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General Aviation Safety Council

A Study of Fatal Stall or Spin Accidents to UK Registered Light Aeroplanes 1980 to 2008

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Preface

GASCo wishes to thank the members of the stall/spin working group, who were:

AvM John Brownlow, CB, OBE, AFC, FRAeS	Member of the RAeS General Aviation Group, Former Test Pilot and GASCo Board Member
Nigel Everett, MA(Cantab)	Private Pilot and Editor of GASCo's 'Flight Safety'
Dr Guy Gratton, C.Eng, FRAeS, MIMechE, MSETP	Test Pilot and Senior Visiting Research Fellow in Aeronautics, Brunel University
Mike Jackson, BSc (Maths and Statistics)	Private Pilot and GASCo Board Member
Irv Lee, BSc(Aero Eng)	GA Instructor and Editor of the GASCo 'Fly on Track' Web Site
John Thorpe, FRAeS	GASCo Chief Executive 2003-2010

Special recognition is given to Mike Jackson and John Thorpe who were the principal compilers of this report. They undertook a very large amount of research and analysis for its preparation.

Grateful thanks also to a number of senior instructors/examiners who gave their time for consultation during the research.

These included:

Pat Chandler, Paul Doble, Nick Goodwyn, Malcolm Hunt, Roger Mills, Patricia Nelmes, David Scouller, Chris Stringer, Barry Tempest.

Abstract

Examination of fatal aeroplane accidents between 1980 and 2008 revealed that loss of control due to a stall or spin was the largest single factor, being present in **36%** of them.

This study addresses single engine piston aeroplanes excluding microlights, as defined in the Air Navigation Order 2009, and warbirds. The **110 accidents** were analysed to determine the factors affecting each one

Amongst the findings were that:

- the percentage of fatal accidents due to stall/spin has remained almost unchanged during the period;
- there has been a major change in the pattern of accidents during the period. Early in the period there was a high percentage of accidents during low aerobatics/displays/beat-ups which were all but eliminated towards the end of the period. Conversely, in the 1980s there was a very low percentage of accidents following engine or airframe problems but since 2000 it has become the trigger for half of the accidents;
- there are marked differences in accident rates per 100,000 hours between aeroplane types. Also, there are many types with a significant number on the UK register and zero stall/spin accidents. For instance, the Piper PA28 has the greatest number of hours of all types and every one of the accidents were to the earlier constant chord wing version;
- early in the period the stall/spin accident rate for aircraft under 600kg max gross weight was very much greater than that for heavier types. Since 2000 the figures have improved markedly, but are still considerably greater;
- the accident rate for the Slingsby T67 was throughout the period much greater than any other certified type and has been treated as a special case;
- with only one accident involving the Cessna 152 in 2.5 million flying hours, its record is similar to the tapered wing PA28, whereas the Cessna 150 K, L and M models have had eleven in one million hours. Investigating this, Brunel University, Uxbridge have carried out flight trials on several Cessna 152, 150L and 150M aeroplanes using calibrated data recording equipment to determine control loads etc. This showed significant differences, e.g. the stick force to stall the aeroplane was greater in the C152 thus providing a better alert to the pilot;
- turning finals was long held to be a high risk point but the climb-out has now replaced this;
- it is a matter of concern to the group that in 22% of the accidents there was an instructor on board as a crew member, although not always performing a training function. There has only been one fatal accident to a solo student since 1987;
- apart from the Slingsby T67, no significant problem has been revealed in spin recovery.

For each of the accidents the Air Accidents Investigation Branch (AAIB) reports were carefully examined to enable a range of other possible causal factors such as weather hazards to be considered. Pilot experience and the influence of spectators were also analysed. Professional advice has been taken to ensure that none of the findings were simply 'statistical blips'. As a result of the investigation, nine Recommendations have been made covering education, certification, supervision and pilot training.

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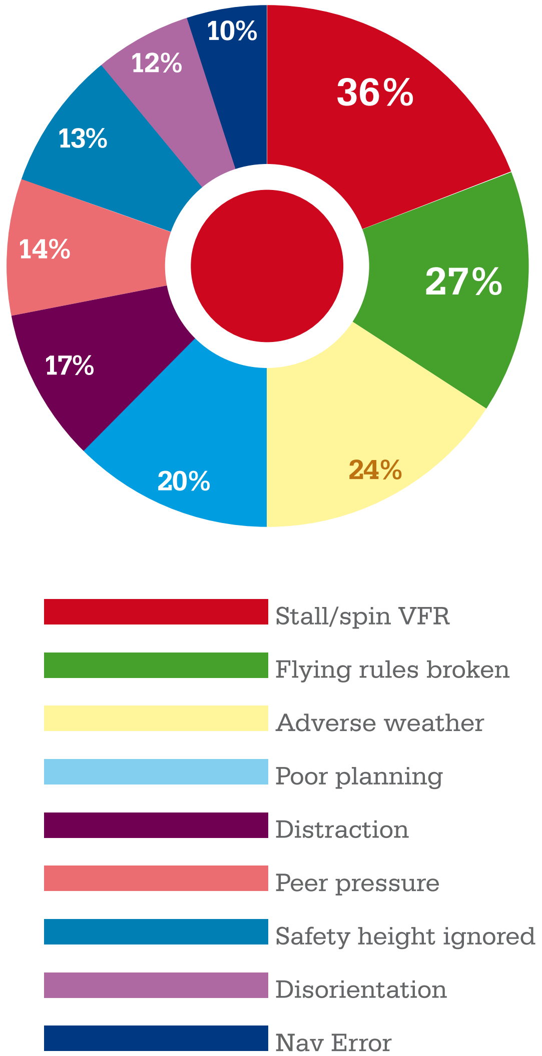
Contents

1. Introduction

a) During the period 1980 to 2008 there were 359 fatal accidents to UK registered aeroplanes of 5,700 kg maximum gross weight and less. After careful analysis of this total, 130 were found to be due to the pilot failing to maintain control resulting in a stall or a spin, i.e. 36%. These occurred in a variety of different types of accident including the result of the pilot deliberately low flying, performing a beat-up or aerobatics close to the ground, during display practice, losing control during a forced landing, mishandling in the circuit or during training. Loss of control for reasons other than stall/spin e.g. in Instrument Meteorological Conditions (IMC), were not considered.

b) From Fig.1 it can be seen that during this 29 year period stall, which sometimes resulted in a spin, in visual flying conditions was the biggest single factor in fatal accidents. This resulted in 216 deaths, more than 7 people per year. Accordingly, GASCo established a small working group (See Preface) to examine the accidents in depth to determine the contributory factors and to propose measures to reduce the number. These accidents were studied in much greater depth than for the CAA study of all fatal accidents 1985 to 1994, published in March 1997 as CAP 667 'Review of General Aviation Fatal Accidents 1985 to 1994'. Also, by covering a much longer period, significant trends have been revealed.

Fig. 1 Percentage of fatal accidents to aeroplanes of 5,700 kg & less 1980 – 2008



2. Accidents and Aircraft Excluded from Analysis

a) Only fatal accidents were considered as these are able to be precisely defined and have been fully investigated and comprehensively reported by the Air Accidents Investigation Branch (AAIB), or where outside the UK, by the relevant foreign authority. A data base of these accidents was available for this study and is summarised in Appendix 1. No comparable data base for non-fatal accidents is available, and the usefulness of the study could have been compromised by a lesser level of or non-existent investigation. This might have led to doubt as to whether stall/spin was a factor in the accident had the study included findings of other possibly less thorough investigations.

b) In order to concentrate the analysis on the sort of aeroplanes flown or owned by private pilots, whilst providing a reasonably sized data sample, of the 130 fatal stall/spin accidents the following have been excluded from the analysis:

- twin-engine aeroplanes, (11 stall/spin accidents, most were loss of control after failure of one engine);
- warbirds, including Harvards, (6 stall/spins, most frequently in an airshow/practice environment);
- jet powered aeroplanes (3 stall/spin accidents);
- microlights, as defined in the ANO, gliders (but motor gliders are included), helicopters and gyroplanes;
- the Slingsby T67, (8 fatal accidents) was excluded from the main numerical analysis but was studied as a special case (See Appendix 2).

c) There were a few 'unusual' accidents with unique circumstances which it could be argued should not be included in the analysis. Examples include three cases of pilots who were flying while under the influence of alcohol or drugs, a case of carbon monoxide poisoning, an unintended first flight and a pilot who had a heart attack during flight while suffering from a major known but undeclared medical condition. Nevertheless, these aircraft stalled or spun and are therefore included in the analysis.

d) Thus during the 29 year period, the analysis is left with 103 fatal stall/spin accidents involving readily available single-engine aeroplanes, that resulted in the death of 165 people.

3. Analysis and Discussion

3.1 Annual Trend

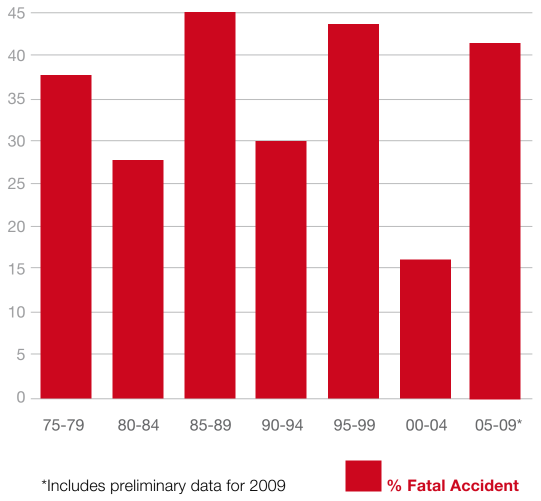


Fig. 2 Aeroplanes of 5,700 kg & less, stall/spin accidents as a percentage of all fatal accidents

In Fig. 2 it can be seen that there has been little change overall in the percentage of fatal accidents which are the result of the aeroplane stalling or spinning, although there is considerable variation in the 5 year blocks. Nevertheless, this masks major trends in the accident rates over the period for different circumstances, particularly for aerobatics, when coping with an engine or airframe problem, and for light weight aircraft. These are addressed later.

3.2 Aeroplane Type

a) Table 1a lists the number of accidents for each type judged to have had a stall or spin when it crashed fatally, bearing in mind that the number of each type on the UK register varies widely.

b) The aeroplane types with three or more fatal accidents have been examined in greater detail using hours data from Certificate of Airworthiness (C of A) and Permit to Fly records to obtain a rate per 100,000 flying hours. As can be seen in Table 1b there were major differences between those types which had a significant number on the register. There are two features that significantly influence the results, namely the warning when approaching the stall and behaviour at the stall.

c) The Slingsby T67 has lost 10% of its UK civil fleet in stall/spin accidents and it was decided to treat these 8 accidents as a special case (see Appendix 2) to prevent a bias in the general results.

d) There have been 11 accidents on the Cessna 150 but only one on the Cessna 152, with 60% more hours flown by the C152. Further work revealed that all 11 cases were on the Cessna 150 K, L and M models. The single K model accident was when both pilots were under the influence of alcohol, but this was not a factor in accidents in any other model C150. The 10 cases on the L & M models were out of 155 on the UK register, with zero accidents on the 100 A to H models.

e) As a result of this finding Brunel University, Uxbridge, under Dr Guy Gratton have undertaken detailed flight testing of the C150 L and M and the C152 with the aim of pin-pointing the differences in flying qualities between them. One of the findings was the difference in elevator stick force at low speed to achieve a stall in the Cessna 150 L & M when compared with the C152. The latter's stick force was greater, thus making it harder for the pilot to inadvertently enter this regime. The C150 results appear to be at variance with current certification requirements. It was therefore felt that this was best addressed by Familiarisation Training. There is a comprehensive description of the low speed flight characteristics of the Cessna F150L on page 85 of AAIB Bulletin 7/2007* as part of the investigation of the 2006 Southend accident. This included the following:

"In level flight the aircraft decelerated and eventually stalled, with a high nose attitude, at approximately 42 mph IAS (37 KIAS). Approaching the stall, the IAS fluctuated by approximately ± 2 mph. As it stalled, the example aircraft rolled quickly to the left, adopting a bank angle of approximately 60º within one second. Simultaneously, the nose dropped approximately 45º below the horizon and a high rate of descent developed. Holding the control column fully aft produced a tighter turn but no reduction in the rate of descent. Entering the manoeuvre from a turn to the left resulted in a high rate of turn as soon as the aircraft stalled. Recovery was achieved by relaxing the back pressure on the control column and applying full power, which resulted in a height loss of at least 400 ft. Without positive recovery action the aircraft entered a steep spiral dive with anti-clockwise rotation as viewed from above. Each time the manoeuvre was repeated, the aircraft behaved in the same manner. On each occasion an audible stall warning sounded approximately 5 mph before the stall". (Recommendations 5.1 and 5.2).

* Available on www.aaib.gov.uk via Publications, Bulletins, Archive and year listing.

Flight tests carried out by GASCo indicate that the C152 may lose much less height than the C150 when tested as above.

f) Examination of the Piper PA 28 accidents revealed that there were six accidents to the older constant chord straight wing PA28-140/180, but the UK record shows no fatal stall/spin accidents to the tapered wing PA28, introduced in 1975, i.e. models -151, -161, -181, -201, and -236, of which there are about 650 on the UK register.

g) The record by aircraft type clearly shows that there are some which have 50 or more on the UK register (although the number which are active is variable) and which have not had any stall/spin accidents. These are listed in Table 2. Pilot anecdotes for some types reveal that they have ample natural warning and benign characteristics.

3.3 Weight Category

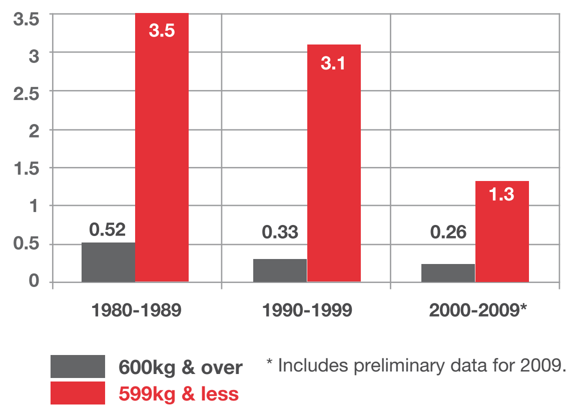


Fig. 3 Stall/spin accident rates per 100,000 flying hours for the two weight categories

Analysis showed that the accident rate was much greater for lighter weight aeroplanes. The figures show that this rate increases sharply for those below 600kg maximum gross weight, although the rate improved markedly during the period of study. Nearly all of these aeroplanes are amateur built, and are known to vary considerably in handling characteristics, especially around the stall. Pilots of microlights, as defined in the ANO(2009) and excluded from this study, are required to be trained in that class of aircraft, whereas for light weight aeroplanes which do not come in that category, the required training is that for a normal PPL. This may ill prepare them for lightweight types. Recognising this, the Light Aircraft Association has for many years operated a coaching scheme, tailored to the particular type flown by each pilot. Pilots operating such types are strongly recommended to participate in this scheme or obtain training with an instructor well experienced on the type. (Recommendation 5.3).

Above 600kg, the accident rate for amateur built types is not significantly greater than for certificated aeroplanes, there being no stall accidents on types such as the Lancair, Glasair or the RV series and the only one to a Europa was during an unintended flight by the owner with zero hours on the type.

3.4 Activity and Circumstances

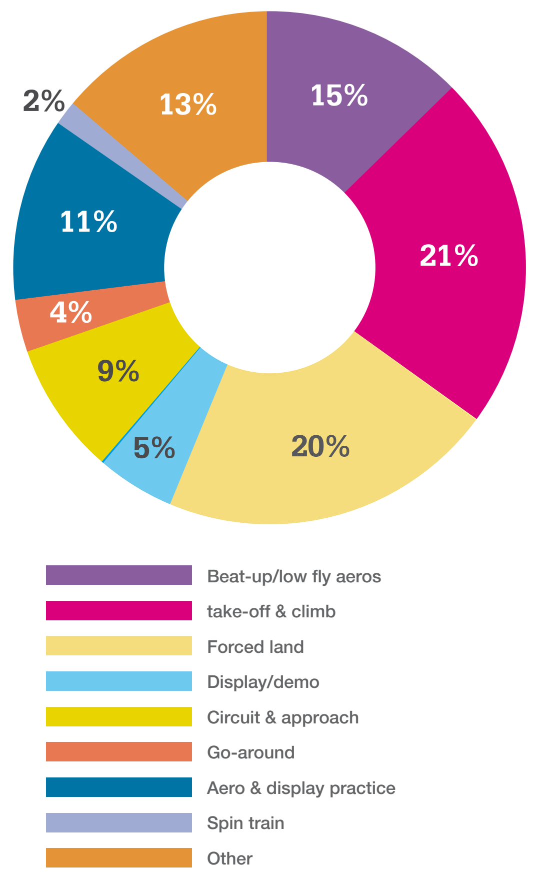


Fig. 4 Activity or flight phase at time of accident 1980 - 2008

a) The accidents occurred in a range of up to 25 different identifiable circumstances, see Fig. 4 for the 8 main circumstances. There were 21 cases during take-off and climb, particularly during slow or steep climbing turns. This is followed by 20 forced landings, and by cases of beat-ups and low aerobatics/flying with 15 fatal accidents. Next are 11 cases during climbs as part of aerobatic sequences (particularly show-off climbing turns). There were 4 during actual spin training*. The 'Other' group ranged from air-to-air photography to air racing and scud-running in a blind valley. The numbers indicate that responsible normal flying carries little risk whereas beat-ups, displays, low flying and showing off carry a much higher risk.

* See Civil Aviation Authority (CAA) Handling Sense Leaflet 3 'Safety in Spin Training', available on the CAA Web Site www.caa.co.uk

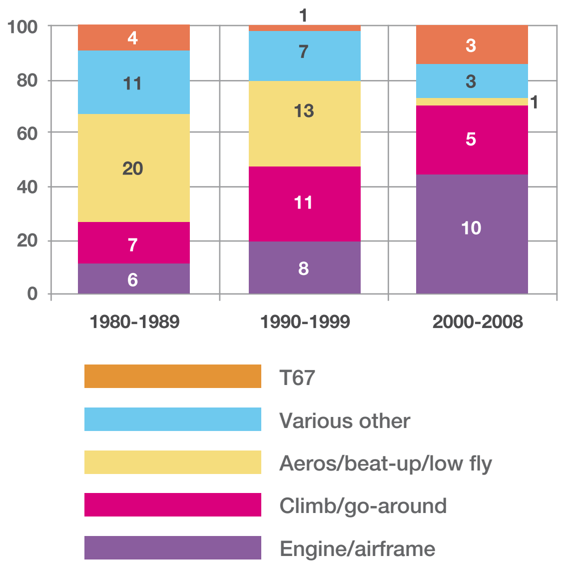


Fig. 5 Number of accidents by decade and circumstances

b) Examination of the accidents by decade and circumstances reveals that the number and pattern of causes has changed significantly during the period 1980 to 2008 as shown in Fig. 5. With the exception of the Slingsby T67, there has been near elimination of cases of display/aerobatic accidents and a reduction of near-random causes. However, there has been a steady increase in the number of accidents where pilots failed to maintain control when confronted with or distracted by an engine or airframe problem. This group accounted for the largest proportion of the cases since the year 2000. Preliminary information indicates that this trend continued in 2009. This factor alone shows that there is a need for the work to be followed-up. The 'traditional' high-risk situation when turning finals appears to no longer be true. (Recommendation 5.4).

3.5 Location

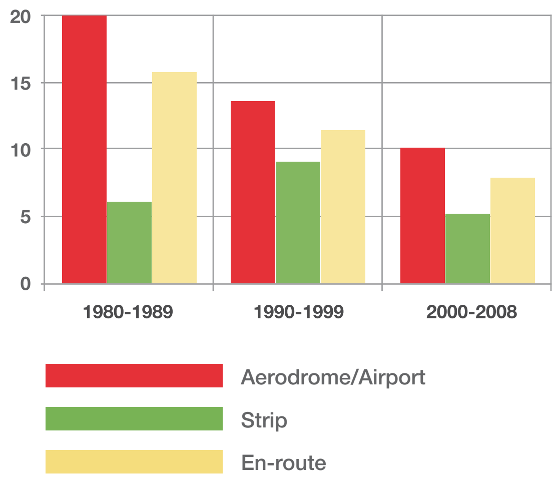


Fig. 6 Location of stall/spin accidents

The location of the accident reveals that the majority happened at licensed aerodromes and airports, with a smaller number en-route which covers the open Flight Information Region (FIR), practice area, or while on a cross-country. The lowest numbers were at strips, where there is probably a much smaller amount of activity compared with the aerodromes/airports and where any degree of control or supervision is much more difficult.

3.6 Height

a) Obviously the more height in hand, the better the chance of recovering from an inadvertent stall or spin, which is why the vast majority of fatal accidents were estimated by witnesses to have followed loss of control at a low height. Because of the different pattern of accident circumstances this decade, the analysis of cases by aircraft height, were examined to see if this has also changed. Whilst the numbers are relatively small, it is clear that there are only high and low, without any intermediates with the majority at a low level from which spin recovery would be impossible. As may be expected, the high level cases were all from developed spins from which recovery was mishandled or not made in time. Figures between 2000 & 2008 are:

300' and below	12	
500' to 800'	4	
800' to 1800'	0	
Over 1800'	3	(plus three SlingsbyT67s; two of which were with a student under instruction)
Total		(22 if T67 is included)

b) The three miscellaneous 'High' accidents were:

- Piper PA24 Comanche where both occupants were affected by carbon monoxide poisoning from a cracked exhaust manifold.
- Grumman/Gulfstream AA1 at 5,000ft on a navigational exercise, widely fluctuating speed seen on radar, may have been practice stalls. It was over the maximum permitted weight and the centre of gravity, cg, was aft of the permitted limit. The ensuing spin was probably in an untested region of the flight envelope and possibly irrecoverable.
- CAP 222 inverted spin after error in completing practice aerobatic manoeuvre from 2,300 ft.

3.7 Stall Leading to Spin

a) According to eye witnesses and/or ground impact evidence it appears that in 50 of the 103 accidents, a spin or incipient spin had developed. In a few cases the aircraft was in a spin deliberately and the recovery was too late. There are aircraft types where it is known that a spin will readily develop when the aircraft stalls whilst some are reluctant to spin and may enter a spiral dive, or just nod or mush down, whilst others exhibit classic pitch-down without a wing drop.

b) There are those who regret the removal of compulsory spinning from the Private Pilot Licence (PPL), syllabus in the mid-1980s, although it is retained in the gliding training syllabus. The fact that in this paper a large proportion of accidents where a spin develops were too low for recovery, whilst a further 4 accidents (2 being in the T67) were during spin training, would seem to support its removal. However, it should be borne in mind that pilots can if they wish, request spinning during their training or at any time. All instructors are required to undertake spin entry and recovery during instructor training and revalidation.

c) It would appear that with the exception of the Slingsby T67, there is no further reason to address spins and spin recovery.

3.8 Type of Stall Warning

a) Stall warning is usually provided to pilots by the onset of natural buffet, or visual, audio, vane, or combined warning light and reed audio systems. It has not been possible at this stage to obtain enough information to draw meaningful conclusions on the relative effectiveness of the different types of stall warning. Furthermore stall warning systems can sometimes be miss-rigged so that early spurious warnings 'cry wolf' and pilots become blasé and ignore the warning. It is also well known that the panel light, as on early Piper PA28s and others, can be readily overlooked in bright sunlight. The recent withdrawal of the requirement to air test an aircraft as part of the C of A renewal means that the important airborne check of stall warning accuracy will in future not be done, although it will continue to be checked on a Permit aeroplane. The long term consequences of this change remain to be seen.

b) Some military and transport aircraft have for many years relied upon angle of attack indication to warn of the onset of the stall under all flight conditions including during 'g' loading, sometimes reinforced with a stick shaker or even a stick pusher. Development of electronic flight panels for general aviation aircraft now means that angle of attack indication is available at reasonable cost either as part of a panel or separately. Investigation of these systems would determine their effectiveness and limitations. (Recommendation 5.5).

c) Psychologists have shown that particularly when a pilot is under stress, audio warnings may not be perceived under some circumstances. They have also shown that a pilot's ability to process information reduces with increasing stress*.

References: *(1) RD Patterson & TF Mayfield, Auditory Warning Sounds in the Work Environment, Philosophical Transactions of the Royal Society of London, 327, 485-492 (1990)*
(2) H Selye, The General Adaptation Syndrome and the Diseases of Adaptation, The Journal of Clinical Endocrinology Vol. 6, No. 2 117-230 (1946).

3.9 Weather

Most accidents were in good weather, but turbulence, low cloud, thunderstorm, mountain downdrafts, scud running and high ambient temperatures all featured in others. Low cloud resulting in pilots attempting to perform aerobatics, or aerobatic practice with insufficient height or room to recover from a poorly executed manoeuvre, was also an effect of the weather.

3.10 Pilot Experience

a) Overall data on pilot hours is not readily available, however in the absence of any other source AAIB Bulletins provide the details on both Total Hours and Hours on Type. All 140 non-fatal accidents in one recent year to UK registered aeroplanes of the classes considered in this Study were analysed to use as a basis for comparison. It appears that up to 100 hours on type or total, a pilot is more likely to have a fatal accident than a more minor accident whilst with 100 hours or more the percentages are similar until a pilot has over 1,000 hours when the chances of a pilot having a fatal accident compared with a non-fatal accident, diminish.

	Total Hours		Hours on Type	
Hours	All non-fatal accidents	Fatal stall accidents	All non-fatal accidents	Fatal stall accidents
0-9	0%	0%	11%	17%
10-99	8%	13%	41%	46%
100-499	44%	41%	32%	30%
500-999	14%	21%	7%	6%
1,000+	34%	25%	8%	2%

b) Pilot experience could be thought to have a major influence on ability to recognise the symptoms of the onset of a stall or incipient spin and the likelihood of it occurring in a particular flight regime. In 47% of fatal stall/spin accidents the pilot had more than 500 hours, (all accidents 48%), of which 26%, (all accidents 34%) had over 1,000 hours and two had more than 10,000 hours. In the early days when flying dual or under supervision the number of stall/spin accidents was lower but were more likely when the pilot was finding his feet than later on with over 1,000 hours. It cannot be determined what part distraction, complacency or other factors contributed to the outcome.

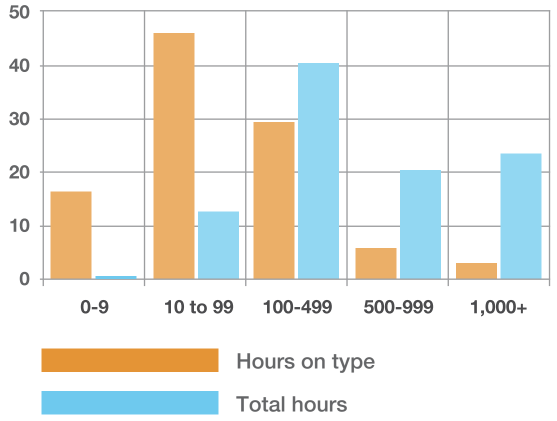


Fig. 7 Number of accidents versus hours on type and total hours

c) However, when it comes to hours on type, this is much more relevant than total hours. Fig. 7 clearly demonstrates this observation as over 60% of fatal stall/spin accidents are to pilots with less than 100 hours on type and close to 20% have 9 hours or less. It may be that a significant factor is the need for pilots to remember important speeds such as best climb/glide and landing threshold speed, and under stress they may use numbers relevant to a different type, or forget them altogether (see para 4.4). Nevertheless, in two accidents the pilot had more than 1,000 hours on type. In the 10 Cessna 150 L & M model accidents, 4 of them were during:

- a display practice by an instructor,
- an experienced PPL in a precision flying competition,
- an experienced PPL undertaking low level photography and
- an instructional flight by a new instructor.

The remaining 6 were low time PPLs or students with an average of 61 hours total time and 40 hours on type.

d) Although about 5% of pilots are female, all pilots involved in the accidents studied are believed to be male.

3.11 Disorientation and Distraction/Overload

a) Disorientation is generally associated with loss of control in instrument conditions, most often leading to a high speed spiral dive. Nevertheless, there appeared to be at least 6 stall spin accidents where it seemed the pilot had become disoriented. The circumstances included spin training, carbon monoxide poisoning, patchy cloud and tight low-level turns in a strong wind.

b) It was difficult to judge from the information available to the AAIB when producing their reports, whether the pilot had got into or been placed in a situation where he was overloaded or distracted from the main task of flying the aeroplane whilst simultaneously too much was going wrong at once to be able to cope with. Where this could be established from the witness or ground evidence, in at least 9 cases, with a number of possible others, the pilot was in such a situation. This is impossible to verify as the evidence is lost with the pilot. However, the accident almost always followed something else going wrong. These ranged from strong winds and seat slippage to an open baggage door and being faced with an engine failure when out of flying practice.

3.12 The Contribution of Engine and Airframe Problems

In 16 (16%) of the accidents, total or partial loss of power acted as a trigger for the accident. Mishandling of the attempted forced landing or inadvisably turning back at too low a height often followed these trigger events. On a few occasions, an aircraft problem such as an open hatch or door was the trigger. As detailed in para. 3.4b, since the year 2000 there has been a doubling in the rate since the 1980s and steps should be taken to address this issue via education, in particular that pilots should regularly practice forced landings and glide approaches. (Recommendation 5.4).

3.13 The Influence of Spectators

The presence of spectators, even a couple of family or friends, contributed to pilot behaviour as many are extroverts keen to show off their supposed skills by playing to an audience. Sadly, on 26% of accidents the pilot had an audience when he was killed. The near elimination of this type of accident during this decade compared with the previous 20 years may be an encouraging sign that the message has got through. Nevertheless, the message still needs to be repeated so that new pilots are not tempted to push themselves or the aeroplane to the limit and beyond just because people are watching.

3.14 Presence of an Instructor

a) It is a matter of considerable concern to the group to find that in 22% of the accidents (when the T67 was included) an instructor was either in command or was on board as part of a training flight or was accompanying a qualified pilot. Some might consider this is an unacceptably high percentage. This matter necessitates further investigation and education but may in part be covered by the recommendation that instructors should be checked out on type before they train pilots yet to obtain their licence. This is not intended to include the biennial one hour of flight instruction required by qualified pilots to retain their licence. (Recommendation 5.6).

b) There has been just one solo student case since 1987, the C150 at Southend in 2006, (see AAIB Bulletin 7/2007) whereas in the same period there were 12 cases where an instructor was on board with a student. Reports from the US also show that there is a much higher incidence of a fatal stall/spin when a student is with an instructor than when solo.

4. Further Discussion

4.1 General

a) The underlying emphasis should be the encouragement of accurate flying habits which keep pilots well clear at all times from being unintentionally near the stall. One school of thought among experienced instructors is that the habits acquired during initial training influenced a pilot throughout later flying, see also para. 4.7 c.

b) Earlier in the paper it was pointed out that from the 1980s to 2000s there had been a substantial reduction of fatal accidents as a result of low aerobatics, displays and beat ups etc, leading to their near elimination. Furthermore, with the exception of the Slingsby T67, there have been no recent instances of unrecovered spins from reasonable height, apart from cases where other known factors applied. It was therefore concluded that no further investigation of spin recovery was needed within this study.

c) The rate of fatal accidents due to stalling in other situations has remained almost constant over the whole period, masking the fact that the accident rate due to stalling when the pilot was coping with an aeroplane problem has doubled. It is also apparent that contrary to popular belief, stalls during the base/final turn are now rare whilst they now occur much more frequently during the climb-out.

d) Since regulation is unlikely to be effective where stall/spin is concerned, the only realistic option is education. Although there are two CAA Handling Sense Leaflets*, No.2 'Stall/Spin Awareness' and No.3 'Safety in Spin Training', these are little known and have not been widely distributed, publicised. or made available in hard copy except as part of LASORS. By comparison, the comprehensive series of CAA Safety Sense Leaflets are well known and widely available but do not include one on 'Stall Spin Avoidance'. Every effort should be made to prepare and distribute a copy of a new 'Stall Spin Avoidance Leaflet', which draws on this study, to all pilots. Consideration should also be given to the production of a DVD'. This would also assist in meeting a number of other recommendations. (Recommendation 5.4).

* Available on CAA Web Site www.caa.co.uk by following Safety Regulation, Ops & Airworthiness, Flight Operations, to General Aviation where they are listed.

4.2 Aeroplane Types

a) The Slingsby T67 stood out strongly, not just because of 8 fatal accidents to the 80 on register, but because it was the only type with a record of unrecoverable intentional spins from a supposedly safe height, with a spin-trained pilot in command and no other known factors. The only other cases were an unusual one on a Piper PA28-140 where the cg was too far forward and on a Piper PA38 Tomahawk. Thus the T67 was treated as a special case. All were on the smaller engine -160 and -200 types, of which there are now less than 50 on the register. The RAF consider that they are a significantly different type from the larger engine -260 version.

b) The Cessna150/152 and Piper PA28 were discussed in para. 3.2 d & e the numbers being as follows:

	Cases	Hours 1980-2008	Rate/100,000 hrs
T67/4cyl	8	206,000	3.9
T67/6cyl	0	112,000	0
C150 A-J	0	425,000	0
C150 K/L/M	11	1,103,000	1.0
C152	1	2,630,000	0.04
PA28 tapered wing	0	2,808,000 (estimated)	0
Aircraft 600kg and over	83	22,460,000	0.37 per 100,000 hours
" less than 600kg	25	1,754,000	2.50 per 100,000 hours

c) The Piper PA28 tapered wing and the C152 together have had just one fatal stall accident in over 5.4 million hours. These types are currently used for a substantial proportion of ab-initio flight training. Consideration should be given to suitable training/briefing/education to prepare these students to fly aeroplanes which may 'bite' at the stall. (Recommendation 5.7).

4.3 Out of Balance

Accidents are more likely when the pilot in command has low number of hours in the aeroplane type. Behaviour around the stall differs greatly between types, especially with respect to the presence or absence of pre-stall buffet or wing-drop. Furthermore, certification standards do not require stall behaviour to be tested with the aircraft in yaw. Since a large proportion of unintended stalls occur after engine failure or other aircraft problem, the aircraft may well be out of balance when the stall occurs, which may be expected to increase the rate and/or the angle of wing drop, hence height loss before recovery. It may be that the Design Requirements of European Aviation Safety Agency (EASA) CS-23, Certification Standards for General Aviation Aeroplanes should also require stalling tests to be carried out with the aircraft out of balance by a set but realistic amount e.g. by one ball width. CS-VLA, for Very Light Aircraft, does require stalls to be tested with 5 degrees of yaw.

4.4 Air Speed Indicator, ASI, Markings

a) EASA Certification Standards for light aircraft, CS-23, only require the ASI for single engine aircraft to be marked with a few limits, comprising flap deployment, stalling speed at maximum gross weight, maximum airspeed (Vne), and maximum for normal operation (Vno). In addition to these marked speeds, there are four essential speeds for safe flight which the pilot is expected to remember. These are best climb speed - Vy, best glide speed - Vbg, take-off speed - Vr and threshold speed when landing - Vref. For powered sailplanes, governed by CS-22, the ASI is also required to be clearly marked with two speeds, a yellow pointer for minimum recommended approach speed, and a blue line for best rate of climb. This latter is compatible with the CS-23 requirement for twin–engine aeroplanes of a blue line marking best single engine climb speed, Vyse, although the formal definitions would be slightly different. It is suggested that such markings should be required by CS23 to remind aeroplane pilots of the appropriate speed and would be consistent with CS22 since the need is little different.

Fig. 8a Motor glider

Fig. 8b Aeroplane ASI with 'CS22 markings' added

b) It will almost always be satisfactory for singles to use Vy for glide, and Vref for Vr, even though the book figures may be a few knots different. Thus these two ASI markings, yellow and blue, which are not currently required, cover four of the important speeds necessary for disciplined flight. An important purpose of these marks is that at times of stress, distraction, or unfamiliarity with the aeroplane, a quick glance will show whether the aeroplane is at a safe speed, without the pilot having to think about it and recall the numbers. A glance at the ASI would suffice enabling the pilot to better visually assess the accuracy of the climb or landing approach and perhaps keep an improved lookout for other aircraft. It may be valuable to learn the lessons from the gliding fraternity. Recent ad-hoc trials conducted by one instructor using temporary markings, resulted in students achieving better speed control. With the advent of Electronic Flight Information Systems, 'glass displays', the markings could be put on standby ASIs, although manufacturers of EFIS displays could easily incorporate them. (Recommendation 5.8).

4.5 Instructors

a) As noted earlier, overall about 22% of stall/spin cases were with an instructor on board as a crew member, not necessarily during a formal instructional flight. Several of the early cases were during public events etc., but in the recent 10 year period 1999 to 2008 there were 6 cases, again about 20% of total, all of which were with students under instruction, either dual or solo.

These were: (see below table)

1999	C150L	Instructor flying demonstration of practice Engine Failure After Take-Off (EFATO).
1999	PA28-140	Trial lesson, new instructor, not flown type before
2001	PA24 Comanche	Carbon monoxide poisoning
2002	T67	Spin training from proper height
2005	T67	Stall training from proper height
2005	PA38 Tomahawk	Real EFATO, instructor (also examiner) not flown type before.

b) Recommendation 5.6 in para. 3.14(a) proposes that an instructor should not take up a student in a type in which the instructor has not been checked out as proficient to instruct, and that such a check should include stalling. Otherwise the instructor will not have had experience of pre-stall and post-stall characteristics, which may differ considerably from type to type. See 4.6 b) below.

4.6 Flying Training Organisations

a) Studies of accidents and discussion with highly experienced instructors, have revealed wide variations in the conduct of flying schools. One very experienced examiner commented on the lack of published information of what constitutes good practice. Examples include:

- Check-out of instructors new to the type, (see para. 3.13),
- Avoiding filling to full-fuel on, those aeroplanes, eg C150/152, PA38, which can readily put the aircraft over maximum weight,
- That the first pre-flight of the day should be done by instructor rather than relying on a student,
- Appropriate revision of earlier lessons. (In the Southend C150 accident, the student had one lesson in Exercises 10 &11 which includes stall avoidance and that was 3 months prior to the accident),
- Tuition of the glide approach, Ex 13e, before Ex14, the first solo,
- Appropriate supervision of flying instructors by the Chief Flying Instructor (CFI),
- The importance of operating to Pilots Operating Handbook (POH), on speeds, weight & balance, use of carburettor heat etc.

b) A few accidents revealed inappropriate standards in the operation of the flying school. Two examples are the PA28-140 at Bournemouth and the PA38 at Biggin Hill, where in both cases the CFI approved the flight when the instructor was new to the school, had not been checked out by the CFI, had never flown the aircraft type before and the aircraft had a known defect that was relevant to the accident. No formal action was taken. However, as a result of the Bournemouth PA28 accident Aeronautical Information Circular AIC 22/2001, Pink 19, dated 5th April 2001* 'Newly Appointed Flying Instructors at Registered Facilities' was issued. It includes 'The CAA should recommend to Registered facilities that newly appointed instructors undertake a flight with the Chief Flying Instructor, or other nominated person, to confirm the instructor's instructional ability and flying ability. If the Registered Facility operates a class or type of aeroplane not covered by the experience of the newly appointed instructor, specific differences should be identified to the instructor and the differences training recorded in his/her logbook'. The above only applies to Registered Facilities but should be applied to all training facilities.

* Available from www.ais.org.uk via AICs, Pink, listed under Flight Crew Training.

c) Predictably, there will be strongly held and sometimes opposing views among highly experienced instructors on some of these items. In the absence of 'Standards Checks', of flying training organisations, as in the Military Services, a step in the right direction would be the production of a flying training organisation Code of Practice. (Recommendation 5.7).

4.7 Training

a) Discussion with a number of experienced instructors has revealed a range of differences of opinion on slow-flight training. Opposing views are held on tuition methods for slow-flight and stall avoidance (not recovery). A Flight Instructors Manual, and an understanding of RAF Central Flying School (CFS), training methods, both put great emphasis on accurate flying to 'book' airspeeds.

Examples from Campbell*:

"Many accidents which occur during the approach to land and shortly after take-off do so as a result of inadequate speed control or marked imbalance at low speeds. Considerable emphasis must be placed upon the necessity to maintain correct speeds and balance during these phases of flight. Turning practice at higher altitudes gives the student the opportunity to develop accuracy in relation to both speed and balance."

"As with the straight climbing exercise the student will normally have more difficulty in maintaining the correct speed during climbing turns due to his limited reference to the natural horizon. Only practice and quickening of his instrument scan will enable him to overcome this difficulty. Descending turns with flap down will also often create the same difficulty in airspeed maintenance due to the significantly lower position of the aircraft nose relative to the natural horizon. This difficulty will normally be overcome through practice and a repeated reference to the ASI." –

* R.D Campbell – 'Training for the Private Pilot Licence'.

The following comes from the RAF CFS: 'Students are prohibited from flying below Vy at any time except when on approach or immediately after takeoff, unless conducting approved exercises at an approved height. For the Grob 115E Tutor the figures are 80 kts Vy, 75 kts initial approach, 70 kts final to achieve a 65 kts at threshold. From the first lesson, students are required to select and fly visual attitudes and to monitor the primary instruments, namely ASI, ALT, DI, Ball and pwr setting to confirm that the attitude selected is correct for the performance required. Airspeed is monitored closely, especially in the circuit. The workcycle of Lookout-Attitude-Instruments is emphasised in order to get the habit ingrained in their 'motor memory' during the course of initial training.

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b) The view of some instructors is that over-reliance on the ASI is a poor technique as it is only valid at 1g whereas teaching a pilot to recognise the correct angle of attack is much more important.

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c) Furthermore, the Joint Aviation Requirements, JAR, standards for the PPL General Skill Test, GST, allow +/-15kts for climb and approach, and +15/-5kts at Vref, landing threshold speed. It is understood that within the CAA some senior personnel regard this as far too lax, but has been accepted as consequence of JAR unification across Europe. It is perhaps timely to review these standards. (Recommendation 5.9).

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5. Recommendations

5.1 Based on the accident record, further tests flights are necessary to verify the study's initial flight test indication that the Cessna 150 L & M model aircraft may not comply with the criteria for stick force gradient in CS-23 and Federal Aviation Requirements, FAR 23 for light aeroplanes (see para 3.2 e).

5.2 The Cessna 150 and Cessna 152 should not be treated as the same type and in particular pilots transferring from the Cessna 152 to the Cessna 150 should undertake formal Familiarisation Training (see para.3.2 e).

5.3 Pilots of lighter weight aeroplanes are strongly recommended to obtain training with an instructor well experienced on the type or participate in the Light Aircraft Association Pilot Coaching Scheme (see para 3.3).

5.4 The increased proportion of stall/spin accidents in the climb and during attempted forced landings following an engine or airframe problem, should be publicised - for example in safety publications and posters, and within flying training environments. Thus, as a priority the CAA is strongly requested at the earliest opportunity to produce a new Safety Sense Leaflet on 'Stall/Spin Avoidance' incorporating suitable elements of the Handling Sense Leaflets and the findings of this study. Ways should be sought to distribute the leaflet to all pilots (see paras. 3.4 b, 3.12 & 4.1 d).

5.5 Further research should be implemented into the suitability and use of angle of attack indicators in light aeroplanes (see para. 3.8 b).

5.6 The authorities should give consideration to mandating (as opposed to recommending) that flying instructors at any training facility may not undertake training flights with student pilots or passengers until after they have flown with and been checked for proficiency to instruct in the aeroplane type to be flown, by a Chief Flying Instructor, Examiner or Senior Instructor. This should not apply to the biennial one hour of flight instruction. Accordingly, in the absence of formal inspection of PPL training organisations, the flying training industry must be encouraged to formulate a 'Best Practice Code' and encourage all such organisations to use it (see paras. 3.14 & 4.5 b).

5.7 A Code of 'Best Practice' for type conversions within the Single Engine Piston (SEP), class must be encouraged, including the need for thorough familiarity with the stall warning and characteristics for the aeroplane type they are to fly (see paras. 4.2 c & 4.6 c).

5.8 Further investigation should be conducted into the possible benefits of using the CS22 requirements for motor glider ASI markings in other aeroplane classes. In the meantime owners may wish to assess the usefulness by marking their own ASIs (see para. 4.4 b).

5.9 The authorities are recommended to review the PPL Skills Test tolerances that allow a wide margin in both climb speed and landing threshold speed and do not reflect differences between aeroplane types (see para. 4.7 c).

Table 1a

Aeroplane Types with Fatal Stall/Spin Accidents, 1980 to 2008

AA1	1	Mooney M20	2
AA5	1	MS733 Alcyon	1
AS202 Bravo	1	MS880 Rallye	2
Beech 33 Bonanza	1	Pazmany PL2	1
Brasov IS28	1	Percival EP9	1
CAP222	1	Percival Provost	1
Cassut Racer	1	Piel Emeraude	1
Cessna 150	11	PIK 20	1
Cessna 152	1	Piper PA18 Cub	2
Cessna 172	3	Piper PA24	1
Cessna 182	1	Piper PA28–140	5
Christen Eagle	1	Piper PA28-180	1
Denny Kitfox	1	Piper PA32	1
DHC1 Chipmunk	3	Piper PA38 Tomahawk	4
DH Tiger Moth	2	Pitts S1	3
D31 Turbulent	1	Pitts S2	2
Dyn Air MCR 01	1	Pulsar	3
Edgley Optica	1	Rand KR2	1
Europa	1	Robin 1180	1
Fairchild Cornell	1	Rollason Beta	1
Fokker D8 Replica	1	Rollason Condor	1
Fournier RF5	1	SF23 Sperling	1
Gardan Horizon	1	Sipa Minicab	1
Grob 109	1	(Slingsby T67	8)
Grob 115	1	Steen Skybolt	3
Jodel D9	1	Stolp Starduster	1
Jodel 112	2	Taylor JT1 Mono	2
Jodel 117	1	Taylor JT2 Titch	1
Jodel 120	1	TB10 Tobago	2
Jodel 1050	3	TB20 Trinidad	1
Laser Akro 200	1	WAR Sea Fury	1
Maule M5	1	Wittman Tailwind	1
Monnett Moni	1	Zlin 526	1

Table 1b

Aircraft with factor stall/spin and 3 or more fatal accidents between 1980 & 2008, number, hours and rate per 100,000 hours

Cessna 150	11	1,529,000	0.71
[Cessna 152	1	2,630,000	0.04]
Cessna 172	3	1,324,000	0.23
DH Chipmunk	3	203,900	1.5
Jodel 1050/1	3	73,200	4.1
PA28, straight	6	1,625,000	0.36
[PA28 tapered	0	2,808,000	0]
Piper PA38	4	895,000	0.45
Pitts S1/2	5	69,700	7.2
Pulsar	3	7,300	41.0
(T67, 4 cyl	8	206,000	3.9)
(T67, 6 cyl	0	112,000	0)
Steen Skybolt	3	5,030	57.0

Notes: + Hours via CAA data base of C of A & Permit returns, with estimates for 1980 to 1983 and for types with a C of A in 2007/8.

Table 2

Aeroplane Types with Over 50 on UK Register & Zero Stall-Spin Fatal Accidents 1980 – 2008 (number active variable)

Auster J1/J3	169	natural
Beagle 121 Pup	62	vane
Cessna 150 A to H	100	reed
Luscombe	80	natural
Piper PA22 Colt/Tripacer	66	natural
Piper PA28 151/161/181/201/236	650	vane
Piper PA28R (all types)	205	vane
Piper PA32 Cherokee 6 etc	104	vane
Robin DR400	152	vane
Rockwell 112/114	68	vane (but 1 N Reg stall/spin)
Stampe SV4	51	natural
Slingsby T61	56	vane
Vans RV6	80	vane
all Vans	220	vane
YAK 52	66	vane

Appendix 1 Brief Details of Fatal Stall Spin Accidents Reviewed

AAIB BULLETIN REF.	DATE	AIRCRAFT TYPE/ SERIES (engine where relevant)	WEIGHT <600KG	DEATH	LOCATION	FLIGHT PHASE/ LOCATION	HOURS TOTAL/ TYPE	TECH PROBLEM	INSTRUCTOR	BRIEF DESCRIPTION OF EVENT
AAR 11/81	27 May 80	PA38 Tomahawk	No	2	Nr. Oxford, Kiddlington	Spin Training	508/305		yes	New Instructor with student on 6th flight. Spin from 5,000 ft. Technique or freeze?
10/80	7 June 80	Cessna F150M	No	1	Nr. E. Haddon, Northants	Finals, Solo PFL	35/35			Student solo PFL, low go around and spin turning finals for next attempt
10/80	14 June 80	Jodel 1050	No	2	Sandown A/D, I of W	Approach	227/23			Runway 23, Wind 200 30/35 kts, aircraft lower than normal and in turbulence
AAR 6/81	2 July 80	Percival EP9 (Lycoming GO-480)	No	6	Ashford A/D, Kent	Base leg	2,000/500	Eng		Para flight, returning with eng problem, stall warn sys. u/s, worn engine & water in fuel sys. No medical/licence
12/80	24 Aug 80	Taylor JT1 Mono	Yes	1	Pimlico Strip, Herts	Climbing turn	410/1.6			Medium turn manoeuvring to formate with other a/c, incip spin & late recovery
9/81	3 Mar 81	Piper PA28-140	No	1	Chigwell, Essex	Beat up	87/70			Pilot & pax drunk, low aeros and near vertical climb, pilot killed
15/81	23 May 81	DHC1 Chipmunk	No	2	Billericay, Essex	Beat Up	374/74			Alcohol, low level loop and roll, spun in a steep turn, cloud base 1,200 ft.
11/81	6 June 81	Zlin 526 Trener	No	1	Seething A/D, Norfolk	Display Practice	1,230/106			Aero practice for display, flicked off top of vertical climb and into inverted spin
GASCo 8112	15 Aug 81	DHC1 Chipmunk	No	1	Nr. Ancona, Italy	Display	582/21			aerobatic display at show, inadvertent spin at end of tight climbing turn
15/81	21 Aug 81	Fokker D8 Replica	No	1	W. Waltham A/D, Berks	Display Practice	5,000/12		yes	Tight low turn, stalled
AAR 3/82	4 Sept 81	Maule M5	No	3	Cranfield A/D, Beds	Demo	2,068/41		yes	Demo at show, low steep turn, flicked
12/82	9 May 82	PIK 20E motor glider (Rotax 501)	Yes	1	Lasham A/D, Hants	Initial climb	114/N/K	Eng		Engine stopped, attempted turn back from 100 to 300 ft, cause undetermined
13/82	30 July 82	Jodel 117	No	2	Brunton strip, Northumbs.	Beat up	311/290			Beat up & steep climbing turn, power died away
GASCo 8305	22 April 83	TB10 Tobago	No	4	Le Touquet Airport, France	Turn for r/w	185/60			While in turn of 320° for r/w stalled and flicked, 50 kg overweight & cg just behind aft limit, gusty winds in thunderstorm

AAIB BULLETIN REF.	DATE	AIRCRAFT TYPE/ SERIES (engine where relevant)	WEIGHT <600KG	DEATH	LOCATION	FLIGHT PHASE/ LOCATION	HOURS TOTAL/ TYPE	TECH PROBLEM	INSTRUCTOR	BRIEF DESCRIPTION OF EVENT
6/83	15 May 83	Jurca Mustang Replica	No	1	Barton A/D, Lancs	Display	1,168/8			Crashed level inverted in slow roll at low speed. Not cleared for aerobatics
6/83	5th June 83	Pazmany PL2	No	2	Barton A/D, Lancs	Circuit	145/29			Joining 3 others for formation flypast, steep roll which inverted and spun several times
12/83	2 July 83	DH82A Tiger Moth	No	1	Cranfield A/D, Beds	Air to air	14,600/6	Poss Air		Pax flying, owner in rear, in turn flicked into spin. Possible camera jamming controls
12/83	10 Sept 83	Gardan GY201 Minicab	Yes	1	Nr. Hook, Hants	In steep turn	278/125			Pax stated was in steep turn at 3,000 ft when nose dropped & spun
AAR 1/86	15 May 85	Edgley EA7 Optica	No	2	Ringwood, Hants	Low flypast	445/15			Turning stall, Police observation trial, possibility of pax interference or of fuel tank change
8/85	3 June 85	Cessna F150L (Continental 0-200)	No	2	Otby, Linc	IMC?	80/?	Poss eng		Crashed 60º nose down, low cloud in area, eng no power, carb ice? C of A 8 months expired
10/85	1 July 85	Monnett Moni	Yes	1	Tibenham A/D, Norfolk	Beat up	5,000/6.5			Best up and steep climbing turn, spinning prohibited, V tail
3/86	8 Sept 85	Pitts S2E	No	2	Wellesbourn A/D, Warwcs	Beat up	1,300/ 76			Low aeros, apex of half loop, spun
2/86	8 Nov 85	PA28-180 (Lycoming 0-360)	No	2	Drumlanrig, Scotland	Take off	2,050/50	Poss eng		Taking off from drive of castle , stalled into trees, possible carb ice, wrong flap setting
7/86	29 April 86	Jodel DR1050	No	3	Stapleford A/D, Essex	Landing	460/137			Slightly high, spoilers out, wing drop at 20ft, cartwheeled and burnt
9/86	5 May 86	Slingsby T67M	No	1	Cranfield A/D, Beds	Display	3,200/580		Yes	Top of manoeuvre, flicked to right , steep nose down, struck 30 deg right wing low
7/86	13 June 86	Piper PA18 Cub	No	1	Eaglescott A/D, Devon	Beat up	118/44			Low steep turn, engine power reduced bank increased and nose dropped and cartwheeled
10/86	15 June 86	Rand KR2	Yes	1	Swansea A/D, S. Wales	Forced landing	877/37	Eng		In right turn, rolled to right, pitched nose down & dived almost vertically into field. Out of fuel
8/86	3 July 86	AA5A Cheetah	No	1	Denham A/D, Bucks	Go-around	324/100		Yes	Nose too high in go-around, flicked and nose dropped. Student escaped
10/86	10 Sept 86	Cessna F150M	No	1	Norwich Airport, Norfolk	Display practice	7,472/?		Yes	Recovered from deliberate spin but failed to pull out of dive in time

AAIB BULLETIN REF.	DATE	AIRCRAFT TYPE/ SERIES (engine where relevant)	WEIGHT <600KG	DEATH	LOCATION	FLIGHT PHASE/ LOCATION	HOURS TOTAL/ TYPE	TECH PROBLEM	INSTRUCTOR	BRIEF DESCRIPTION OF EVENT
9/87	3 Oct 86	Gardan GY30 Supercab	No	1	Nr Bethersden Kent	En route	186/22	Eng		2000 ft, eng stopped out of fuel, entered left hand spiral & crashed, pax survived
9/87	23 Jan 87	Cessna FRA 150M (Continental 0-240)	No	1	Perth A/D	Go-around	70/70	Poss eng		Seen steeply banked, engine dead, steep nose down impact. Solo student
8/87	22 Mar 87	Scheibe SF23 Sperling	No	2	Bellaghy, strip, Londonderry	T/O climb	208/4			Long t/o run, stalled clearing trees, nose dropped and crashed nose down
8/87	10 May 87	Jodel D112 (Continental A65)	Yes	2	Trefgraig strip Gwynedd	Climb	297/107	Poss eng		In climb after t/o crashed nose down at low airspeed, possible carb ice
12/87	17 May 87	Steen Skybolt	No	2	Brunton strip, Nothumb	Beat -up	200/27	Poss air		Steep turn nose dropped & crashed possible control obstruction from pax bag
9/87	12 June 97	Slingsby T67A (Lycoming 0-235)	No	2	Nr. Effingham, Surrey	Aeros	420/4	Poss eng		Aerobatics under TMA, flicked during recovery from loop, possible loss power in negative g
GASCo 8714	12 July 97	Slingsby T67A (Lycoming 0-235)	No	1	Uppsala, Sw	Low aeros	325/21			Low aeros at home, steep pull up stall/spin
12/87	31 July 87	Rollason D62 Condor	No	1	Eye disused A/D, Suffolk	Forced land	113/40	Eng		Glider towing, attempted forced land, stall on finals out of fuel
12/87	6 Sept 87	CP 301 Emeraude	No	2	Perth A/D Scotland	T/O Climb	55/2			Laboured T/O, turbulence, nose & r wing drop. 2nd Permit renewal flight
1/88	22 Sept 87	DHC1 Chipmunk	No	2	Husbands Bos A/D, Lincs	Final turn	77/15			Steep low final turn, nose dropped and flicked to right
12/87	25 Sept 87	Cessna A150K Aerobat	No	2	Nr. Tollesbury, Essex	En-route	3,060/?		Yes	Low aerobatics whilst both instructors were drunk. Crashed inverted at low forward speed
3/88	17 Dec 87	Rollason Beta	Yes	1	Wattisham A/D, Suffolk	Beat up	906/2	Air		Low level turn during beat up, stall light inoperative
9/88	23 April 88	Laser Akro Z200	No	1	Tempsford, Beds	Aero practice	288/30			During aero practice entered spin & recovered but spun other way.
12/88	11 July 88	Pitts S1D	Yes	1	Chessington strip, Surrey	Go-around	201/75			Go around at short strip using less than full power, spun in turn, some control surface mods
1/89	18 Sept 88	Jodel D120A	No	2	Slinfold strip, W Sussex	Circuit	490/290			Right turn onto base leg, up to 2 revolutions First visit
3/89	20 Nov 89	Slingsby T67C	No	2	Nr Aylesbury, Bucks	Spin training	1,533/400		Yes	Multi turn spin, failed to recover. Start of aerobatic training for new PPL

AAIB BULLETIN REF.	DATE	AIRCRAFT TYPE/ SERIES (engine where relevant)	WEIGHT <600KG	DEATH	LOCATION	FLIGHT PHASE/ LOCATION	HOURS TOTAL/ TYPE	TECH PROBLEM	INSTRUCTOR	BRIEF DESCRIPTION OF EVENT
GASCo 8902	7 June 89	Grob G109B	No	1	Nr. Alicante, Spain	Mountain flying	984/300		Yes	First visit to area, was gliding downdraft in valley, turned and stalled. Crashed at 2,500 ft
12/89	29 July 89	Brasov IS-28 (Limbach SL1700)	No	2	Woodford A/D, Cheshire	Circuit	61/9	Poss eng	Yes	Spun while turning left, may have been in coarse pitch, pilot not flown it for 6 months
11/89	7 Aug 89	Steen Skybolt	No	1	Scofton d'used A/D, Notts	Aero practice	275/80			Aero & spin practice at 4,000ft, possible control jam during stall turn recovery, pax survived
11/89	24 Aug 89	Piper PA 18 Super Cub	No	1	Portmoak A/D Scotland	Glider tugging	750/520			Dropping rope at low level in turn and likely turbulence & windshear
6/90	18 Mar 90	Fournier RF5	No	1	Rattlesden A/D, Suffolk	Take off	285/9	Air		Nose high, buffet, crashed in steepening turn, pax survived. Stall warner U/S
6/90	24 Mar 90	Cessna F150M	No	2	Nr. Mere, Wilts	Precision flying	1,430/800			Precision flying over turning point from into wind to downwind in wind of 30 kts at 1,000 ft
6/91	31 Mar 91	PA38 Tomahawk	No	2	Coventry Airport W Mids	Beat Up	616/314		Yes	Formation flypast of 3 aircraft and break, up to 90 deg bank crashed in right spiral
8/91	19 May 91	Percival P56 Provost	No	1	Wasing Farm strip, Berks	Display Practice	1,850/180			Low pass & steeply banked turn, pilots DA allowed flypasts at 50ft
11/91	6 July 91	Taylor JT2 Titch	Yes	1	Frampton Cott erell strip Avon	Turn after t/o	1,000/117			Low steep turn with 60 deg bank at about 100 ft after take off
11/91	17 Aug 91	Christen Eagle II	No	2	Pangbourne, Berks	Aero Training	1,250/10		Yes	Entered inverted spin in patchy cloud base 2,500 tops 6,000, overweight, outside cg range
8/92	3 April 92	Grob G115 (Lycoming 0-235)	No	2	Loch Muik, Ballater, Scot'	En-route	1,170/10	Poss eng	Yes	Spiral dive or spin, some power at impact. Carb ice? As snow in area. Cause unknown
GASCo 9204	9 May 92	Pitts S1	Yes	1	Albenga Airport, Italy	Display				Deliberate spin failed to recover in time
3/93	4 Oct 92	Cessna F172D (Lycoming IO-540)	No	1	Sheepwash, strip, Devon	Take off	790/500	Eng		3rd attempt to take off, wet grass, humid stalled after t/o & impacted hedge etc. Carb ice?
2/93	17 Nov 92	Pitts S2A	No	1	Nr. Chesham, Bucks	Aerobatic training	351/109		Yes	Under 2,500 ft TMA & ground 500 ft, poss student froze on controls, Instructor no memory

AAIB BULLETIN REF.	DATE	AIRCRAFT TYPE/ SERIES (engine where relevant)	WEIGHT <600KG	DEATH	LOCATION	FLIGHT PHASE/ LOCATION	HOURS TOTAL/ TYPE	TECH PROBLEM	INSTRUCTOR	BRIEF DESCRIPTION OF EVENT
12/93	18 Mar 93	AS202 Bravo	No	2	Maybole, Ayr Scotland	Low flying	9,322/500		Yes	Steep turn at low level, evidence of impact at nr stall speed & entry into spin
10/93	21 Mar 93	TB20 Trinidad	No	3	Nr. Swindon, Wilts	Forced land	228/105	Air		Left Dublin with alternator OFF, elect fail after battery drained & radio lost, crashed inverted
11/93	20 July 93	Beech F33C Bonanza	No	2	Nr. Ashford, Kent	Low flying	5973/51		Yes	Low orbit of village, wing drop seen at 100 – 200 ft
GASCo 9309	5 Sept 93	Aerodesign Pulsar	Yes	1	Spanish Point A/D, Ireland	Take off	783/30			T/O rw 06, steep turn at about 150 ft out of wind after T/O at fly-in, wing dropped
2/94	3 Oct 93	Stolp Starduster Too	No	1	Askerswell strip, Dorset	Take off	396/3	Air		One of right wing attach bolts missing on US built a/c & wing twist may have caused spin
9/94	25 June 94	Steen Skybolt	No	2	Nr. Trenow Cove, Cornwall	Aeros	500/18	Air	Yes	Aerobatics prohibited, extinguisher fell out, poss. stunned pilot. Half loop tops 1,000 ft into spiral dive or spin
11/94	1 Aug 94	MS733 Alcyon	No	2	Framlingham Strip, Suffolk	Take off	704/87			Steep turn at 200 ft after T/O, flicked into spin/spiral dive 40 deg nose down impact
7/95	5 May 95	Denny Kitfox 4 (Rotax 912UL)	Yes	1	Dolphinton strip, Lanarks	Take off	217/126	Poss eng		Steep climb & entered inadvert spin or spiral, engine noise ceased at apex, no fault found
10/95	16 June 95	MS880B Rallye Club	No	2	Dunkeswell A/D, Devon	Take off	138/11			Slow high attitude climb with 3 on board , semi stall wing drop into spin
9/95	9 July 95	Aerodesign Pulsar	Yes	2	Corby strip, Northants	Take off	248/43			Steep climbing turn onto downwind at fly-in
5/96	2 March 96	Jodel D9 Bebe (VW coversion)	Yes	1	Shoreham A/D, Sussex	Approach	701/1	Eng		Landing on first flight after purchasing, carb ice may have caused power loss on finals, stalled
10/96	4 May 96	Slingsby T67M-200	No	1	Old Warden A/D, Beds	Display	3,675/ 2,500			Intentional 7 turn spin, failed to recover, crashed inverted not usual A/C
9/97	31 May 96	Cessna 152	No	2	Lydd A/D, Kent	Go around	380/242	Poss Air		Steep bank low turn & incip spin in strong wind. Medical condition & low annual hours. Possible asymmetric flap
4/97	15 June 96	Robin R1180 Aiglon (Lycoming 0-360)	No	4	Nr. Buxton, Derbyshire	Go around	865/4	Eng		Loss of power, attempted forced land, eng recovered, go around & failed again stalled. Fuel system anomaly.
2/97	26 Aug 96	MS880 Rallye Club (RR Contin 0-200)	No	2	Barton A/D, Greater Manch	Take off climb	107/53	Eng		Shallow nose high climb, stall & vertical spiral descent. Worn engine. Possible miss-set trim

AAIB BULLETIN REF.	DATE	AIRCRAFT TYPE/ SERIES (engine where relevant)	WEIGHT <600KG	DEATH	LOCATION	FLIGHT PHASE/ LOCATION	HOURS TOTAL/ TYPE	TECH PROBLEM	INSTRUCTOR	BRIEF DESCRIPTION OF EVENT
12/96	1 Sept 96	WAR Sea Fury replica	Yes	1	Crosland Moor A/D, Yorks	Take off climb	3528/6			Steep climbing turn at fly in, speed decay, stall
3/97	25 Sept 96	PA28-140 Cherokee	No	2	Nr Woodvale A/D, Lancs	Spin training	7,350/7,000		Yes	Deliberate spin, failed recover, cg too far forward, POH & placard from SB not embodied
5/97	21 Nov 96	C172P Skyhawk	No	1	Compton Abb. A/D, Dorset	Go-around	104/0.5	Air		Seat slid back during go-around, high pitch, low speed, stalled. Seat latch damaged
1/98	6 May 97	Cessna F150M	No	1	NrCumbernauld A/D, Scotld	Aerial Photos	731/241			Circling, bank and pitch oscillation at 2-300 ft, banked abruptly & nosed down, windy
2/98	25 July 97	Pitts S1E	Yes	1	Meppershall strip, Beds	Low aeros	570/193	Poss eng		Shortly after take off, two rolls in climb out & vertical turn, incipient spin, engine wear
8/98	17 May 98	Taylor JT1 Mono (Peacock VW)	Yes	1	Andrewsfield A/D, Essex	Take off	536/14	Eng		Power loss due several engine faults, gentle turn stalled into spiral
12/98	26 July 98	Jodel 112 (Continental A65)	Yes	2	Nr. Bentworth, Hants	Forced land	388/128	Eng		Engine stopped, gentle turn bank increased into 1 turn spin, out of fuel, gauge fault
4/99	4 Aug 98	D31 Turbulent	Yes	1	Swanton Mor. A/D, Norfolk	Display	748/219			Tail chase & steep wing over, nose dropped & R wing tucked, crashed inverted
4/99	15 Aug 98	Fairchild M62A Cornell (Ranger 6-440)	No	1	Woburn Abbey strip, Beds	Climb out	1,306/142	Eng		Loss of power at approx 150 ft, low turn to return, incipient spin, pax survived
8/99	28 Aug 98	Cessna FRA 150L	No	1	Nr. Ardglass, N. Ireland	Practice stall	84/24			Seen doing 2 stalls, later spiralling down from about 1,800 ft, pilot on prescript drugs
5/99	4 Feb 99	Cessna FRA150L	No	1	Turweston A/D, Northants	EFATO Dem	470/93		Yes	Wing drop on training flight with 9 hr student. Wind gusting 30 kts, possible flap problem
1/2000	29 April 99	Mooney M201J (Lycoming IO-360)	No	4	Nr. Selby, Yorks	En-route	437/205	Eng		Steady loss of power due cam lobe wear while VFR on top with autopilot in use until the a/c stalled & spun
10/99	9 May 99	Jodel DR1050	No	2	Nr. Cromarty, Scotland	En route	215/126			Scud running, loss of control in turn, crashed inverted. Stall warning poorly adjusted
12/99	3 July 99	Cassut 3M Racer	Yes	1	Bembridge A/D, I of W	Air race practice	717/10			Lost control during required aileron roll, speed low and attitude wrong F1
8/00	18 Dec 99	Piper PA28-140 Cherokee	No	3	Bournemouth Airport, Dorset	Take off	272/174	Poss eng		New instructor, not flown PA28-140 with roof trim, not been checked by Club. ASI in mph. Possible carb ice & cabin misting.

AAIB BULLETIN REF.	DATE	AIRCRAFT TYPE/ SERIES (engine where relevant)	WEIGHT <600KG	DEATH	LOCATION	FLIGHT PHASE/ LOCATION	HOURS TOTAL/ TYPE	TECH PROBLEM	INSTRUCTOR	BRIEF DESCRIPTION OF EVENT
9/00	24 Mar 00	Europa	Yes	1	Nr. Upwood strip, Cambs	Take off	91/0	Air		Un-intended first flight in strong wind, doing fast taxi run, trim at full travel, stalled with wing drop
10/01	27 Apr 01	TB10 Tobago	No	1	Sherburn A/D, Yorks	Circuit	690/420	Air		Baggage door open on t/o, downwind track to return misjudged, final turn 80° bank, stalled
3/02	12 May 01	Cessna 182S	No	2	Leicester A/D, Leices	Take off	464/398	Air		Stalled nose high after autopilot runaway causing push force of 60+lbs to overcome
12/02 & Addendum	12 May 01	PA24 Comanche (Lycoming 0-540)	No	2	Osea Island, Essex	En route	2,590/0	Eng	Yes	Carbon monoxide from fractured exhaust, spun in during possible stall exercise
7/02	15 Aug 01	PA28-140 Cherokee (Lycoming 0-320)	No	1	Nr. Halesworth Suffolk	Forced land	211/32	Eng		Massive engine mechanical failure, skidding turn onto finals, stall and wing drop
8/03	3 Nov 02	Slingsby T67B	No	2	Nr. Banbury, Oxon	Spin training	1,600/200		Yes	Failed to recover from intentional spin entered at between 4 to 5,000 ft
11/06	16 Oct 04	Mooney M20J (Lycoming IO-360)	No	1	Jersey Airport, CI	Circuit	783/311	Eng		Loss of power attempted return from 300 ft, seen to stall/incip spin, magneto defect
3/06	25 May 05	Slingsby T67C Firefly	No	2	Nr Pottersbury Beds	Stall training	6,000+/25+		Yes	Student 13th flight, oscillating stall training at over 2,000+ft, inadvert spin, failed recover
4/06	8 July 05	CAP222 Modified	No	1	W. Waltham, A/D, Berks	Aero training	10,149/115		Yes	Ex Champion, advanced aero training, max of 2,500 ft below TMA, error & inverted spin
6/06	7 Aug 05	Cessna FR172E	No	1	Bracklesham Strip, Sussex	Take off	373/170			V steep climbing turn after t/o from familiar strip, poss fatigue, local noise issue
7/06	18 Aug 05	DH82A Tiger Moth	No	2	Nr. Henley on Thames, Berk.	En route	289/107	Poss eng		Poss engine problem & attempted forced land, spun. Medical aspect, no fault found in engine
6/06	2 Oct 05	Dyn Air MCR-01	Yes	2	Nr. Lymington, Hants	En route	1,059/290	Poss eng		No reason for departure from cruise into field, possible medical. No fault found in engine
11/06	22 Oct 05	PA38 Tomahawk	No	2	Biggin Hill Airport, Kent	Take off	4,451/0	Eng	Yes	Water in fuel, attempted turn back & stall, 140lbs overweight. Instructor first flight on type
11/06	17 Nov 05	Grumman AA-1B	No	2	Nr. Bugbrook, Northants	En-route	80/6			155 lbs overweight, cg aft of rear limit, at 5,000 ft, no reason for stall 7& prohibited spin entry

AAIB BULLETIN REF.	DATE	AIRCRAFT TYPE/ SERIES (engine where relevant)	WEIGHT <600KG	DEATH	LOCATION	FLIGHT PHASE/ LOCATION	HOURS TOTAL/ TYPE	TECH PROBLEM	INSTRUCTOR	BRIEF DESCRIPTION OF EVENT
10/07	16 July 06	Slingsby T67M (Lycoming IO-320)	No	1	Nr. Hoxne, Suffolk	Ad hoc aeros	83/18	Eng		Spun during loop from 5,000 ft giving private display, part way through aero training. Engine had stopped, no fault found
7/07	19 July 06	Cessna F150L	No	1	Southend Airport, Essex	Go-around	15/15			2nd solo, instructed to go-around at 1nm final, did not reconfigure a/c or increase power, stalled, situation beyond experience
GASCo 0605	10 Sept 06	Wittman W8 Tailwind	No	1	Winzeln Schr- amberg, Germany	Take off	?/?	Eng/Air		Reported smoke in cockpit, attempted turn back and spin. 30 hrs in last 90 days. 2,200 ft amsl.
3/08	17 Apr 07	Pulsar (Rotax 582)	Yes	1	Worleston strip, Cheshire	Take off	1,266/ 194	Eng		Engine stopped, cause unknown, attempted to return, steep turn & stalled at about 60 ft.
7/08	8 July 07	Cessna F150L (Continental 0-200)	No	2	Clutton strip, Somerset	Take off	79/60	Eng		Steep climb, engine stopped at 200 ft, rolled to left into vertical dive. Pilot had taken drugs.
10/08	5 Aug 07	PA28-140 Cherokee (Lycoming 0-320)	No	4	Sandown A/D, Isle of Wight	Take off	687/143	Eng		Slow climb after T/O, pitched up to clear trees and stalled. Engine cam lobes worn.
10/08	16 Sept 07	PA32-301 Saratoga	No	1	Shotteswell strip, Oxon	Take off	200/4			After lift off cleared hedge, stalled, struck tree & cartwheeled. Runway too short with up-slope.
9/09	17 Oct 08	PA38 Tomahawk (Lycoming O-235)	No	1	Robin Hoods Bay, N Yorks	En-route	50/50	Eng		Reason unknown for power loss when over sea, stalled & cart-wheeled while ditching.

Appendix 2

The Slingsby T67

a) The T67 stood out strongly, not just in having 8 fatal accidents from the 80 on register, but being the only type with a record of unrecovered spins from a notionally safe height, with a spin trained pilot in command and no other known factors, with the exception of one unusual case on a Piper PA28-140.

b) Further examination revealed that all 8 cases were from the 50 4 cylinder engine versions on regular Standards Board checks. It would therefore be expected that the resulting record would be blemish free. Thus it cannot be deduced from the statistics that there is a significant difference in the stall/spin accident risk between different types of T67 although such a difference may exist, e.g. due to the different rotational dynamics with the heavier engine. As stated in para 4.2a), the RAF, with considerable experience of all types of T67, regards the type as significantly different.

c) Examination of the 4 cylinder engine versions, shows a much higher high accident rate per 100,000 hours than had been previously detected.

d) The spinning characteristics of the T67 were comprehensively covered in AAIB Bulletin 10/2007 page 54 when reporting on the 2006 accident near Hoxne, Suffolk. (www.aaib.gov.uk via Publications, Bulletins, Bulletin Archive and 2007).

Extracts from AAIB Bulletin 10/2007 Slingsby T67M-MkII Firefly, G-BUUD

Spinning and aerobatics

General

The CAA General Aviation Handling Sense 3 leaflet, entitled *'Safety in Spin Training'*, explains that: *'the spin is a stalled condition of flight with the aeroplane rolling, pitching and yawing all at the same time. There are aerodynamic forces and gyroscopic forces (caused by the rotating mass of the aeroplane) which may be pro-spin or anti-spin. In a stable spin the aerodynamic and gyroscopic forces balance out leaving the aeroplane rolling, pitching and yawing at a constant rate.'*

The CAA General Aviation Safety Sense Leaflet 19a, entitled *'Aerobatics'*, advises pilots who are learning to fly aerobatics to: *'become familiar with the entry to and recovery from a fully developed spin since a poorly executed aerobatic manoeuvre can result in an unintentional spin. Training in recovery from incorrectly executed manoeuvres and unusual attitudes is essential.'*

Following a spinning accident to G-BLTV on 3 November 2002, the AAIB made the following Safety Recommendation:

'The Civil Aviation Authority should conduct a review of the present advice regarding the use of parachutes in GA type aircraft, particularly those used for spinning training, with the aim of providing more comprehensive and rigorous advice to pilots.' This was accepted by the CAA and an updated Safety Sense Leaflet 19a *'Aerobatics'* was published containing the following information on parachutes: *'While there are no requirements to wear or use specific garments or equipment, the following options are strongly recommended: ….Parachutes are useful emergency equipment and in the event of failure to recover from a manoeuvre may be the only alternative to a fatal accident. However, for physical or weight and balance reasons their carriage may not be possible or practicable, the effort required and height lost while exiting the aircraft (and while the canopy opens) must be considered. If worn, the parachute should be comfortable and well fitting with surplus webbing tucked away before flight. It should be maintained in accordance with manufacturer's recommendations. Know, and regularly rehearse, how to use it, and remember the height required to abandon your aircraft when deciding the minimum recovery height for your manoeuvres.'*

T67 information

During the investigation G-BUUD's weight and CG position were calculated and found to be within the prescribed limits. The Take off Weight was 852 kg (the maximum for aerobatics is 975 kg), and the aircraft CG was at 24.7% mean aerodynamic chord, which represents a mid CG position. As such, the aircraft was approved for aerobatics. The manufacturer's Pilot's Notes advise the following precaution: *'Ensure that aerobatics are carried out at sufficient altitude to recover to normal flight and to switch fuel tanks if the engine should cut.'* The advised entry speeds for the slow roll and the loop are given as 110 kt IAS and 115 kt IAS, respectively. The Pilot's Notes also give guidance on the height loss to expect during a spin. They state: *'The height loss is about 250 ft per turn and recovery takes about 500 ft. These height losses may vary, dependant on how many turns of the spin are done and how prompt and correct the recovery action is. They may be used as a basis for planning recovery which should be complete by 1,500 ft above ground level. It is recommended that inexperienced pilots allow a further 1,000 ft to the entry height. Thus the entry height for a 4 turn spin for an inexperienced pilot should be…… 4,000 ft above ground level.'* The technique for intentional spin entry is: *'At stall warning apply full rudder in the intended direction of spin and at the same time bring control column fully back. Hold these control positions. If the correct control movements are not applied a spiral dive may develop as shown by an airspeed increasing above 80 kts.'*

The Pilot's Notes also include the following information about Erect Spin Recovery.

The Standard Recovery Technique is:

a) Close the throttle.
b) Raise the flaps.
c) Check direction of spin on the turn coordinator.
d) Apply full rudder to oppose the indicated direction of turn.
e) Hold ailerons firmly neutral.
f) Move control column progressively forward until spin stops.
g) Centralise rudder.
h) Level the wings with aileron.
i) Recover from the dive.

WARNING: WITH C OF G AT REARWARD LIMIT THE PILOT MUST BE PREPARED TO MOVE CONTROL COLUMN FULLY FORWARD TO RECOVER FROM SPIN'

The guidance for use in the event of an Incorrect Recovery is as follows:

'A high rotation rate spin may occur if the correct recovery procedure is not followed, particularly if the control column is moved forward, partially or fully, BEFORE the application of full anti-spin rudder. Such out-of-sequence control actions will delay recovery and increase the height loss. If the aircraft has not recovered within 2 complete rotations after application of full anti-spin rudder and fully forward control column, the following procedure may be used to expedite recovery.

a) Check that FULL anti-spin rudder is applied.
b) Move the control column FULLY AFT then SLOWLY FORWARD until the spin stops.
c) Centralise the controls and recover to level flight (observing the 'g' limitations).'

Later in the same publication information is given about the aircraft's characteristics during erect spinning. After initiation:

'the spin progressively stabilizes over about three turns, ending up with about 50° of bank and the nose about 40° below the horizon. The rate of rotation is about 2 seconds per turn [and] the IAS stabilizes at about 75 kts to the right and 80 kts to the left. If full pro-spin control is not maintained throughout the spin, the aircraft may enter a spiral dive or a high rotational spin. A spiral dive is recognised by a rapid increase in airspeed with the rate of rotation probably slowing down as the spin changes to a spiral dive. The wings can be levelled by using aileron with rudders central and the dive then recovered using elevator. A high rotational spin is recognizable by a steeper nose down attitude and a higher rate of rotation than in a normal spin; airspeed will be higher than a normal spin but will not increase rapidly; recovery is as given [for] Incorrect Recovery.'

This guidance indicates that the rate of descent during a stable spin is about 6,000 fpm. As part of the investigation a flight was conducted in a T67M-MkII, during which aerobatic and spinning manoeuvres were carried out. In the course of performing a loop, it was noted that the vertical distance between the top and the bottom of the manoeuvre was 600 ft. An aileron roll was also completed, as well as exercises in stalling and intentional spinning. The height loss during a four-turn spin to the left, plus standard recovery, was 1,500 ft, as advised in the Pilot's Notes. A further two loops were carried out, during which the controls were mishandled after the aircraft had reached the top of the manoeuvre, in an attempt to induce a spin. On each occasion the aircraft departed from controlled flight. The controls were immediately centralised, the normal procedure for recovery from an incipient spin, and the aircraft responded within one turn. This flight also demonstrated the potentially disorientating effects of spinning. These results reflected the comments by the manufacturer, T67 instructors at two UK military flying training establishments and an experienced international aerobatics competitor, that the aircraft is predictable and responds as described in the manufacturer's Pilot's Notes. Their comments also complemented the results of tests on other models of the T67, all of which have been designed with the stability characteristics required for an aerobatic aircraft. As a military training aircraft, the T67M-MkII has been spun many hundreds of times. Instructors involved in this training have observed students using the correct and incorrect techniques to recover from spins. In all cases, the aircraft recovered when the correct technique was employed.

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