Department of Trade

Report on the accident to Piper PA 38-112 Tomahawk G-BGGH at Wood Farm, Kiddington, Oxfordshire, on 27 May 1980

List of Aircraft Accident Reports issued by AIB in 1981

No	*Short Title*	*Date of Publication*
1/81	BAe HS 748 G-BEKF Sumburgh Airport, Shetland Islands July 1979	July 1981
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10/81	Piper Azect PA23–250F G–BOST Nr Riplingham, N Humberside January 1981	January 1982
11/81	Piper PA31–112 Tomahawk G–BGGH Wood Farm, Kiddington, Oxfordshire May 1980	

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Department of Trade
Accidents Investigation Branch
Kingsgate House
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10 December 1981

The Rt Honourable John Biffen MP
Secretary of State for Trade

Sir

I have the honour to submit the report by Mr J S Owen, an Inspector of Accidents, on the circumstances of the accident to Piper PA 38-112 Tomahawk G–BGGH which occcurred at Wood Farm, Kiddington, Oxfordshire, on 27 May 1980.

I have the honour to be
Sir
Your obedient Servant

G C Wilkinson
Chief Inspector of Accidents

Accidents Investigation Branch

Aircraft Accident Report No 11/81
(EW/C698)

Registered Owner:		CSE (Aircraft Services) Ltd
Operator:		Oxford Air Training School
Aircraft:	*Type:*	Piper PA 38
	Model:	PA 38-112 Tomahawk
	Nationality:	British
	Registration:	G–BGGH
Place of Accident:		Wood Farm, Kiddington, Oxfordshire Latitude 51° 52′ 30″ North Longitude 01° 24′ 30″ West
Date and Time:		27 May 1980 at 1442 hrs All times in this report are GMT

Synopsis

The accident was reported to the Department of Trade Accidents Investigation Branch (AIB) and the investigation commenced the same day.

The aircraft was engaged on a dual *ab initio* instructional flight which included an introductory spinning exercise. The aircraft's last reported altitude was 5,000 feet and there were no eyewitnesses to the final flight path until it was seen spinning at a low height before crashing. Both occupants were killed. Following initial enquiries the Civil Aviation Authority (CAA) prohibited deliberate spinning on Tomahawk aircraft pending further investigation. The CAA conducted an effective investigation into the aircraft's spinning characteristics in co-ordination with the AIB investigation.

The accident was caused by the failure to recover from a deliberately induced spin. The reasons for the non-recovery have not been established, however, it is considered that control misapplication was an essential ingredient. Failure to report previous incidents of delayed spin recovery on Tomahawk aircraft, including the incident which had already been experienced by the commander, were contributory factors to the accident.

The report recommends that the existing flight test requirements for flying instructors on Tomahawk aircraft should be more positively implemented with regard to the full spinning exercise. Attention is also drawn to a number of spin training accidents which have occurred in the UK and questions the need for spin training as a licensing requirement for a basic Private Pilot's Licence in the UK.

1. Factual Information

1.1 History of the flight

The accident occurred during the student pilot's sixth dual instructional flight which was intended to include an introductory exercise in spinning. The aircraft had just returned to service following rectification and the fuel tanks were filled to capacity. After carrying out a pre-flight inspection the instructor and student boarded the aircraft, the instructor seated on the right and the student on the left. The aircraft took off from Oxford aerodrome between 1400 hrs and 1420 hrs and it later reported by radio to Oxford that it had passed over the aerodrome from east to west at 5,000 feet. This was the last message received from G–BGGH.

There were no eyewitnesses to the final flight path until the aircraft was seen spinning at a low height just before crashing into a corn field approximately 5 miles northwest of the aerodrome. One witness said it 'was spinning slowly like a corkscrew' and another witness heard engine power increase before it crashed. The police were alerted and on receipt of the alarm the Oxford air traffic controller diverted a helicopter to the scene but rescuers found both occupants were dead. The accident occurred approximately 30 minutes after take-off.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2	–	–
Non-fatal	–	–	–
Minor/none	–	–	

1.3 Damage to aircraft

Damaged beyond economic repair.

1.4 Other damage

None.

1.5 Personnel information

1.5.1 *Commander:* Male, aged 26, weight 140 lb (63.5 kg)

Licences: Private Pilot's Licence (PPL) first issued 30 August 1978 for Landplanes in Group A and Self Launching Motor Gliders; Flying Instructor's Rating re-validated on 20 May 1980 with restriction: 'No aerobatic flying instruction except spinning'. Instrument Meteorological Condition (IMC) Rating and Night Rating

Last medical examination: 20 March 1980, valid Class 1 with no limitations

Flying experience:	Total all flying: 508 hours Total on PA 38: 305 hours 20 min Total hours as a flying instructor: 281 hours Total flying during previous 48 hours: 2 hours 40 min.
Types of aircraft flown:	Cessna 150/152/172, Piper PA 28 and PA 38
Recorded spinning exercises:	Prior to instructor's course: 3 During instructor's course: 4 As a qualified instructor: 18

Relevant flying history

The commander learned to fly on the Cessna 150 and 152; subsequent to qualifying for a PPL he also flew the Cessna 172 and Piper PA 28. He was selected for sponsored training as a flying instructor by the Oxford Air Training School where he commenced his course of instruction on PA 38 aircraft in August 1979.

During this course he was instructed in spinning exercises which included prolonged spins of up to six turns; his instructor recalled that he had no difficulties with these exercises nor did he show signs of disorientation or fear. During these exercises he was also shown examples of incorrect spin recovery such as a student might take.

Having completed the instructor's course the commander was tested for an assistant instructor's rating by an authorised examiner; the test report shows that his pre-flight briefing and technical knowledge were above the average but he had to be re-tested in his air work. In particular his demonstration of the incipient spin and recovery was confused and ailerons were used incorrectly. The examiner attributed this poor showing to 'nerves', however, on being re-tested three days later by the same examiner the incipient spin and recovery were safely demonstrated.

He was subsequently employed as an assistant instructor at the Oxford Air Training School where, approximately six weeks before the accident, he experienced a delayed spin recovery in a PA 38 (not G–BGGH) whilst demonstrating a developed spin during an instructional flight with a student. After landing, he casually discussed the incident with his flight manager who questioned him about his technique and concluded, that as far as he could ascertain, the commander had handled the aircraft correctly. The matter was not considered to have been sufficiently serious to have warranted filing an incident report and it was left to the instructor to inform the flight manager if there was a recurrence on that particular aircraft.

The flight manager was aware that the commander was due to be re-tested for a full instructor's rating and was under the impression that the test would include spinning.

One week before the accident the commander was tested for up-grading to Full Instructor and his ability was assessed as 'average overall'. During the test he was unable to carry out a full spinning demonstration because of unsuitable weather, however, the recoveries from stalls and an incipient spin were demonstrated to an acceptable standard. The examiner was not aware that the commander had experienced a delayed recovery from a spin.

As a practising instructor, his manner was described as meticulous with a tendency to be over-precise. When demonstrating the introductory spinning exercise on the

PA 38 his attention to pre-spin checks and detail were exact. Before taxying he would ensure that the trainee correctly adjusted his seat to obtain full rudder control then to re-check that full rudder travel could be obtained whilst taxying. According to trainee pilots who had flown with him the commander normally commenced a spinning exercise above 4,000 feet and would ask the trainees to 'follow him through on the controls' in order to let them experience the entry into and recovery from a spin before trying it themselves.

Student pilot:	Male, age 44, weight 175 lb (79.38 kg)
Licence:	Not applicable, student pilot, was medically examined on 16 May 1980.
Flying experience:	5 hours 10 mins. as a student pilot, all of which was dual instruction on the PA 38. According to his regular instructor, who had flown with him on all previous exercises, he was making good progress. The student pilot had also flown for 880 hours as a navigator in the RAF, having last flown in this capacity in 1961.

Relevant history

On the day of the accident the commander agreed to take the student on his introductory spinning exercise because his regular instructor was indisposed. The student had already been briefed for the exercise which should have been completed on his last instructional flight six days earlier. On this last occasion, after carrying out a stalling exercise the instructor decided not to continue with spinning because of hazy weather. After landing from this exercise the student expressed his relief that he had been unable to complete the exercise and mentioned that he once had to abandon an aircraft in a spin by parachute when he was in the Royal Air Force. Subsequent enquiries during the investigation revealed that this had occurred following a mid-air collision in September 1955 whilst on a training flight as navigator on night fighter aircraft.

A few days before the accident the student made a casual remark to an acquaintance that he was not looking forward to spinning.

1.6 Aircraft information

1.6.1 Relevant data (specific to G–BGGH)

Type:	Piper PA 38 – 112 Tomahawk
Constructors serial number:	38 – 79A 0164
Date of manufacture:	1978
Certificate of Airworthiness:	No 8656–1 in the Transport (Passenger) category, issued by the Civil Aviation Authority (CAA) on 29 March 1979, valid until 28 March 1982 conditional on being maintained in accordance with an approved maintenance schedule.

Certificate of Maintenance:	Renewed 8 May 1980 at aircraft hours 435 hours 35 minutes and valid until 18 June 1980 or 100 flying hours, whichever is the sooner.
Total airframe hours:	510
Engine type:	Lycoming 0–235 L2C
Propeller:	Sesenich
Engine and propeller running time:	510 hours
Maximum weight authorised:	1670 lb (757.5 kg)
Estimated weight at impact:	1625 lb (737 kg)
Estimated centre of gravity (cg):	75.35 ins aft of datum
CG limits appropriate to weight:	73.5 ins to 78.5 ins aft of datum
Estimated fuel remaining:	22 Imperial gallons
Type of fuel:	AVGAS 100LL

Prior to the accident flight the aircraft was serviceable and there were no deferred defects. During a period of 10 flying hours in the week preceding the accident the aircraft had been regularly spun and no unusual characteristics were apparent.

Significant modifications:	The aircraft was fitted with flow strips at wing station 169 during manufacture. Flow strips were subsequently fitted to the inboard section of the wing at station 93.5 in accordance with the provisions of Piper Service Letter 876.

1.6.2 *Aircraft details*

1.6.2.1 *General*

The PA 38 Tomahawk is a single engined low wing 'T' tail monoplane which was designed primarily as an *ab initio* training aircraft capable of stalling and spinning provided it is loaded within approved weight and centre of gravity limits.

The following information was contained in the Tomahawk Pilot's Operating Handbook (POH): Section 4 Normal Procedures

> '4.43 Spins
>
> Only when wing flaps are fully retracted, are intentional spins approved. No baggage should be carried since it might break loose during the spin. Before entering an intentional spin, the pilot should be sure that all loose equipment is stowed. Seat belts and shoulder harnesses should be fastened in such a manner that they do not hinder the pilots moving the controls through their full travel. The spin should be initiated at an altitude which will result in full

recovery above 3,000 feet agl to provide a margin of safety. A one turn spin will require approximately 1,000 feet to complete, while a six turn spin will require approximately 2,500 feet. After more than one complete turn, recovery will require ½ to 1½ turns after recovery control input.

Spins should be entered from a power off full stall with full aft control wheel and full pro-spin rudder application. This control configuration should be held through the spin until recovery is initiated. The ailerons must remain neutral throughout the spin and recovery, since aileron application may alter the spin characteristics to the degree that the spin is broken prematurely or that recovery is delayed. The following techniques should be used for spin recovery:

(a) Apply and maintain full rudder opposite to the direction of rotation.

(b) As the rudder hits the stop, push the control wheel fully forward. As the stall is broken, relax forward pressure to prevent excessive speed build up.

(c) Check that the throttle is closed and the ailerons are neutral.

(d) As rotation stops, neutralise the rudder and smoothly recover from the dive.

Variation in weight and cg position will change the characteristics of the spin, most noticeably in pitch attitude. The preceding recovery technique should always be used to ensure recovery with the minimum altitude loss.'

In its original form, the wing profile was clean with no flow strips fitted to the leading edges. However, during the time of its original FAA certification programme, flow strips were fitted to the outboard sections of the wing leading edges in order to reduce consistent roll-off to the left during stalls and to improve its spin characteristics. More than 300 spins were done during the flight test programme. Later, during the production programme, flow strips were added to the inboard section of the wing to soften the stall characteristics and this resulted in a four knot increase in the flaps-up stalling speed and a two knot increase in the landing configuration stalling speed. Following the fitment of the inboard flow strip a further 150 spins were conducted. A diagram showing the location of the flow strips is given at Appendix 1.

1.6.6.2 *Spinning – airworthiness requirements*

The relevant criteria for certification purposes in the United States are contained in Federal Airworthiness Requirements (FAR) 23.221 which states, *inter alia,* that an aircraft certificated to acrobatic spin requirements must be able to recover from 'any point in a spin in not more than 1½ turns after normal recovery application of the controls . . . . the spin test must proceed for six turns or three seconds, whichever takes longer . . . .' also 'it must be impossible to obtain uncontrollable spins with any use of the controls'.

The criteria for United Kingdom certification for spinning is contained in British Civil Airworthiness Requirements (BCARs). Section K Light aeroplanes, Sub Section K2–12 deals with 'Handling – aerobatics.' The following extracts are relevant:

Para '3.1 General

Single engined aeroplanes

All single engined aeroplanes, the maximum weight of which is 4,000 lb or less, shall either be demonstrated to be characteristically incapable of spinning . . . . or shall recover from a one turn spin, power off, in all configurations intended to be used in normal operation, with the controls applied normally for recovery in not more than one additional turn and . . . . without exceeding either the limiting airspeed or the limit manoeuvring load factor. In addition, no excessive forward pressure on the control column shall be required during the spin or recovery. It shall not be possible to obtain uncontrollable spins by any possible use of the controls'.

'3.2 Tests

Unlimited spinning permitted

It shall be possible . . . . to recover from a spin (in each direction) by the Standard method * without the use of engines, when action for recovery is initiated after (a) three (b) eight turns. The aeroplane shall recover from the spin in not more than 1½ additional turns. Excessive control forces shall not be needed for this recovery . . . .'

1.6.3 *Certification spinning trials in the USA.*

1.6.3.1 The PA 38 was subjected to a programme of spinning in the USA prior to its certification by the FAA. No uncontrollable characteristics were apparent during these trials which included deliberate misuse of controls during entry into and during the spin itself. It was found that, irrespective of the load distribution or of the method entering into a spin or the number of turns during the spin, the aircraft would recover within one and a half additional turns after spin recovery control was applied.

According to the manufacturer, the most effective spin recovery technique was to apply full rudder against the direction of the spin followed immediately by pushing the elevator control fully forwards. This method was incorporated in the spin recovery procedure written into the POH. The PA 38 was duly certificated by the FAA in both 'Normal' and 'Utility' Categories, the Tomahawk POH was also approved as the 'Airplane Flight Manual' and thus formed part of its Certificate of Airworthiness.

1.6.3.2 When the PA 38 was imported into the UK it was subjected to scrutiny by the CAA Airworthiness Division which included limited flight tests conducted in May 1978, over a two day period by the CAA test pilot, with the object of investigating stalling during turns and behaviour when spinning. These tests showed that lively wing drops occurred in turning stalls to the right, which could be contained with fast corrective action. The spin characteristics were excellent with no traps found. The aircraft was recommended for certification in the Transport category.

* Included in Sub-Section K2 – 12 of BCARS is the following Note:
'The present standard method of recovery from a spin is to apply opposite rudder (ie against the direction of rotation of the spin); pause; ease the control column forward until the rotation ceases and the aeroplane becomes unstalled; centralise rudder and allow the aeroplane to dive out.'

1.6.6.3 *Summary of spin behaviour*

The spinning tests were carried out on the first PA 38 to be registered in the United Kingdom and it was flown solo with 125 lb of ballast behind the pilot's seat. Its weight at take-off was 1670 lb (maximum authorised) with a cg 78.28 ins aft of datum (near aft limit). The test programme consisted of a total of twelve spins which included spins of two, four and eight turns, left and right, one reversed recovery (elevator before rudder), and two with in-spin and out-spin aileron applied during entry. The aircraft exhibited no uncontrollable characteristics and in all cases recovery was effected in half a turn to a maximum of one turn after applying spin recovery control. Less than full nose-down elevator was needed during recoveries.

The FAA type certification was validated in the United Kingdom and the Tomahawk POH was approved as the Flight Manual which forms part of its Certificate of Airworthiness. Each PA 38 imported into the UK is subjected to a flight test which includes two-turn spins, in each direction, before its UK Certificate of Airworthiness is issued.

1.6.4 *PA 38 Stall/spin accidents*

Up to the time of the accident to G–BGGH there were five fatal accidents to PA 38 aircraft which were attributed to inadvertent stalls or spins that occurred at too low an altitude to permit recovery; One in Canada, three in the USA and one in Sweden. The subject accident was the first known fatality during a dual spinning exercise on the PA 38.

1.6.8 *Delayed spin recoveries*

Subsequent to this accident several reports were received from pilots who had experienced delayed or protracted recoveries from deliberate spins in the Tomahawk when it had continued to spin for as many as five turns after recovery control had been applied. Most of these reports originated from instructor pilots in the UK, but others were received from Australia and Kenya. The incident in Australia was investigated by the Australian Department of Transport but no reasons for the delayed spin recovery was found. Examination of the reports received in the UK also produced inconclusive results, however, it was noted that several of the instructor pilots who reported delayed recoveries were relatively inexperienced and their previous spinning experience, prior to the PA 38, had been gained on types of aircraft that are known to have less positive spin characteristics.

There were a number of reports from instructors and by aviation journalists who had experienced no difficulties and described the PA 38's spin characteristics in favourable terms. However, there were other comments such as: 'first spin may take most people by surprise', 'spins stable, steep and fast'. It was noted that the majority of instructor pilots who had no difficulties with the PA 38 were well acquainted with other types of aircraft which have positive or classic spin characteristics.

There was, however, one recurring criticism of the spin recovery procedure as published in the Tomahawk POH: If the control wheel is 'pushed fully forward' the resulting attitude on recovery from the spin can be very steep and could exceed the vertical, with a risk of exceeding the limiting airspeed whilst recovering from the ensuing dive. A flight examiner noted that some instructors demonstrated a tendency to limit the forward movement of the elevator control during spin recovery.

1.7 Meteorological information

At the time of the accident there was a shallow depression over northeast England which gave rise to an unstable showery south easterly airstream over central England. The 1500 hrs weather observation showed: Surface wind 250°/10 knots, visibility more than 10 km, occasional light showers, cloud 6/8 cumulus at 5,000 feet QFE 999, QNH 1009. At the time of the accident it was daylight and light conditions were good. Weather conditions are not considered to have been a factor in the accident.

1.8 Aids to navigation

Not relevant.

1.9 Communications

Radio communication between the aircraft and Oxford Air Traffic Control (ATC) were apparently normal; there was no speech recording equipment installed in ATC.

1.10 Aerodrome and ground facilities

Not relevant.

1.11 Flight recorders

Not fitted or required to be fitted in this aircraft.

1.12 Wreckage and impact information

Impact information

Ground impact markings indicated that the aircraft had struck the ground with a pitch attitude of approximately 20° nose-down whilst spinning to the right with its wings substantially level. It was evident that the aircraft had no forward speed at impact but that it had developed a high rate of descent. The nose section and cockpit floor structure had been severely disrupted by impact forces and both wing fuel tanks had ruptured as a result of damage sustained by the wings. The propeller, which had detached from the engine, showed evidence of rotation under power at the time of impact.

1.12.2 Subsequent examination

Subsequent examinations were concentrated on those aspects that could have influenced attempted spin recovery. The flow strips, which were attached to the inboard and outboard wing leading edges, were found to have been fitted in accordance with the manufacturer's instructions. Examination of the flap control mechanism revealed that the flaps were up, both exit doors were locked shut and an extensive examination of the aircraft's flying controls revealed no evidence of pre-crash malfunction or failure. The elevator trim system and particularly the elevator trim wheel assembly, which had been replaced prior to the accident flight, were also examined in detail. Due to disruption of the trim wheel assembly it was not possible to establish the elevator trim setting, however, it was evident that the trim wheel assembly had been correctly installed. The range of movement of the flying control surfaces were checked and all surfaces were found to be within the manufacturer's tolerances.

Damage to the elevator horn balance had occurred during the ground impact sequence when the elevator was in the full up position.

The elevator trim bias springs will move the elevator to the fully 'up' position when the tension on the control cables is released. Early in the impact sequence the tail boom structure buckled and this would have released the control cable tension. It is not possible, therefore, to state whether the elevator was in the 'up' position when the aircraft first struck the ground, or that it had taken up that position during the impact sequence.

Impact witness marks on both seat rails were noted and compared with a specimen aircraft. A subject with equivalent leg lengths seated in either position showed that, with the seat settings as found, it was possible for either pilot to have obtained full rudder travel.

Both control wheels showed signs of being forced forwards at impact; however, the left hand wheel and its hand grips bore evidence of having been subjected to forces which twisted them forwards whilst the wheel and its connecting column were forced to the left and downwards. The deformation of the right hand control wheel was less pronounced and was consistent with having been struck obliquely from right to left.

1.13 Medical and pathological aspects

Post mortem examination of both occupants revealed that death as a result of multiple injuries was instantaneous. There was no evidence of pre-existing disease and tests for alcohol, drugs and carbon monoxide proved negative. It was noted that the occupant of the left hand seat was still holding the control wheel hand grip in his left hand; there was also a large swollen bruise on the back of his right hand which was resting on his right thigh. Subsequent examination revealed other abrasions on the knuckles of both hands which were probably caused by contact with the instrument panel but, in the opinion of an aviation pathologist, the bruise on the back of the right hand was sustained at least one to two minutes before the aircraft crashed. The severity and pattern of injuries to his lower limbs, particularly the left, indicated that the left leg was fully extended and braced at the moment of impact.

In the case of the occupant of the right hand seat, no comparable pattern of injuries was evident.

1.14 Fire

There was no fire.

1.15 Survival aspects

Both occupants were wearing a safety harness with diagonal upper torso restraint but the injuries due to decelerative forces were beyond human tolerance and consequently the accident was non-survivable. It was noted that the occupant of the right-hand seat had fallen sideways to the left at impact and had slid out of his diagonal upper torso restraint.

1.16 Tests and research

1.16.1 The CAA arranged for further spinning tests to be conducted in the USA. The tests were in two parts: The first was conducted by the manufactuer and the second by the CAA to confirm results in critical areas of the former. These tests were then followed by a further programme in the UK which was conducted by the same CAA (Airworthiness Division) (AD) test pilot who participated in the previous programmes in the USA. The aircraft used during the UK tests were those on which protracted recoveries had been experienced and the seven pilot instructors who reported the incidents also participated in the programme. A separate assessment of the PA 38 spin characteristics was also made by another CAA (AD) test pilot.

A resumé of events leading up to the tests, summaries of the results obtained and recommendations made by AD test personnel, may be seen at Appendix 2.

The manufacturer has stated that the faster spinning mode, which was encountered during the CAA spinning trials (see Appendix 2 page 5 para 7.6), was not revealed during the 450 spins carried out during certification tests in the USA. These tests were described as 'comprehensive and well balanced.' The manufacturer has also stated that 'the curtailment of tests in any given area was made only after it was determined to the satisfaction of the test pilot (PAC) and the FAA inspector.'

The effects of mishandled controls during spin recovery were not described in any detail in the POH other than to draw attention to the need to 'maintain ailerons neutral throughout the spin and recovery' (see para 1.6.2.1 ('4.43 Spins')). PAC chose not to expand this information in the POH 'because of the sizeable number of situations and consequences requiring coverage. The emphasis has been on a simple and effective recovery procedure easily understandable to the operator'.

As a result of the tests conducted by the CAA subsequent to the accident, UK registered PA 38 Tomahawk aircraft were re-cleared for spinning and the knowledge gained was incorporated in a revised edition of the Tomahawk POH. The text of the revised section of the POH dealing with spins was agreed with the manufacturer and was published as an amendment to the POH. The text of this amendment may be seen at Appendix 3.

1.17 Additional information

1.17.1 *Spinning*

Spinning, or autorotation, is a condition of stalled flight in which an aircraft describes a spiral descent during which it will be simultaneously rolling, yawing and pitching as well as losing height rapidly and descending vertically. The development and characteristics of a spin will depend upon aircraft design and the distribution of its mass as well as the deflection (operation) of its control surfaces. An aircraft may rotate several times in an erratic manner before settling down to a more stable spin and the pitch angle can vary from steep to flat. Entry into a spin can be made from many flight attitudes, however, spin entry normally occurs when the aircraft is at or near a stalled condition and is accompanied by a yawing moment around the normal axis. Entry into a spin is achieved by bringing the aircraft close to the stall and then applying full left or right rudder to create the necessary yaw whilst applying full up-elevator.

1.17.1 *The incipient stage*

The incipient stage of the spin is the period after entry but before the spin has progressed to the developed stage. From a training viewpoint, the incipient stage can be described as that interval before the wings roll past the vertical and is thus similar to a positive 'wing drop' which may accompany a stall. The time between spin entry and the development of a steady spin can be short.

1.17.3 *Instruction in spinning*

Among various reference books on stalling and spinning instruction the following extracts from the Instructor Manual, approved by the Aircraft Owners and Pilot's Association (AOPA) and recognised by the CAA, are relevant:

'Spinning forms a vital part of the student's training and it is essential for all students to experience full spins and to recognise the development and direction of a spin, in addition to carrying out prompt and effective recovery . . . . The action of entering, sustaining and recovery from a spin will usually involve a relatively large loss of height, and even when spins are of short duration some 500 to 700 feet can be lost before the aircraft is once again under the positive control of the pilot . . . . Before the commencement of the spinning exercise some gentle spins of short duration should be demonstrated on a preceding flight. This will introduce the student to the unusal attitudes the aircraft adopts in the incipient and developed stages. It will also give him some experience of the physical sensations which are experienced, and develops his confidence in the ability of the aircraft to recover to normal flight when the controls are used correctly. Physiological effects are most pronounced during and after stable spins and when the spin stops they can often cause a sensation of spinning in the opposite direction . . . . When a particular aircraft type is capable and also certificated to carry out prolonged spins the student should be given the opportunity to practice these in the later stages of his spin training. He must be warned of any changed recovery characteristics, such as temporary speeding up in rate of roll, steepening of the pitch attitude, or a delay in the eventual recovery. When such characteristics occur it will be important to stress that the standard recovery action must not only be applied, but must be maintained.'

1.17.4 *Standard Recovery – Instructor Manual*

The AOPA Instructor Manual also contains the following spin recovery drill under exercise 11–14:

'Standard Spin Recovery (See also the Note on page 11–20)

Throttle closed

Ailerons held neutral

Full rudder applied – opposite to spin direction

Pause – momentarily

Ease the control column forward – continue this action until the spin stops

When the spin stops – immediately centralise the rudder and level the wings by the use of ailerons

When the wings are levelled – ease out of the dive.

The following Note is on page 11–20

'NOTE: In recent years, certain foreign manufactured aircraft whose spin recovery characteristics are different to those built and certificated in accordance with British Civil Airworthiness Requirements, have been introduced into the UK.

The Flight Manuals of some of these aircraft therefore outline spin recovery procedures which are a little different from that which has historically become known as the 'Standard Spin Recovery'.

Pilots must therefore check the Aircraft Manual for the particular type to ensure that they are aware of the recommended spin recovery technique for the aircraft they are currently flying.'

1.17.5 *Spin training at the Oxford Air Training School*

Student pilots are given limited instruction in spinning before being allowed to fly solo, the emphasis being on the recognition of the entry into a spin and to prevent it from developing beyond the incipient stage; every effort is also made to avoid frightening the student by exposure to a prolonged spin. Later on during their training they will be given further instruction in spinning of a more advanced nature. The following extracts from the Lesson Notes issued to trainee flying instructors at Oxford are relevant:

SPINNING *PART 1*

'Introduction

Whether or not to teach spinning before a student carries out his first solo is a subject of some discussion between instructors. In some aircraft the spin can be very violent and consequently very frightening to the beginner. It is arguable that the under-confident and nervous may reverse any signs of progress if made to endure fully developed spins. However, all students *must* be shown that recovery at the incipient stage, as soon as the symptoms are recognised, is effective and will lead to very little height lost. When introducing the nervous student to spinning, recovery from increasingly extreme unusual attitudes may build up his confidence . . . .

AIR EXERCISE

1 Demonstrate entry with student following through. Emphasise FULL rudder and control column *FULLY* back to make the aircraft spin. Recover, emphasising large control movements and order of use.

2 Make student enter spin and recover, calling out recovery, 'CLOSE THROTTLE, Full Opposite Rudder – PAUSE – Control Column Forward (progressively until rotation stops) CENTRALISE' when rotation stops. Level wings with horizon and ease out of dive.

3 Show how spin will not develop when recovery action of 'Control Column Forward CENTRALISE Rudder' is taken, as soon as rotation is recognised. This may well be the stage at which it is politic to discontinue the exercise since most students will not learn when either terrified or struggling (with nausea) . . . ..

CONCLUSION

The major objective must be to ensure that the student recognises when he is about to spin and avoids exacerbating the situation. As in stalling, the emphasis must eventually be NOT to spin . . . . '

1.17.6 *Student briefing*

In the case of the subject accident, the flight authorisation book showed that the commander intended carrying out Part 1 of the spinning exercise. A loose-leaf black notebook, which was recovered from the wreckage, was identified as the property of the student. Notes of the exercises were typewritten and the last page contained details of the spinning exercise for which he had already been briefed. The spin recovery drill was recorded as follows:

'Recovery

Check direction of rotation

Close throttle

Apply full opposite rudder (spin rate will increase)

Control column progressively forward until rotation stops

Centralise rudder

Ease out of dive, put on power as the nose passes horizon.'

The foregoing indicates that the student had been briefed for the Standard recovery procedure as opposed to the procedure given in the Tomahawk POH and there is evidence that the Standard procedure was generally recognised and taught at Oxford.

1.17.7 *Spin training and test requirements for PPL candidates*

Pilot licensing authorities throughout the world differ in their requirements for spin training and test requirements for a PPL. For example, in Denmark a PPL is endorsed for a specific aircraft type and the test only requires a candidate to demonstrate a spin and recovery if the aircraft type is cleared for spinning; a similar requirement applies in Switzerland if a pilot seeks an aerobatic rating to be included on the PPL. Also in Switzerland, spinning is permitted only on aircraft which are certificated for aerobatics, which the PA 38 is not, and a parachute is required to be worn; a similar requirement exists in Sweden. Demonstration spin and recovery is not a requirement in France. In Australia there is no requirement to demonstrate either an incipient or a fully developed spin and recovery, for a basic PPL, unless an endorsement is sought for spinning and aerobatics. In the United Kingdom, PPL candidates are required to demonstrate their knowledge of 'spinning and recovery' during their qualifying flight test unless they can produce evidence that this exercise was covered during their course of training. The Training Syllabus for a PPL, produced by AOPA and approved by the CAA, emphasises the need to recover at the incipient stage but recognises that entry and recovery from a fully developed spin is a necessary part of this exercise. Civil Air Publication (CAP) 53, which deals with Private Pilot's Licence requirements, does not state whether the test should include a recovery from a fully developed spin or from the incipient stage. In Canada, training in the recovery from both fully developed and incipient spins are mandatory requirements and, during the qualifying test for a PPL, demon-

stration of entry to an incipient spin and immediate recovery, and a demostration of a ½ turn spin and recovery are required. In New Zealand, there are no mandatory training or flight test requirements for spinning at any licensing level.

1.17.8 *Spin recovery and pilot licensing requirements in the USA*

In 1949, the Civil Aeronautics Board (CAB), who were then responsible for regulatory matters, eliminated the requirement that an applicant for a commercial or private pilot certificate should demonstrate their proficiency in spin entry and recovery. In place of spin training, the CAB prescribed dual instruction in the prevention of, and recovery from, power-off and power-on stalls entered from all normally anticipated flight attitudes. Thus, the main focus of pilot training since 1949 has been the early recognition of stalls, as it was recognised that a spin results from an aggravated stall.

Over 60% of all stall/spin accidents occur during the take-off and landing phases of flight. Emphasis is therefore placed on simulating take-off, departure, and approach to land stalls at altitudes which provide adequate height above ground for recovery. Because the flight altitudes associated with take-off and landing normally do not allow for recovery from a fully developed spin, it is accepted that spin avoidance rather than spin recovery is the appropriate approach to avoid these accidents. Analysis of stall/spin accidents data indicates that only 7% of stall/spin accidents occur from altitudes where a spin proficient pilot could effect complete recovery.

In 1973, the FAA, now the body responsible for regulatory matters, further emphasised spin avoidance training with the adoption of up-dated regulations which incorporated the provisions of the Flight Test Guide (FAR Part 61). At the same time, the Flight Test Guide itself was revised to move away from requiring the performance of training manoeuvres, exercises which frequently had no practical application. Instead, the emphasis was shifted towards requiring a demonstration of skills in pilot operations, which more closely simulate those operations a pilot actually conducts during the normal use of the aircraft. In a further effort to more closely simulate actual conditions, the FAA issued an advisory circular announcing that flight tests will incorporate distractions to the pilot during the testing of stall manoeuvres, since NTSB data has indicated that most actual stalls occur when the pilot's attention has been diverted from the primary task of flying the aircraft. In a four year period prior to the elimination of spin training in 1949, 48% of all fatal accidents were stall/spin related. In the period 1967 to 1969 the number was reduced to 22%. Between 1972 and 1977 the incidence of stall/spin accidents had fallen to 13% of all fatal accidents.

1.17.9 *Spin training in the Royal Air Force (RAF)*

The present policy of the RAF is not to introduce *ab initio* student pilots to the spin, incipient or fully developed, until after their first solo and the consolidation exercises which follow, and have reached a stage when they are sufficiently advanced in their syllabus to commence training in aerobatics.

1.17.10 *Flying instructor qualification and testing*

At the time of the accident, the minimum flying experience necessary to qualify for an Assistant Instructor's Rating in the United Kingdom was 150 hours pilot-in-command (PIC) with 5 hours as PIC of the type of aeroplane to be included in the rating. To qualify, a pilot would first have to undergo an approved course of training

as a flying instructor and to hold an Instrument Rating or an Instrument Meteorological Conditions Rating. Having completed such a course, the candidate would be tested by an examiner authorised by the CAA for that purpose. Subsequent testing for up-grading or re-validation of the instructor's rating would also be conducted by an authorised examiner. The existing code of flight testing for an instructor on single engine aircraft, which is observed by the panel of examiners, does not specifically require a demonstration of a fully developed spin; recovery at the incipient stage would suffice at the discretion of the examiner. There is no Regulatory requirement for an instructor to demonstrate a full spin as part of his flight test.

Australian and Canadian regulations require flying instructors to demonstrate both full and incipient spins in order to qualify. In New Zealand, spin recovery is an item in the flying instructor's rating syllabus, being non-mandatory at Category C and B level and mandatory at Category A level. In Switzerland an instructor has to be qualified in aerobatics and is required to demonstrate a fully developed spin and recovery.

1.17.11 Physiological and psychological aspects of spinning

1.17.11.1 Physiological – disorientation

The following extract is taken from the AOPA Instructor Manual:

'An important factor in spin recovery action is the positive recognition of the direction of the spin by reference to the turn indicator, but care must be taken not to induce disorientation by asking the student to note instrument aspects (indications) during the early stage of spin training.

A rapid and erratic spin can also disorientate and confuse an experienced pilot.

1.17.11.2 'Freezing'

This is a condition which is identified by extreme muscular rigidity in the sufferer, described as being accompanied by a fixed and rigid facial expression, complete silence and lack of response to question, instruction or commands.

A brief reference to the foregoing, together with a philosophical discussion on the need for spin training may be seen in Appendix 4.

1.17.12 Evidence of 'Freezing' on a PA 38

During the investigation, a report was received from a flight examiner who had experienced the effects of 'freezing' by a flying instructor who was being tested for the renewal of his instructor's rating. The candidate, who had made one previous familiarisation flight in a PA 38, was asked to demonstrate a spin and recovery. The spin was entered from level flight at 5,000 feet and after two turns the candidate was told to recover. After a further two turns, with no response by the candidate, the examiner noted that his eyes were 'glazed', he was perspiring, gripping the control wheel and holding on full pro-spin rudder and elevator control. After telling him again to recover and elbowing him forcibly in the bicep the examiner physically took control at 2,500 feet and recovered from the spin.

1.17.13 *Aircraft safety harness*

The Air Navigation Order (ANO) Schedule 5 specifies that aeroplanes flying for purposes other than public transport are to be equipped with safety harnesses (ie 'full harness') for every seat in use when carrying out aerobatic manoeuvres, provided that in the case of an aircraft carrying out aerobatic manoeuvres consisting only of erect spinning, the Authority may permit a safety belt with one diagonal shoulder strap to be fitted if it is satisfied that such restraint is sufficient for the carrying out of erect spinning in that aircraft and that it is not reasonably practicable to fit a safety harness in that aircraft.

On 12 February 1980 CSE (Aircraft Services) Ltd Oxford, sought permission from the CAA to operate G–BGGH with seat belts and diagonal shoulder straps. The CAA were satisfied that a seat belt and diagonal shoulder strap was sufficient restraint for demonstration of erect spinning but were of the opinion that it was reasonably practical from the engineering aspect to fit full safety harnesses although they were not available for fitment at the time. Consequently, since they were unable to issue a Permanent Permission to use seat belts with diagonal shoulder straps in this aircraft a Temporary Permission was granted for six months to enable CSE to procure and fit safety harnesses; This was the situation at the time of the accident. With effect from 31 July 1981 the CAA required that all PA 38 aircraft used for spinning shall be fitted with a CAA approved shoulder harness.

1.17.14 *Reports of student pilots slipping out of diagonal shoulder straps.*

During the investigation two flying instructors reported that they had experienced incidents when *ab initio* students had fallen sideways out of their diagonal shoulder restraining straps during entry into a spin to the left. In each case the student's bodies had interfered with or obstructed the instructor (in one case fell across the instructor's lap between him and the control wheel) as the aircraft entered the spin. In both instances the instructors were able to recover but not without some physical difficulty, and in one case, with excessive height loss. Both incidents occurred during the introductory spinning exercise. Consequential to the foregoing, the CAA (AD) pilot carried out some tests on a PA 38 with a Chief Flying Instructor in an attempt to assess the risk of slipping out of the diagonal upper torso restraining strap during a spin. A number of spins (8 left and right) were carried out including 4 spins with abused recoveries. For the latter, the AD test pilot disconnected his diagonal strap, leaving the lap strap fastened. The AD pilot reported that at no time were either pilots thrown around in the cockpit; when the diagonal strap was released for the abused recoveries the lap strap restrained him adequately and there was no particular lateral load imposed on the torso.

1.17.15 *Rate of descent and turn in a spin*

According to the manufacturer the rate of descent by a PA 38 in a fully developed spin is approximately 3,000 feet per minute. The rate of rotation is roughly 16 turns per minute, however, an aft CG will slow rates of both rotation and descent. The CAA (AD) test pilot timed the rate of rotation at 2 to 3 seconds per turn, usually nearer 2 seconds, with a height loss of 150 to 200 feet per turn in a smooth developed spin.

1.17.6 *Spinning accidents in the UK*

CAA records show that in the 20 year period, 1960 to 1979, there were 61 accidents which resulted from spinning, of which six occurred during intentional spinning exercises. The proportion of all General Aviation accidents attributed to the spin/stall during this period is not known.

2. Analysis

2.1 The evidence shows that the aircraft was serviceable when it took off from Oxford, it was correctly loaded, it had been properly maintained, a recent rectification of its trim wheel assembly had been properly carried out and no pre-crash defects were found.

The instructor pilot was licensed and qualified to give instruction in spinning but he was not aerobatically qualified. His skills, with the exception of a full spin and recovery exercise, had been recently checked by an authorised flight examiner. The intended exercises on the accident flight included an introductory spinning demonstration but there were no eyewitnesses to the sequence of events which preceded the final stage of the spin which culminated in the accident. It is not known if the spin was preceded by another, neither is it known at what height the spin was initiated, however, since the last reported height was given as 5,000 feet it is reasonable to assume that the spin would have been entered at a height sufficient for safe recovery. It is possible only to speculate as to the precise chain of events which led to the accident but there is, nonetheless, a substantial amount of circumstantial evidence worthy of consideration. This evidence includes: The spinning characteristics of the Tomahawk, the commander's recent flying and training history, the student pilot's aviation background and the results of spinning tests conducted as a result of reported delayed recoveries from spins. There is also the medical evidence. It is proposed therefore to examine the significance of the foregoing in an endeavour to determine the most likely or probable causative chain or contributory factors. The current UK policy on spin training for PPL candidates and Flying Instructor Rating Test requirements are also considered.

2.2 **The accident**

The aircraft was spinning to the right when it struck the ground in a relatively shallow nose-down angle of about 20°. The propeller bore evidence of a degree of power being delivered at impact and this assessment is supported by eyewitness evidence of an apparent increase in engine power just before it crashed. The mechanical evidence of up-elevator being applied at impact is inconclusive. The Tomahawk normally spins in a relatively steep nose-down attitude and it is considered likely that the shallow impact angle may have resulted from the application of engine power whilst spinning with the elevator 'up'. Tests have shown that if a spin is entered with engine power applied the spin will translate into a spiral dive when recovery rudder is applied with the elevator 'up'.

2.3 **Medical – aspects**

It is possible to deduce from the nature of leg and foot fractures that the student pilot was applying full left rudder (anti-spin) at impact, he was also firmly holding the control wheel in his left hand. There was a heavy bruise on the back of his right hand which was caused by striking, or being struck by an object which was not solid but relatively 'soft'. Informed opinion is firm in the belief that the bruise was sustained between one to two minutes before death which was instantaneous at impact. Although the reason for the bruise cannot be established, tests have shown that arm flailing would not occur from accelerative forces during a spin. It would have taken the aircraft about 90 seconds to crash if the spin originated at about 5,000 feet and if medical opinion of the timing of swelling is accepted it follows that the bruise was sustained early in the spin. There is no evidence that the bruise was sustained before the pilots boarded the aircraft.

2.4 Psychological aspects

It is possible to speculate that either of the occupants could have 'frozen' during the spin; there is evidence that this had occurred on at least one occasion in a Tomahawk when an instructor, unfamiliar with its spinning characteristics, was being tested for upgrading. The flight examiner had to resort to physical action and take control. However, since the instructor on the accident aircraft had already gained some experience of the spin characteristics of the Tomahawk, he would be less likely to 'freeze' and hold the control wheel fully back than the student, who had already been involved in a frightening episode in the air as a navigator some 25 years previously, when he had to abandon an aircraft by parachute following a mid-air collision. The student was clearly anxious about spinning, he mentioned this on two occasions shortly before the accident, and it would be difficult to speculate upon whether this went beyond a natural anxiety, which is present in most student pilots when faced with their first spinning exercise. There was, however, a further element which could have adversely affected the issue in the circumstances.

It is considered that the instructor probably had some reservations about spinning the Tomahawk, bearing in mind his experience of a delayed recovery from a spin some six weeks before, and the apparent difficulty he seemed to have with the incipient spin exercise under test conditions at the end of his instructor's course; he was also relatively inexperienced. The student was, in all probability, following the instructor on the controls as is normal practice. The unusually steep nose-down attitude during a spin in a Tomahawk can take most people, including experienced pilots, by surprise when experienced for the first time and tends to inhibit the decisive forward movement of the control wheel which is vitally necessary for prompt recovery. Whether or not the instructor failed to apply sufficient down-elevator, or was prevented from doing so, will never be known but tests results clearly show that continued application of up-elevator or insufficient down-elevator are the only known conditions of control misapplication which can prevent spin recovery on the Tomahawk when spin recovery rudder has been applied. If the assumption that recovery rudder was being applied is accepted it must follow that the aircraft failed to recover from the spin because of control misapplication.

2.5 Tomahawk spinning – certification and subsequent tests

Following its type certification by the FAA the first Tomahawk imported into the UK was subjected to a degree of scrutiny and testing considered appropriate for such an aircraft of this weight category which has already demonstrated satisfactory flight characteristics to a recognised airworthiness authority, having been designed and developed by a well established aircraft manufacturer. It was not until after the accident to G–BGGH, and in the knowledge of delayed spin recoveries which were subsequently reported, that its spin characteristics were more critically examined by the CAA Airworthiness Division. Moreover, since flying instructors in the UK were also critical of the spin recovery procedure given in the Tomahawk POH, as opposed to the 'standard' recovery method normally taught and recognised in the UK, the effectiveness of the 'standard' spin recovery drill on the Thomahawk was also appraised during the tests which were subsequently carried out by CAA (AD) pilots. These tests revealed it was possible to generate a much faster and potentially disorientating spin mode than was apparent to the CAA during its initial validation tests. There was no mention of this characteristic in the POH because it had not been revealed during certification and development testing. Whilst recognising that such a spin mode results from abused or incorrect recovery control applications, which are totally at variance with the drill published in the POH (which the manu-

facturer insisted on being followed), it is nonetheless felt that more specific information on the Tomahawk's spin characteristics should have been included in the POH. The manufacturer decided not to do so because of the number of situations and consequences which would require coverage; they chose only to publish a simple and effective recovery procedure, easily understandable to the operator. The results of subsequent testing by the CAA and the discovery of the more rapid spinning mode confirmed the correctness and effectiveness of the existing POH recovery drill as well as the 'standard recovery' procedure recognised in the UK; however, the manufacturer agreed at the request of the CAA, to include in the POH an amended and more comprehensive chapter on spinning. This reflects a responsible attitude to flight safety as a result of the experience gained.

2.6 Delayed recoveries from PA 38 spins

With regard to the accident under consideration, the fact that the instructor experienced a delayed recovery about six weeks beforehand, and mentioned the matter in passing to his flight manager, is thought to be of some significance as an event leading up to the accident although, at the time, it was not viewed with any concern. The flight manager took what he considered to be adequate steps to satisfy himself that the commander (instructor) had acted correctly. The instructor also agreed to let him know if he experienced a recurrence in that particular aircraft. Since no further difficulties were reported by the instructor, the flight manager made no arrangements to positively check his technique in the air; he was, however, aware that the instructor was due to be re-tested in the near future for up-grading and was under the impression that 'the test would include spinning.' When the up-grading test took place, however, the examiner had no knowledge of the incident of a protracted spin recovery or of the instructor's previous test performance, nor did he test the instructor in the full spin and recovery sequence. The demonstration of this exercise was not a mandatory or legal requirement although the examiners try to include a full spin and recovery demonstration whenever possible. In any event, the weather conditions on the day of the test would have prevented the exercise from being properly demonstrated.

It can only be assumed that the flight examiner would have taken steps to satisfy himself that the instructor was totally competent in the full spinning exercise, had he been aware of the instructor's previous incident or, for that matter, his shortcomings in the incipient spin exercise as shown on test at the end of his instructor's course. The examiner was apparently unaware of these matters, he acted in good faith and conducted the up-grading test in accordance with the procedures observed by the Panel of Examiners. On the other hand, it could be argued that prior knowledge of an instructor's history would not have been in the interests of a fairly conducted test.

When viewed from the vantage point of hindsight, and in the knowledge that other more experienced instructors revealed some disturbing deficiencies in their spin recovery techniques during the spinning trials conducted by the CAA, had there been any similar shortcomings in the commander's handling techniques the existing flight test requirements for instructor testing provided no guarantee that these would have been discovered and rectified. It is not considered, nor is it intended to imply, that the commander of G–BGGH was anything other than competent; he was properly qualified and his competency as an instructor pilot had been confirmed in accordance with accepted UK practice. Nonetheless, it is indisputable that he had never been tested in the full spinning exercise by an authorised examiner, either during his initial qualification test or subsequently on up-grading. It cannot

therefore be stated with any degree of authority that the commander's spin recovery technique on the Tomahawk was known to be correct and had remained so following his course of instructor training.

A number of flying instructors on the Tomahawk had experienced delayed recoveries from spins before the accident to G–BGGH, but no one thought it necessary to report the incidents to the CAA through the Mandatory Occurrence reporting procedure. Had this been done, it is more likely that positive steps would have been taken to investigate the matter at an early stage. It is therefore concluded that the apparent reluctance of flying instructors on Tomahawk aircraft to report instances of delayed recoveries from spins was a contributory factor to the accident.

2.7 Spin training and licensing requirements – Summary

The existing training syllabus for a PPL in the UK requires that student pilots are given training in spinning; the emphasis being on spin avoidance, but it is also recognised and accepted that a realistic training programme based on such a premise requires the student to experience and be competent to recover from a fully developed spin. There have been a number of accidents resulting from spin training in the UK during the past 20 years. The proportion of such accidents to all other General Aviation (GA) accidents (expressed as a percentage) is not known, and in any event it would be difficult to draw valid conclusions by merely comparing UK GA accidents statistics with those of the USA during this period. However, the statistics provided by the FAA for similar types of accidents in the USA show a remarkable reduction in stall/spin accidents from 48% to 13% since spinning was discontinued as a training and licensing requirement in the USA 31 years ago. The emphasis during training being placed on stall avoidance as opposed to spin avoidance, it being recognised that a spin results from an aggravated stall.

Similar policies are followed in Switzerland, Australia, Sweden, Denmark and France, moreover, it is also recognised that instruction in deliberate spinning, when required, say for an aerobatic rating, should be given by instructors commercially qualified with aerobatic ratings. In Canada, on the other hand, a full spin and an incipient spin are required to be demonstrated by PPL candidates. Nonetheless, the instructors are also required to demonstrate their proficiency in this manoeuvre. In Switzerland spinning is only permitted on aircraft certificated for aerobatics, which the Tomahawk is not. It may be seen that spin training and licensing requirements differ throughout the world but it is of no small significance that in countries where spin training is required for PPL or aerobatic ratings, the instructors are also required to be so qualified and to demonstrate their proficiency in the spinning exercise in order to qualify, up-grade or re-validate their instructor's ratings. There is no legal requirement for instructors to demonstrate the full spin and recovery in the UK. The Royal Air Force require flying instructors to be qualified in all facets of flying and, perhaps of equal significance, RAF *ab initio* trainees are not introduced to spinning until after their first solo and the consolidation exercises which follow, and are about to commence aerobatic training. Whilst recognising that spinning and aerobatics are an essential part of a military pilot's training it must also be stated that spin training accidents continue to occur at random intervals in spite of the highest instructional standards.

The question of spin training has long exercised the minds of flying instructors in all parts of the world as well as on either side of the Atlantic; there are arguments for and against spin training, its retention or its reintroduction. This particular accident, the circumstances surrounding it, and the spinning characteristics of aircraft such as the Tomahawk, and the recurring accidents which result from instructional, deliberate or unintentional spinning seems to call for an informed dialogue or debate into the matter of spin training and licensing requirements in the UK.

3. Conclusions

(a) *Findings*

1 The commander was properly licensed and qualified to instruct on PA 38 Tomahawk aircraft; he was also qualified to instruct in the spinning exercises.

2 The aircraft was correctly loaded, it had been properly maintained and it had a valid Certificate of Airworthiness.

3 The intended exercise included deliberate spinning for which the student pilot had been previously briefed.

4 The aircraft entered a spin at a height which was sufficient for a safe demonstration and recovery; it failed to recover whilst spinning to the right.

5 Recovery rudder was being applied when the aircraft crashed.

6 Failure to recover was probably due to control misapplication.

7 The reason for control misapplication cannot be established.

8 The Pilot's Operating Handbook did not contain sufficient information about the Tomahawk's spinning characteristics and the likely effects of mishandled controls during spin recovery.

9 The Tomahawk is a safe spinning aircraft provided the correct recovery drill, given in the Pilot's Operating Handbook, or the 'standard' recovery drill recognised in the United Kingdom, are applied and sustained.

10 In view of his experience and the incident of a delayed spin recovery, the ability of the instructor commander of G–BGGH should have been positively checked in the spinning exercise when he was tested for upgrading to a full instructor's category.

11 Testing requirements for UK flying instructors on single engined aircraft do not ensure that spinning is always included.

12 Spin training at an early stage in a pilot's training is of questionable value and the need to include this exercise in a PPL syllabus should be reviewed.

(b) *Cause*

The accident was caused by the failure to recover from a deliberately induced spin. It is considered probable that control misapplication was the major factor in preventing recovery from the spin. Failure to report previous incidents of delayed recovery from spins in Tomahawk aircraft, including the incident which had already been experienced by the commander, were contributory factors to the accident.

4. Safety Recommendations

It is recommended that:

1 Flying instructors on PA 38 Tomahawk aircraft in the UK should be positively checked in their ability to correctly demonstrate the full spin and recovery sequence during their initial qualification test and on subsequent up-grading or rating re-validation.

2 The need for spin training for basic PPL licensing requirements in the UK should be critically reviewed.

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