more nose-down than would be expected for any flap configuration in the speed range determined from the CCTV video, which would have resulted in the aircraft pitching nose-down unless countered by a pull force on the control yoke. If the flaps had still been up then it would have taken between about 17 and 22 seconds for the electric trim to reach the 'as found' position, resulting in the pilot needing to pull on the control yoke with a high force of about 30 daN (67 lb). This is close to the two-handed temporary application force limit of 33.4 daN (75 lb) that existed at the time of the PA-23-250 certification, and in excess of the current 22.2 daN (50 lb) force limit for one-handed temporary application on a control yoke. However, the report on '*Evaluation of Muscular Forces that can be Applied to Flight Controls*' indicates that the certification figures are not sufficiently conservative: 68% of participants in the study could not pull and hold 22.2 daN (50 lb) for 3 seconds with one hand on the control yoke. Research studies also show that in a pitch trim runaway situation it is likely that the control forces will need to be held far in excess of 3 seconds to diagnose the problem and isolate the trim. In the FAA study on automation failures, the time to pull the pitch trim circuit breaker averaged 36.4 seconds after the initial action in a pitch trim runaway situation.

If the pilot had already selected half-flap, as would be normal on base leg, then the out-of-trim control forces would have been about half as much, 14 to 16 daN (31 to 36 lb). It should have been possible to hold this force for longer, but possibly not long enough to prevent an accident from a low height.

The specified action in the event of a pitch trim runaway on the PA-23-250 was to pull the trim circuit breaker. The more quickly it was pulled the less time the control forces would have to build up. Pulling the circuit breaker requires removing one hand from the control yoke which would have reduced the force the pilot could apply. The test pilot found that it was not possible to hold any control force on the control yoke while simultaneously reaching for and pulling the electric trim circuit breaker. The circuit breaker was also difficult to visually identify. The test pilot considered that it was very unlikely that a pilot in a trim runaway event, under the circumstances described in this accident, would have had sufficient time or capacity to find and pull the electric trim circuit breaker.

If a pitch trim runaway had occurred and was the result of the autopilot being engaged, then disengaging the autopilot could have stopped it. However, the autopilot disengage switch on the control yoke was missing for unknown reasons, so the pilot would have needed to remove his hand from the yoke to disengage the autopilot on the Autopilot Console which would have increased the difficulty in maintaining or regaining control.

Mechanisms that could have caused a pitch trim runaway

If the autopilot had not been engaged, then a pitch trim runaway could have been caused by two independent short circuits in the wiring between the electric trim switch on the control yoke and the pitch trim servo. Wiring insulation deteriorates with age, so it is a possible failure mode, but for two independent short circuits to occur in a short space of time is unlikely. There were reports from two pilots who stated that they used the electric trim after the annual inspection. If one wire had short circuited to live or earth, then activating the trim switch would have caused the electric trim circuit breaker to trip. Therefore, the problem would likely have been detected before a second wire had a chance to short. Another possibility is that the trim switch stuck in the nose-down position after being actuated. This was a known problem with the older type of trim switches fitted to the PA-23 (Figure 13), but not a known problem with the type fitted to G-BKJW; however, this possibility could not be discounted. One of the previous co-owners had experienced an issue with the trim moving further than would be normal so had stopped using it. It is possible that this was an indication of the start of a problem which subsequently worsened.

If the autopilot had been engaged, then a single fault could have caused a pitch trim runaway. The pitch trim sensor (Figure 20) moves mechanically from side to side as the cable tension is varied. If this sensor sticks to one side, then the pitch trim will be commanded to run continuously. Single faults in the autopilot amplifier such as a shorted transistor could also have caused a pitch trim runaway. If any of these faults had caused a trim runaway then there is a pitch trim light that is designed to illuminate just above the Autopilot Console; however, as the autopilot had been placarded INOP, this light had not been tested during the annual inspection, or as part of any known pre-flight checks. Furthermore, the light is low on the instrument panel and is not accompanied by an aural alert so could be missed, especially in a high workload situation.

The final descent manoeuvre

A pitch trim runaway on the PA-23-250 is more likely to occur with the autopilot engaged due to it only needing a single failure. As the pilot was considered more likely to have been hand flying the aircraft during the manoeuvre onto the base leg, the autopilot would have probably been turned off. However, it is possible that the pilot was using the autopilot in the descent just before this. The flight test revealed that a descent rate of 1,200 to 1,300 ft/min could be achieved at the -6° attitude limit. If a trim runaway had occurred during this descent, then it would have been initially masked by the autopilot pitch servo compensating for it and holding the stabilator in the desired position. In this case, once the pitch servo clutch slipped there would be a sudden unexpected nose-down pitch. If the servo clutch force was higher than the required 17 ±3 lb setting (which is possible as it had not been checked), then the duration of masking would have been longer and the nose-down pitch greater. The flight trial revealed that at 130 KIAS with the flaps up, a 5 second nose-down trim input that was held on the controls and then released caused the pitch to reduce suddenly by 5° and the g to reduce to 0.5 g. Longer duration trim inputs were not attempted at this speed due to the fear of going into negative g. At higher speeds, such as those during the final descent (about 168 kt), before the aircraft turned onto base, the effect would have been greater. If the aircraft had gone into negative g, then recovery could also have been made more difficult by the fact the pilot was likely not wearing his lap strap, so could have floated out of his seat.

If a trim runaway had started prior to the turn on to base then the muscular fatigue from having to hold the controls would have been greater by the time the aircraft reached the start of the final nose-dive, than if the trim runaway had started on the base leg. The slight reduction in descent angle (between pylons 3 and 4 in Figure 4), before the descent angle steepens sharply, might indicate a final attempt to pull and recover before muscle fatigue reduced the force that could be applied.

Accidents and incidents involving pitch trim runaway

The search of the NTSB database revealed two fatal PA-23-250 accidents that might have been caused by a pitch trim runaway, although there was insufficient evidence for this to have been determined as the ‘probable cause’. Without recorded data of the control positions, it is difficult to determine pitch trim runaway as the probable cause of an accident, so it is possible that there have been more like it. In recent years the AAIB has investigated one fatal accident where pitch trim runaway was a possible cause (N250AC). However, the AAIB has spoken to two pilots who had separately experienced pitch trim runaways in a PA-23-250. In one of these events the trim runaway was in the nose-down direction, with the aircraft losing 800 feet before it was recovered despite the pilot having the assistance of an observer in the right seat who was also pulling on the controls. Although not in the checklist, the pilot had switched the electrical master switch off which immediately stopped the trim. If he had tried to find and reach for the electric trim circuit breaker the altitude loss would probably have been greater.

Pitch trim runaway summary

As with the aforementioned accidents, there was insufficient evidence to determine that a pitch trim runaway was the cause of the accident to G-BKJW. No physical evidence of a wiring short or autopilot component failure could be identified to prove the theory. However, the position of the pitch trim drum, the steep nose-down pitch, and the results from the flight trial all supported this as a possible cause. Further weight to this theory was provided by research studies and anecdotal reports from pilots who have experienced pitch trim runaways and lost significant height.

Summary of the possible causes considered

There was insufficient evidence to determine a definitive cause of the accident, but in considering the available evidence and possible causes, a pitch trim runaway was the most likely of these.

Maintenance

The wreckage examination did not reveal any defects that could have caused or contributed to the nose-dive. The autopilot disengage switch on the control yoke was found to be missing, and a photograph from October 2020 showed it missing then, but no maintenance record concerning its removal could be found. As the autopilot was placarded INOP it would not have been a requirement to have the autopilot disengage switch installed, so the missing switch did not constitute a defect, although this could have contributed to the accident if the cause was a pitch trim runaway while the autopilot was engaged.

The autopilot should not have been operated as it was placarded INOP, but the AAIB has information from three pilots who said they had done so. If the autopilot circuit breaker had been pulled and locked out with a tie wrap then this would have prevented pilots using the autopilot.

The maintenance engineer who oversaw the aircraft's last annual inspection said the autopilot circuit breaker had not been pulled because he thought it provided power to the intercom, a radio or the electric trim (although it was unlikely to be electric trim as there was a separate circuit breaker for it). The circuit breaker labelled 'Autopilot' was 10 Amp instead of the expected 5 Amp which indicates there may have been a modification for it to power something it was not originally intended to. By doing this it prevents the autopilot being easily isolated without also losing the function of other equipment sharing the same circuit breaker. When considering the importance of the ability to isolate an autopilot when it is placarded inoperative, such modification would seem undesirable. There is no requirement for a circuit breaker to only power one system. However, when an aircraft has a dedicated autopilot circuit breaker this breaker should be pulled and locked if the autopilot is inoperative. If the autopilot is intended to remain inoperative for a prolonged period, then it should be deactivated by other means or removed (see safety action 7). In the US, regulation FAR 91.213 requires that inoperative equipment is deactivated but there is no such equivalent requirement in the UK. However, according to Part ML the autopilot should have been repaired 'as soon as practicable' and yet there was evidence that it had been inoperative since 2012.

Risk of using an autopilot that is placarded inoperative

The AAIB is aware of three pilots who used the autopilot on G-BKJW. One of the owners of the maintenance organisation at Bagby said that while it was INOP he believed the heading function still worked, so there was an awareness that the autopilot was being used. This implied that it may have been considered an acceptable practice. Pilots may not appreciate the risk of using an autopilot that has not undergone any maintenance, such as having the bridle cables, the clutch override, the trim operation, and any pitch trim warning light checked and tested. The autopilot repair organisation in the US had experience of finding six pitch servos with a breakaway torque in excess of 100 in-lb, almost six times the required torque setting of 17 in-lb. The Altimatic IIIB Operating Instructions state that '*approximately nine to fifteen pounds of pressure on the control wheel should override both the roll and pitch functions*'. So, with a torque in excess of 100 in-lb the force at the yoke to override the pitch servo could have been in excess of 88 pounds or 39 daN. If the autopilot started to malfunction in pitch the pilot would need to immediately push or pull with this level of force to regain control and hold it until they had disengaged the autopilot. In addition, with such a high clutch override force a pitch trim runaway, with the autopilot engaged, could be masked until it has reached almost full nose-down trim.

Therefore, pilots should not use autopilots that are placarded INOP.

Differences training

There was no evidence that the accident pilot had undertaken the required differences training before flying G-BKJW. Such training could have potentially assisted him in handling an emergency. The AAIB has talked to a number of pilots with MEP ratings, of whom some were also not aware of the differences training requirement. The information on the CAA's website at the time of the accident about the differences training requirement was not as clear as it could be. Improved information was added in June 2024, but as this was only within a section about SEP differences training it could have been missed by MEP pilots; it also did not refer to the *'UK Class & Type Rating Endorsement List – Aeroplanes'* which a pilot must read to determine if the MEP variant or type they want to fly requires differences training. The CAA intends to update the information on their website to rectify these points (see safety action 5).

Ways to reduce the risk of a pitch trim runaway event

Irrespective of whether the accident to G-BKJW was caused by a pitch trim runaway, the investigation revealed that although occurrences appear to be rare, when they do occur the results can easily be catastrophic, particularly if it occurs at low altitude where there is limited time to respond. The investigation considered that the following measures could help mitigate the risk of a pitch trim runaway event on any aircraft type:

1. *Training for a pitch trim runaway*. There was no evidence that the pilot had received any in-flight training on autopilot or trim runaway failures. Training for such failures in flight and going through the actions, such as pulling circuit breakers, helps to build muscle memory that can be quickly employed in an emergency. Training also helps with faster identification of the cause. The CAA has safety action plans to address such training (see safety actions 1, 2, 3, 4 and 6).
2. *Tagging the autopilot and electric trim circuit breakers*. Some aircraft owners fit coloured caps or collars to autopilot and trim circuit breakers to make them easier to identify in an emergency (Figure 26). Combined with training, colour tagging these circuit breakers would help a pilot more effectively deal with a pitch trim runaway (see safety action 8).
3. *Deactivating inoperative autopilots*. As previously discussed, deactivating inoperative autopilots would prevent pilots from using them (see safety action 7).
4. *Designing aircraft with trim disconnect switches on the control yoke*. Later models of the PA-23-250 have an electric trim switch that incorporates an autopilot disengage switch that must be pressed before the trim switch operates. The Piper PA-31-350 has a trim on-off switch on the control yoke when the Altimatic IIIB-1 is installed. Removing the need to reach for and pull a circuit breaker, particularly if in a difficult to reach location, will improve safety. The current certification requirements on trim runaway in CS 23.677 should help to address this for new aircraft.

5. *Carrying out pre-flight checks of the autopilot*. If an autopilot is fitted, then it is important to carry out the appropriate pre-flight checks. This may include: the override clutches, any pitch trim warning light, and checking that the autopilot can be disengaged.

Safety actions

As a result of the findings of this investigation and discussions with the CAA, the CAA has agreed to the following safety actions:

1. The CAA plans to produce a new video/webinar on trim runaways. The video will feature targeted advice on managing trim runaways including mitigations to prevent an occurrence. This action is planned for later in the 2025/2026 financial year. In the interim period, the CAA plans to review their existing website content related to trim runaways and promulgate a reminder to industry through their Skywise communication channels.

2. The CAA aims to produce safety material regarding autopilots in General Aviation aircraft which could include a section on trim runaways. The CAA stated that this could feature autopilots/trim runaway in a wider Safety Sense Leaflet focusing on the various elements of differences training available or this might be addressed through another short form publication such as a Clued Up Article, Aeronautical Information Circular, or Safety Notice. This action is intended to be completed in the 2025/2026 financial year.

3. The CAA plans to develop new guidance material on the dual refresher flight training requirement[34] which will include electric trim. This would only apply if the aircraft being used for the flight training had electric trim fitted. The CAA is also looking to make better use of this training flight by focusing on key safety risks such as unstable approaches, loss of control in flight, controlled flight into terrain and inadvertent entry into IMC.

4. The CAA plans to update '*Standards Document 14 – Guidance for Examiners*[35]' to include reference to failure of the autopilot and electric trim or trim runaways. The CAA noted that this document already includes demonstrating the '*correct procedure for pre-flight functional check of autopilot*'.

Footnote

[34] To renew a Single Engine Piston (SEP) class rating pilots are required to either pass a proficiency check or skills test every two years, or carry out dual refresher flight training with an instructor if they have completed 12 hours of flying in the previous year of the two-year period. To renew a MEP class rating pilots are required to pass a proficiency check or skills test every year.

[35] Standards Document 14, version 7. Guidance for Examiners and Information for Pilots of Single Pilot Aeroplanes. https://www.caa.co.uk/publication/download/12926 [accessed 13 June 2025].

5. The CAA plans to review and update where necessary the pages on their website for both commercial and general aviation pilots in relation to MEP differences training. In addition, the CAA will amend the 'UK class and type rating lists' to set out in clearer terms when pilots moving between specific aeroplanes that come within the MEP class rating require differences training delivered by an appropriately qualified instructor.
6. The CAA is consulting on proposals to amend the guidance material in the UK Aircrew Regulation on differences training that will incorporate specific elements for autopilots and electric trim. For further detail refer to General Aviation Licensing Review CAP 3094[36].
7. The CAA plans to publish a Safety Notice recommending that inoperative autopilots or electric trim systems are deactivated. The CAA will consider future rulemaking to require it if necessary.
8. The CAA will evaluate and consider the potential of a Safety Notice recommending that aircraft owners, operators and maintenance organisations fit coloured caps or other clearly identifying features to autopilot and electric trim circuit breakers to make them easier and quicker to identify and pull in an emergency.

Conclusion

While on base leg to land on Runway 06 at Bagby, the aircraft entered a steep descent. There was a slight reduction in descent angle before the descent angle steepened sharply and the aircraft struck trees and then the ground at an angle of about 35° to 40° nose-down, with no indication that the aircraft was starting to recover. The key findings from the investigation were as follows:

- The pilot made a normal radio call when he was 4 miles from the airfield, indicating that there were probably no significant anomalies at this stage of the flight.
- The CCTV video showed a wings-level steep descent, indicating there were probably no issues with maintaining roll control.
- The airspeed determined from the CCTV, and an analysis of the flightpath and pitch angles, indicated that the aircraft had not stalled.
- The physical evidence showed that there were no control cable failures in the pitch control system, there was no in-flight break-up and the pitch trim position was found in the near full nose-down position.
- There was no evidence to suggest pilot incapacitation or a deliberate act.

Footnote

[36] CAA General Aviation Pilot Licensing Review. AMC and GM to the UK Aircrew Regulation. A consultation. CAP 3094. First published March 2025. Chapter 2 refers to 'Differences training'. cap3094-aircrew-ga-licensing-phase3-amc-consultation-march-2025-1.pdf [accessed 13 June 2025].

- A failure resulting in a sudden flap retraction, from half-flap or full flap, can produce a significant nose-down pitch and height loss on earlier model PA-23-250's that are not fitted with a flap-to-trim-tab interconnect system, such as the accident aircraft.
- A pitch trim runaway could have produced control forces in excess of 30 daN (67 lb) which is beyond the force that most people can hold with one hand on the control yoke for more than 3 seconds.
- Studies and anecdotal evidence show that it can take a long time for pilots to react, diagnose and then correctly respond to a pitch trim runaway, resulting in significant height loss.
- A pitch trim runaway on the accident aircraft would have required either disengaging the autopilot using the switch on the panel (as the switch on the yoke was missing) or pulling the electric trim circuit breaker which was difficult to see and reach. Turning the master switch off would also have stopped the trim, but this was not on the checklist for a trim runaway.
- The pilot had not conducted differences training with an instructor on the PA-23-250 and probably was not aware of the requirement to do so.
- There was no evidence that the pilot had received any in-flight training on autopilot or trim failures during his MEP class rating or CPL licence training.
- Pilots had been using the autopilot on the accident aircraft despite it being placarded inoperative and were probably unaware of the risks of doing so.

A number of possible causes for the final nose-dive were considered. Of all the causes reviewed, a pitch trim runaway was considered to be the most likely, but there was insufficient evidence to determine that it was the definitive cause of the accident. The CAA is planning eight safety actions to help reduce the risk of an accident involving a pitch trim runaway.

Published: 26 June 2025.