ACCIDENT

Aircraft Type and Registration:	Piper PA-38-112 Tomahawk, G-BODP
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1981 (Serial no: 38-81A0010)
Date & Time (UTC):	16 August 2012 at 1935 hrs
Location:	Near Bruera, Cheshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 2 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	10,440 hours (estimated) (of which at least 150 were on type) Last 90 days - 135 hours (estimated) Last 28 days - 45 hours (estimated)
Information Source:	AAIB Field Investigation

Synopsis

The instructor and student were conducting PPL training for slow flight aircraft handling. At an estimated height of between 2,000 and 3,000 ft, the aircraft turned rapidly through about 180° and descended at a high rate, crashing in a field. The evidence indicated that the aircraft had been in a spin to the left when it struck the surface. Both occupants were fatally injured.

A manufacturer's revision to the Pilot's Operating Handbook (POH), dated May 2012, included advice on the altitudes at which slow flight and stall manoeuvres should be initiated, to provide an adequate margin of safety in the event of an inadvertent spin. This revision, which related to a Safety Recommendation made by the United States of America's National Transportation Safety Board (NTSB) in 1997, reached the flying school in the month following the accident.

History of the flight

The aircraft was on its sixth training flight of the day from Hawarden Airport, with an instructor and student on board. The instructor had operated three of the earlier flights and another instructor had flown the aircraft on the other two, including its penultimate flight. This other instructor had noted no defects on the aircraft, which had been refuelled to full tanks two flying hours prior to the last flight.

The instructor taking over the aircraft, for the last flight, had signed its technical log, noting that the flight was for Exercise 10a (slow flight) and that the remaining fuel was 69 litres. This fuel should have been sufficient for a planned flight of one hour, with reserves of between one and two hours.

The aircraft took off at 1906 hrs and, remaining on the Hawarden Tower radio frequency, the instructor arranged a Basic Service with the Air Traffic Control Officer (ATCO). At 1909 hrs, the instructor requested to operate "NOT ABOVE 4,500 FT." The ATCO responded, "NO ALTITUDE RESTRICTION, REMAIN OUTSIDE CONTROLLED AIRSPACE". This was acknowledged by the instructor. There were no reports of any further radio transmissions by the crew, on this or any other frequency. It was usual for the instructor to land 15 minutes before the airfield closed, to leave sufficient time for a second approach should that become necessary. That evening, Hawarden Airport was scheduled to close at 2000 hrs.

The aircraft initially departed to the south, passing over Wrexham, before routing north-east. No other traffic was reported to be in the area and, although a Basic Service placed no requirement on ATC to monitor the position of the aircraft, the ATCO occasionally confirmed G-BODP's position by referring to the radar display located in the ATC tower.

At 1934 hrs, the ATCO noticed that the aircraft was no longer generating a radar return and attempted to contact the aircraft on both the Approach and the Tower radio frequencies. Concerned by the lack of a reply, Hawarden ATC commenced overdue action and requested that a Police Air Support Unit helicopter search the aircraft's last known position. Shortly after this, the emergency services received phone calls reporting that, at about 1935 hrs, an aircraft had crashed near the village of Bruera.

All three emergency services attended the accident site and discovered that both occupants of the aircraft had been fatally injured.

Witnesses

Three eyewitnesses near Bruera saw parts of what were believed to be the last moments of the flight.

Eyewitness A was driving an agricultural vehicle about 0.75 nm south of the accident site. He had seen an aircraft but, as this was a common sight, had not paid it any particular attention. A minute or two later, he noticed a "cigar shape" which he assumed was an aircraft in a steep descent; he later thought that it might have been turning. The aircraft was only in sight for about two seconds before the witnesses's view was blocked by trees and hedges. He was unable to locate the aircraft again when his view became clear about one minute later.

Eyewitness B was to the north of the accident site, driving a car southbound on Chapel Lane, between 0.55 and 0.25 nm from the accident site. He saw an aircraft descending "vertically", nose down, at a height of a few hundred feet but only had the aircraft in sight for a total of two to three seconds. He stated that he saw a steady red light in the centre of the aircraft during its descent and, as such, did not believe the aircraft had been rotating. He continued driving south, looking in the general direction of where he had last seen the aircraft, and saw an aircraft's vertical fin in a field of crop. He reached the aircraft within a few minutes of the accident but it was apparent to him that both occupants had received fatal injuries.

Eyewitness C was in a field 0.65 nm north of the accident site. She had been aware of an aircraft operating in the local area but had no reason to pay particular attention to it and was unconcerned. A movement then attracted her attention and she looked up to see an aircraft in a steep “vertical” descent. She watched the aircraft for about six seconds until it went out of sight behind some trees. She then heard a loud noise and noticed roosting birds take flight. This witness had not heard any aircraft noise during its descent and described the aircraft’s attitude as being nose down. She also recalled seeing an item or object falling at the same speed as the aircraft, displaced (from her perspective) to the right. This object was described as white with a red or orange top.

Weight and balance

Allowing for fuel burnt during start, taxi and the 30 minutes of flight before the accident, the aircraft was calculated to have been below its Maximum Take Off Mass (MTOM) at the time of the accident. The aircraft’s centre of gravity was calculated as being in the middle of the allowable range throughout the flight.

Wreckage and impact information

The wreckage was located in a wheat field, in which the crop was approximately 80 cm high. The wings were still attached to the fuselage and were largely intact. All the main parts of the aircraft were present and all of the wreckage was located within a few metres of the fuselage or wings. It was concluded that the aircraft had struck the ground intact at low forward speed, with a high rate of descent. There was no evidence of a fire.

Approximately a third of the engine was embedded below the surface, in soft ground, inclined approximately 45° nose down and about 20° left wing low. When the engine was removed from the ground, both propeller blades were still attached. There was little evidence (such as chord-wise scoring, leading edge notches or the tips being bent forward) of the propeller being under power when it struck the ground.

Both the fuel tanks in the wings had ruptured and no fuel was found in either of the two tanks. However, when the engine was lifted, there was a significant pool of fuel approximately 30 cm below ground level, underneath where the engine had been situated, which was considered to have drained from one or both of the wing tanks.

The left main landing gear leg had detached and was lying next to the left wing. Approximately one metre ahead of the left wing there was a linear ground mark, which was consistent with the leading edge of the left wing striking the ground before rebounding. The wheel on the right main landing gear leg was embedded in the ground and there was little evidence of any forward motion. There was a vertical 20 cm deep hole in the ground, below the right aileron mass balance, which itself had earth marks covering 20 cm of its length.

It was concluded that the aircraft had struck the ground in a nose down, left wing low attitude, with the left wing striking the ground before the right wing. The right main landing gear and the right wingtip then probably struck the ground more or less vertically. From the small wreckage area, the relatively modest damage, the asymmetric damage to the wings and main landing gear legs, and the aircraft’s attitude when it struck the ground, it was concluded that the aircraft was probably in a spin to the left on impact with the surface.

Meteorology

The UK Met Office provided an aftercast for the accident area. Additionally, Aircraft Meteorological Data Relay (AMDAR) wind information was obtained from two aircraft that had departed from Liverpool Airport that evening (see Tables 1 and 2). Although the AMDAR information was from positions no closer than 10 nm to the accident site and was not precisely at the time of the accident, it did provide a vertical cross-section through the air mass, which helped to develop a model of the likely wind conditions.

The Met Office estimated that, at the time of the accident, the wind at 2,000 ft was from 200° at 25 to 30 kt. Generally, visibility was assessed as having been in excess of 20 km, with the cloud base no lower than 5,000 ft. However, an approaching front meant that the cloud base was lowering towards an altitude of between 2,500 and 3,000 ft amsl. At 1920 hrs, Hawarden reported a surface wind of 140°/6 kt, greater than 10 km visibility and few (1 to 2 octas) clouds at 3,000 ft.

Altitude in Feet AMSL	Wind direction / speed
898	163°/20 kt
1,601	174°/24 kt
2,099	172°/23 kt
2,500	185°/25 kt

Table 1

AMDAR information reported near Liverpool Airport at 1721 hrs

Altitude in Feet AMSL	Wind direction / speed
1,099	174°/24 kt
1,699	172°/23 kt
2,201	185°/25 kt
2,700	189°/23 kt

Table 2

AMDAR information reported near Liverpool Airport at 2044 hrs

Pilot information

Instructor

The instructor started flying in 1987. He held a Commercial Pilot's Licence (Aeroplanes) (CPL(A)) which was valid until August 2014. His CPL included a Flying Instructor rating, restricted to single-pilot, single-engine aircraft, in accordance with Joint Aviation Regulation-Flight Crew Licensing (JAR-FCL) part 1.330. He was not permitted to instruct aerobatics or at night. His Flight Instructor rating was renewed by flight test in February 2012 and was valid until March 2015.

A logbook (marked '9') was held at the flying school. It commenced on 15 October 2008 and was completed up until 5 May 2012. Other logbooks were not located. Flying school colleagues believed that the pilot's flying career had been entirely on single engine piston aircraft. Logbook '9' noted a total of 10,330 hours and included about 150 hours on the PA-38. There were no references in this logbook to spinning.

The investigation was informed by former students that the instructor had previously worked for at least one other school equipped with a PA-38, so his experience on type is believed to have been in excess of the 150 hours recorded in logbook '9'. He commenced flying for the Hawarden based school in December 2011, flying both the PA-38 and PA-28. The flying school calculated that the instructor flew an average of about 45 hours per month during the summer. It was, therefore, estimated that his total hours were slightly in excess of 10,400 hours.

Student

The student pilot had completed an air experience flight in March 2011 and commenced training for his Private Pilot's Licence (Aeroplanes) (PPL)(A) in May 2012. All his training flights had been in the PA-38, with the same instructor, and the accident occurred on his eighth flight. The student's training records showed consistent progress and the record for his flight on 27 June 2012 stated *'Very good. Exercise completed, Exercise 10A next.'* The student's logbook included details of a flight on 11 July 2012. The remarks column, signed by the instructor, noted the training conducted as exercises *'10a & 10b'* but there was no corresponding entry in the student's training records to amplify this information.

The student had seven hours total flying experience and had just had a five-week break from flying.

Medical

The instructor held a current JAA Class 1 medical certificate.

Post-mortem examinations were conducted by a specialist aviation pathologist. He commented that there was no evidence in either occupant of any natural disease and no compelling evidence for any other medical factors which could have had a bearing on the cause of the accident. The accident was considered to be non-survivable.

Recorded information

Radar data for the accident aircraft was available from three radar heads; Clee Hill, St Annes and Manchester. Each radar head had recorded a combination of primary and secondary returns. However, the secondary returns were Mode A only; hence no altitude information was available. The coverage for each radar head differed, due to their different locations and the elevation of the terrain between the radar head and the aircraft. The first radar contact for the flight was at 1906:35 hrs (Clee Hill), placing the aircraft over the departure end of Runway 22 at Hawarden Airport.

The first radar head which lost contact was St Annes, at 1933:34 hrs, as the aircraft was tracking south-west. Manchester radar head lost contact at 1933:40 hrs and, finally, Clee Hill's last recorded contact was at 1933:46 hrs, over the field where the aircraft crashed.

Clee Hill's radar track for the last eleven minutes of the flight is presented at Figure 1; the time between consecutive points (radar returns) is eight seconds. Figure 2 plots the variation in calculated groundspeed (both point-to-point and five-point average) and the

Figure 1

Clee Hill radar track for the last eleven minutes of the flight

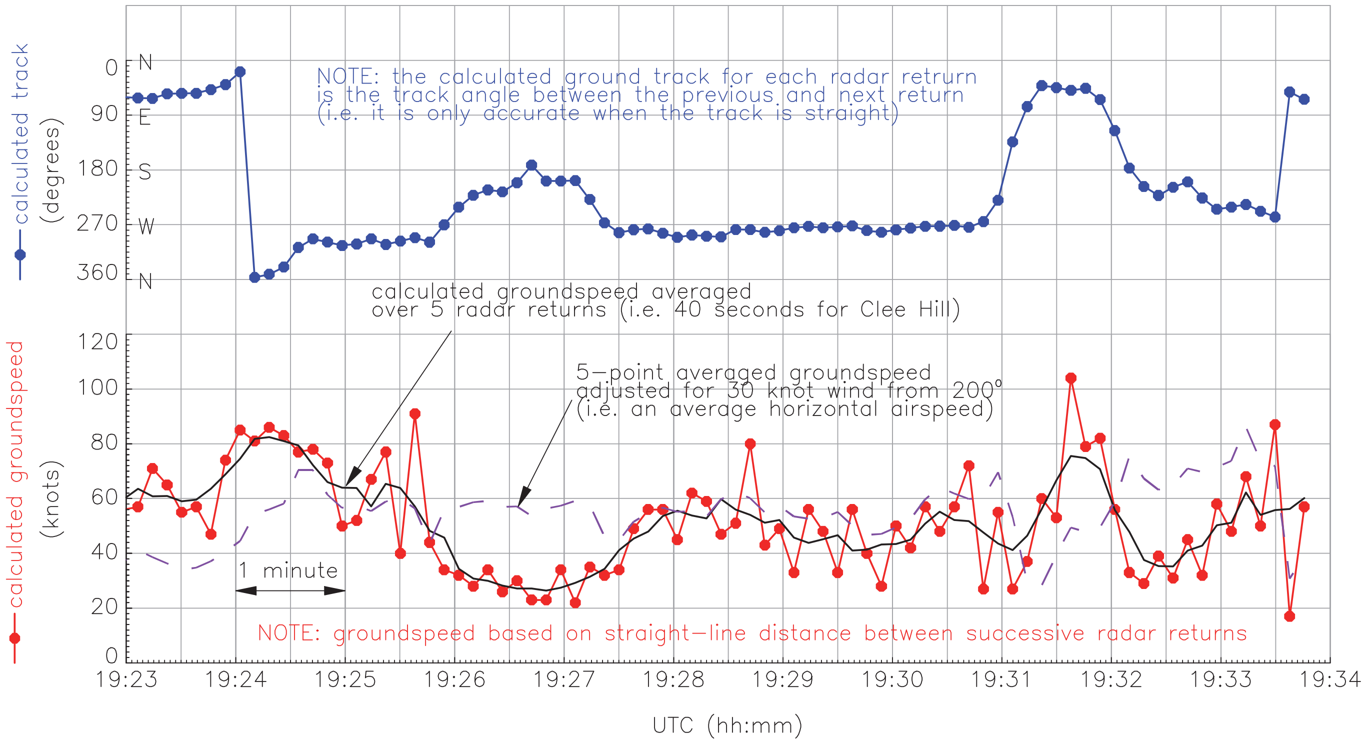

Figure 2

Variation in groundspeed and track for the last eleven minutes of the flight (Clee Hill radar)

corresponding aircraft track for this final portion of the flight. Figure 2 also includes a plot of the estimated horizontal component of the aircraft's airspeed, based on the five-point average groundspeed, corrected for a nominal wind of 200°/30 kt.

Slow speed flight

The five-point averaged groundspeed, adjusted for a 30 kt wind from 200º, gave airspeeds of between about 35 and 90 kt. Given the lack of altitude information, a more accurate wind correction could not be made. Additionally, a vertical speed component could not be included because it was not known whether the aircraft was climbing, descending or flying level. Consequently, the range of airspeeds are more an indication of a variation between slow and cruise airspeeds, rather than specific, accurate values.

As an example, in Figure 2 between 1926 hrs and 1927 hrs, when the calculated average groundspeed was about 30 kt, the aircraft was tracking about 200º ie into the nominal wind. In Figure 1, this corresponds to the section of the aircraft's track in the Manchester CTA where the radar returns appear to be overlapping and the aircraft turned 90º to the left, onto a south-south-westerly track, and then turned right onto a westerly track. Adjusting for a 30 kt wind from 200º gave an airspeed of approximately 60 kt.

Final radar contact

The last two returns from Clee Hill indicate that the aircraft had altered course, through 180º, onto a north-easterly track. The radar data suggests that this track reversal happened between two returns (ie over 8 seconds). However, inaccuracies in the radar data (illustrated in the point-to-point groundspeeds in Figure 2) precluded any further meaningful numerical analysis of the track reversal.

The aircraft's average groundspeed during the 40 seconds preceding this track reversal was about 60 kt and increasing. This equated to an airspeed of 70 kt and above.

Aircraft height

Radar contact is reliant on line-of-sight between the radar head and the target aircraft. Line-of-sight can be interrupted by intervening structures or terrain and it was possible to model, theoretically, the lowest altitude of the radar coverage at a particular point over the ground, for each radar head. The radars at St Annes and Manchester could, in the area surrounding the accident site, track aircraft down to an altitude of between 600 and 700 ft amsl (about 520 to 620 ft agl). Whereas, the Clee Hill radar coverage extended down to between 200 and 300 ft amsl (about 120 to 220 ft agl).

The entire flight was well within the range of each radar head, so it was assumed that radar contact was lost when the aircraft descended below the base of the relevant radar's coverage. Accordingly, between the last Manchester radar head return at 1933:40 hrs and 1933:44 hrs, when the next contact should have been made, the aircraft descended below approximately 600 ft amsl (520 ft agl). Similarly, for the Clee Hill radar (which has a sweep rate of eight seconds) between 1933:46 hrs (the last contact) and 1933:54 hrs, the aircraft descended below about 200 ft amsl (120 ft agl). This would have required a rate of descent of between 1,300 and 5,000 ft/min.

Airspace

Relevant controlled airspace, shown on Figure 1, comprised Airway N864 and the Manchester Control Area (CTA), both of which required ATC's permission for entry. The base of N864 was at 3,000 ft amsl and the base of the Manchester CTA was at 2,500 ft. Hawarden Airport is located 5 nm west-north-west of the accident site and the Hawarden Air Traffic Zone is beneath Airway N864. There was no evidence that the aircraft entered either areas.

Aircraft information

The PA-38 Tomahawk is a two-seat training aircraft of conventional aluminium alloy construction. It has a single engine and a fuel tank in each wing. It has conventional flying controls, consisting of ailerons, rudder, elevator and flaps.

The Pilot's Operating Handbook (POH) lists the stalling speed for a PA-38, with flaps up, (with both outboard and inboard flow strips installed) as 52 kt.

In the event of an engine failure, the speed to be flown is 70 kt.

Section 4 of the POH:

> *'describes the recommended procedures for the conduct of normal operations for the Tomahawk.'*

It states that a one turn spin would:

> *'require 1,000 to 1,500 feet to complete'*

and that normal spin recovery, using the proper technique;

> *'may take up to 1-1/2 turns…Normally the engine will continue to run during a spin, sometimes very slowly. If the engine stops, take normal spin recovery action.'*

Intentional spins:

> *'should only be started at altitudes high enough to recover fully by at least 4,000 feet AGL …'*

The UK CAA supplement to the PA-38 Pilot Operating Handbook states:

'Spin recovery

1. Apply and maintain full rudder opposite the direction of rotation.

2. As the rudder hits the stop, rapidly move the control wheel full forward and be ready to relax the forward pressure as the stall is broken.

3. As rotation stops, centralize the rudder and smoothly recover from the dive.'

It continues with further advice on spinning:

'The recommended procedure has been designed to minimize turns and height loss during recovery. If basic or standard recovery is employed (during which a pause of about 1 second – equivalent to about one half turn of the spin – is introduced between the rudder reaching the stop and moving the control column forward) spin recover will be achieved with equal certainty. However, the time taken for recovery will be delayed by the length of the pause, with corresponding increase in the height lost.

In all spin recoveries the control column should be moved forward briskly, continuing to full forward position if necessary. This is vitally important because the steep spin attitude may inhibit pilots from moving the control column forward positively.

The immediate effect of applying normal recovery controls may be an appreciable steepening of the nose down attitude and an increase in rate of spin rotation. This characteristic indicates that the aircraft is recovering from the spin and it is essential to maintain full anti-spin rudder and to continue to move the control wheel forward and maintain it fully forward until the spin stops. The airplane will recover from any point in a spin in not more than one and one half additional turns after correct application of controls.

Mishandled Recovery

The airplane will recover from mishandled spin entries or recoveries provided the recommended spin recovery procedure is followed. Improper application of the recovery controls can increase the number of turns to recover and the resulting altitude loss.

Delay of more than about 1 ½ turns before moving the control wheel forward may result in the aircraft suddenly entering a very fast, steep spin mode which could disorient a pilot. Recovery will be achieved by briskly moving the control wheel fully forward and holding it there while maintaining full recovery rudder.

If such a spin mode is encountered, the increased rate of rotation may result in the recovery taking more turns than usual after the control column has been moved fully forward.

Dive Out

In most cases spin recovery will occur before the control wheel reaches the fully forward position. The aircraft pitches nose down quickly when the elevator takes effect and, depending on the control column position, it may be necessary to move the column partially back almost immediately to avoid an unnecessarily steep nose down attitude, possibly negative "g" forces and excessive loss of altitude.'

Previous Safety Recommendation

In October 1997 the National Transportation Safety Board (NTSB) issued Safety Recommendation A-97-045. This recommendation was one of five issued following a fatal accident to a PA-38, registration N2495L. The NTSB recommended that the FAA:

> *'...immediately require that the slow flight & stall training in the PA-38-112 be conducted at or above the minimum altitude currently specified in the PA-38-112 pilot's operating handbook for spin training...'*

The FAA agreed that:

> *'...slow flight & stall training in the PA-38-112 should be conducted at or above the minimum altitude specified in the POH. On 8/18/97, the FAA sent a letter to all regional flight standards division managers requesting that they inform all known operators of the PA-38-112 of this recommendation.'*

In May 2012, Revision 14 to the POH was issued by the manufacturer. Section 4.35 '*Stalls*' was amended and renamed as '*Stalls and Slow Flight'*. The amendment added the following text:

> ***'caution***
>
> *Slow flight and stall manoeuvres should be initiated at altitudes high enough to fully recover by at least 4,000 feet AGL, to provide an adequate margin of safety in the event of an inadvertent spin.'*

The manufacturer's UK agent confirmed that the manufacturer operates an update alerting service for owners who register their details directly with the, USA based, manufacturer. In addition, the current revision status of various documents, including the PA-38 POH could be found on the manufacturer's website under '*customer service information'*[1].

Although POH Revision 14 was dated May 2012, the UK agent commented that the revision was only available from September 2012; after the date of this accident.

Training syllabus

At the time of the accident, the PPL syllabus in use, for regulatory purposes, was the JAR-FCL 1 syllabus. Exercise 10a was listed in the JAR-FCL 1 syllabus as '*slow flight*', the objective of which was:

> *'to improve the student's ability to recognise inadvertent flight at critically low speeds and provide practice in maintaining the aeroplane in balance while returning to normal airspeed.'*

The flying school used JAR compliant student study guides from various aviation publishing outlets. The guides split Exercise 10a into two parts, with the exercise first being flown at 10 kt above the stalling speed, then again at 5 kt above the stall. The PPL syllabus continues with Exercise 10b '*stalling*'. In total, the JAR PPL required a minimum of two hours of stall and spin awareness training. The syllabus did not require the student or instructor to spin the aircraft.

Conduct of the exercise

The instructor's methodology was reviewed by interviewing three students who had completed both Exercises 10a and 10b with him recently. The three students each had between 10 and 20 hours flying experience.

Footnote

[1] www.piper.com/company/publications/Customer_Service_Info.pdf

The interviews revealed that there was some variation in altitude flown while conducting the exercises. One student had flown Exercise10a at 6,000 ft amsl. For this student, the instructor had delayed Exercise 10b, while waiting for a suitable cloud base, before the exercise was eventually completed at about 3,000 ft. Another student recalled completing Exercise 10b at 2,100 ft amsl, as the cloud base had been between 2,200 and 2,300 ft. The third recalled the altitude as being about 3,000 ft.

All the students recalled that, at some point, the instructor had demonstrated a full stall involving a significant wing drop. Two of the students recalled that the left wing had dropped, the third could not recall which wing it was.

Procedures

The flying school's Flying Order Book (FOB) detailed the local flying area for activities such as stalling and spinning as being clear of the airways, to the south of the airfield.

Section 3.1 *'Minimum Altitude For Training'* stated that:

> *'Stalling…exercises will commence from an altitude which will allow recovery to straight and level flight by 3000 feet AGL when flying solo and 2000 feet AGL when flying dual*
>
> *Recommended minimum commencement altitudes are:*
>
> *Stalling… 2500 feet dual.'*

In September 2012, in response to Revision 14 of the PA-38 POH the school updated the Flying Order Book:

> *'Stalling and spin recovery exercises will commence from an altitude which will allow recovery to straight and level flight by 4000 feet AGL for PA38.*
>
> *Recommended minimum commencement heights, PA38, are:*
>
> *Stalling 4250 feet.*
>
> *Spinning 5000 feet.'*

Spinning

A spin is a condition of stalled flight in which the aeroplane describes a spiral descent. During a spin an aircraft is stalled and rotating about all three axes; rolling, yawing and pitching, as well as sideslipping, while losing height rapidly.

Engineering investigation

The flying controls, including elevator trim, were checked and no evidence of anything unusual was found.

The flap lever was still attached to its mounting bracket, and the pin, which is attached to the lower end of the lever, was found in the flaps up détente. The damage to the central fuselage was such that the pin could not be moved from this position. It was concluded that the flaps were probably up when the aircraft struck the ground.

Whilst there was significant disruption to the cockpit area, the carburettor heat appeared to be in the ON position and the mixture lever appeared to be in the RICH position.

The fuel selector appeared to be selected to the left tank (there are three positions LEFT, RIGHT and OFF). The fuel selector was removed from the wreckage and a simple blow test demonstrated that the left tank was selected, although from this test it was not possible to ascertain if it was fully open. The valve was disassembled and found to be in good working condition, but the male locating key was found to be just outside the groove for the left tank position. It is conceivable that the key could have been forced out of the groove during the impact sequence.

The majority of the engine was intact. However, there was significant damage to the carburettor. The starter ring gear, which is located just behind the propeller, had broken into two parts with a circumferential fracture. There was no indication of any rubbing on either of the two fracture surfaces, which was further evidence that the engine was not turning when it struck the ground.

A small but significant quantity of fuel was found in the mechanical fuel pump and it was concluded that it was unlikely that the aircraft had suffered from fuel starvation. Nothing significant was found that might explain why the engine appeared to have stopped prior to the aircraft striking the ground. One of the magnetos only produced a spark for one cylinder. However, this was readily explained by the damage to the casing that appeared to have caused the drive pinion to disengage from the rotor gear.

Analysis

The instructor had significant experience instructing the PPL(A) syllabus. He held an appropriate licence, rating and medical certificate, and was current. There was no compelling evidence of any medical factors that could have had a bearing on the cause of the accident.

The departure from Hawarden was without incident and the instructor's request to operate up to 4,500 ft was consistent with an intention to be above 3,000 ft agl when conducting either slow flight or stalling. However, the aircraft's ground track was mainly in the area bounded by airway N864 or the Manchester CTA and, although no altitude data was available, there was no evidence that the aircraft infringed this controlled airspace. Consequently, at the time of the accident the aircraft could have been operating below 3,000 ft agl and above the 2,000 ft agl required by the Flying Order Book. Interviews with students suggested that the instructor had previously completed Exercises 10a and 10b below 3,000 ft. Although the aircraft's airspeed during the flight could not be calculated accurately, its variation was consistent with an exercise on slow flight.

The radar data indicated that the aircraft would have been at or above an altitude of about 700 ft amsl when its position was last recorded by St Annes and Manchester radars. The final two radar positions, from Clee Hill, showed that the aircraft's track had changed direction rapidly through 180°, on to a downwind heading, and the reducing radar coverage from the three radar heads indicated a high rate of descent. This, combined with the vertical nature of the descent identified by the eyewitnesses, the ground marks and wreckage disposition are all indicative of a spin.

A spin is a likely outcome of a loss of control at low airspeed but, although the exercise that was being taught involved slow flight, why the spin occurred and which pilot was handling is not known. The aircraft was at too low a height for an intentional spin and the manoeuvre was neither required nor planned as part of the training. In addition, there were no references to spinning in the instructor's logbook, which went back to October 2008.

The POH data indicates that recovery from a spin, at the height at which the loss of control appears to have occurred, would have been unlikely in the height available. During spin recovery, the immediate effect of applying normal recovery controls may be an appreciable steepening of the nose down attitude and an increase in rate of spin rotation. Whether the witnesses saw the beginning of a recovery is not known, but the evidence from the distribution of the wreckage was that the aircraft was in a spin when it struck the surface.

There was no indication of a radio call from the crew, advising of a problem with the aircraft, and no evidence of a mechanical or a control problem was found during examination of the wreckage. The recorded and reported fuel state was sufficient to complete the flight and the fact that fuel was found below the engine would also suggest that there had not been a problem with the fuel line or fuel selector. The finding of fuel in the fuel pump was strong evidence that running out of fuel or fuel starvation was unlikely to have been a factor in this accident.

The engine did not appear to have been operating with any significant power when the aircraft struck the ground, and may not have been turning at all. No cause for an engine failure could be found but the POH states that the engine may stop while the aircraft is spinning. However, it was not possible to determine when the engine power reduced.

Safety action

In 1997, the NTSB recommended that:

> *'slow flight & stall training in the PA-38-112 be conducted at or above the minimum altitude currently specified in the PA-38-112 pilot's operating handbook for spin training…'*

A manufacturer's revision to the POH, dated May 2012, cautioned that:

> *'Slow flight and stall manoeuvres should be initiated at altitudes high enough to fully recover by at least 4,000 feet AGL, to provide an adequate margin of safety in the event of an inadvertent spin.'*

This revision reached the UK in the month following the accident and the flying school amended their procedures.

Conclusion

The aircraft struck the ground while in a spin. There was no evidence to suggest pilot incapacitation or a fault with the aircraft as being causal to the accident but an engine failure prior to the loss of control of the aircraft could not be ruled out. Although it was not possible to determine why the aircraft entered a spin, the radar data indicates that this happened when the aircraft was at a height from which recovery was unlikely to be successful.