ACCIDENT

Aircraft Type and Registration:	Swift S-1, G-IZII
No & Type of Engines:	N/A
Year of Manufacture:	1993
Date & Time (UTC):	22 August 2010 at 1022 hrs
Location:	Shoreham Airfield, West Sussex
Type of Flight:	Aerial work
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Substantial
Commander's Licence:	Glider Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	473 hours (of which 57 were on type) Last 90 days - 20 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

Synopsis

The glider was in a low level final turn to land when it stalled, departed controlled flight and crashed onto the runway. One Safety Recommendation was made.

History of the flight

G-IZII was to be flown at the Shoreham Air Show as part of a display by a team consisting of a glider and tug aircraft combination and two Twister aircraft. There were two runways in use, asphalt Runway 20 and, to the east, the parallel grass Runway 20. The weather was poor, causing some participants to cancel their displays. The display organiser discussed the conditions with the team leader and they decided that it was suitable for the team to display. Weather conditions reported during the hour leading up to the accident are shown in Table 1.

The team decided that they would fly their low-level display profile, which could be used in cloud conditions that precluded the vertical manoeuvres that were part of their full display. G-IZII would remain on tow throughout the display. One Twister would remain with the glider-tug combination and would barrel roll around the glider during part of the display. The remaining Twister, flown by the team leader, would takeoff but not participate in the display. Towards the end of the display, and while still attached to the tug, the pilot of G-IZII would perform some aileron rolls into wind along the line of asphalt Runway 20. Following this "roll-on-tow", he would release from the tug and land downwind aiming to stop at the launch point near the threshold of grass Runway 20.

Time (UTC)	Surface wind	Visibility	Cloud cover[1]
0920	290° 3 kt	4,200 m	FEW at 300 ft, SCT at 500 ft, BKN at 700 ft
0950	230° 4 kt	6,000 m	SCT at 600 ft, BKN at 800 ft
1002	230° 4 kt	6,000 m	SCT at 600 ft, BKN at 800 ft
1020	210° 6 kt	8,000 m	SCT at 500 ft, BKN at 700 ft

Table 1

Weather reports before the accident

Before departure, the team leader was informed by ATC that there was scattered cloud at 600 ft and broken cloud at 800 ft. The team took off at 1017 hrs and began their display with the team leader holding away from the display area in his Twister. As the display progressed, the team discussed the weather conditions on the radio and the team leader was asked to report the cloud base, which he estimated to be 500 ft aal. The other Twister pilot decided that the weather was not good enough to barrel roll around G-IZII and cancelled that part of the display.

The tug pilot positioned for the roll-on-tow just below the 500 ft cloud base, at between 80 and 90 kt, on the centreline of asphalt Runway 20 and with the crowd on his left. The glider pilot performed three aileron rolls behind the tug but, as he regained upright flight after the third roll, considerable slack developed in the aerotow rope. The pilot disconnected from the tug before the slack was taken up and turned right to position for a landing at the launch point. As the launch point came into view, the pilot judged that he would overshoot it and he extended the airbrakes to bring the landing point closer. Approximately seven seconds later, having crossed to the east of the asphalt runway, he realised he would still overshoot the launch point and that his only option was to turn left through approximately 180° to land on the asphalt Runway 20. He retracted the airbrakes and began a left turn. Figure 1 shows the ground track of the glider.

The pilot recalled feeling that the aircraft was "really low" and after about 45° of turn he felt the left wing drop as the aircraft departed controlled flight. Two seconds later the left wingtip hit the runway surface immediately before the nose, with the aircraft rolling left in a steep nose-down attitude. The nose section broke approximately half way along the canopy rail, although it remained connected to the fuselage, and the canopy detached before the aircraft came to rest. The pilot was able to remove himself from the wreckage but was subsequently taken to hospital with back injuries.

Information from the pilot

The pilot had been displaying gliders since 2006 and had flown 27 displays. He said that the number of low level display training flights the team had completed had been limited because many gliding club managers were not comfortable with the reduced safety margins implicit in the use of display limits during training. However, the pilot met the recency requirements of

Footnote

[1] FEW cloud means there was 1 or 2 eighths of cloud cover; SCT means 3 or 4 eighths; BKN means 5 to 7 eighths.

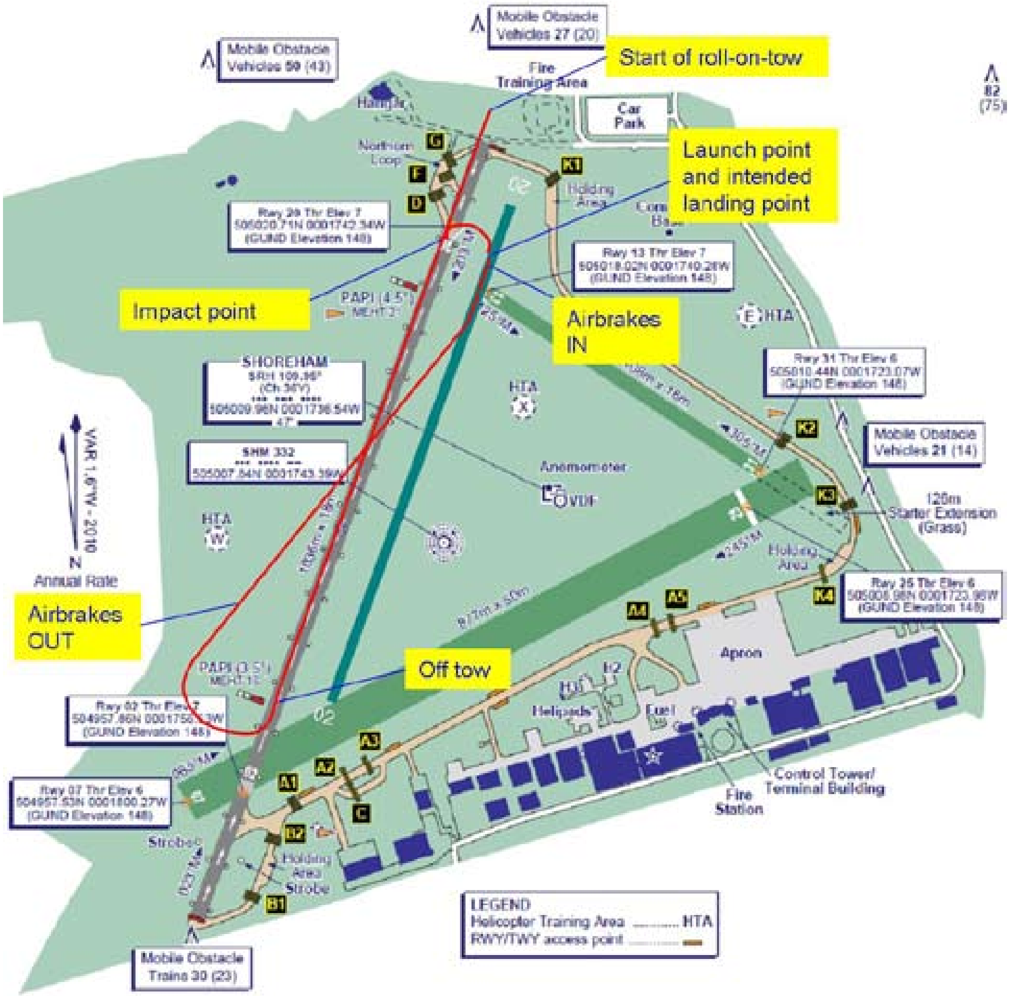

Figure 1

Ground track flown by G-IZII

Civil Aviation Publication (CAP) 403[2] and stated that he never felt under-prepared for a display.

The pilot intended to land at the launch point because it would look good as part of the display and minimise any delay to the team's subsequent departure that might be caused by having to retrieve G-IZII from another point on the airfield. Generally, the pilot preferred to fly past the launch point heading downwind before turning into wind to land but he had often landed downwind and was comfortable in doing so.

Following the third roll-on-tow, the aerotow rope bowed more than normal, prompting the pilot to disconnect from the tug before the slack in the line was taken up. He wanted to avoid breaking the weak link in the aerotow rope and was concerned that maintenance action required to replace the link would delay the team's subsequent departure. The glider was just below the cloud base at approximately 85 kt – the last airspeed the pilot recalled seeing – and he considered

Footnote

[2] CAP 403 – '*Flying Displays and Special Events: A Guide to Safety and Administrative Arrangements*'. The recency requirements were for three full display sequences to be flown within the previous 90 days, with at least one display sequence flown or practised in the specific type of aircraft to be displayed.

that he was suitably positioned to enable him to land at the launch point. This judgement, however, was not based on any prior assessment of the conditions required at release such as height, speed and position over the airfield that would enable a safe landing to be made at the launch point.

The pilot first realised that G-IZII might overshoot the launch point after he disconnected from the tug and turned right through 180°. He considered turning left through 180° immediately in order to land into wind but decided that he would probably overshoot the upwind end of the airfield if he did so. He judged the surface beyond the launch point to be unsuitable for landing.

On reflection, the pilot believed there had been too much emphasis on landing at the launch point to the detriment of good airmanship and he thought this was due, to some extent, to the pressures particular to displaying at an air show. He thought that he had become used to flying with limits lower than those used normally within the gliding community and that "the abnormal had become normal".

The pilot had experienced an actual break in the aerotow rope in similar circumstances once before during training at a different airfield. At the time of the break, the glider was "over the upwind boundary hedge" of the airfield and, having "settled the glider", the pilot turned through 180° to land downwind, although he recalled that the wind on the day was less than 5 kt. The pilot had also landed following the roll-on-tow during training but he reported that he released from the tug no lower than 700 ft aal, which enabled him to fly a normal circuit to land.

Events leading to the accident

Evidence available to the investigation included video taken by spectators, video taken from within the cockpit and professional quality photographs. This evidence, when combined with evidence from the pilot, allowed a detailed assessment to be made of the events leading up to the accident.

The glider impacted the ground 23 seconds after the pilot released from the tug and 18 seconds after the pilot first saw the launch point. For analysis, the events leading to the accident were split into three phases: the 180° turn off tow; the period during which the glider was pointing at the launch point and had its airbrakes extended; and the final turn, the start of which was marked by the pilot retracting the airbrakes.

During the first phase, the pilot used small rudder inputs and there was little sideslip indicated by the piece of string attached to the top of the canopy. The pilot appeared to divide his attention between looking into the turn, looking ahead at the aircraft attitude, and looking at the ASI.

While the aircraft flew towards the launch point in phase two, there were short periods where left bank was applied, each of which was accompanied by the application of left rudder. The pilot looked towards the ASI once, 10 seconds before impact, and stated later that, although he could not recall the indicated airspeed, he would have been aiming for 65 kt IAS. Seven seconds before impact, G-IZII was between approximately 35 ft and 40 ft agl. For the rest of the time in phase two, the pilot was looking ahead either side of the glider's nose with a growing realisation that he was not going to be able to land at the launch point. This realisation was accompanied by increasing alarm at his lack of options.

During the third phase, the pilot did not look left into the turn towards the new landing area or look at the ASI; his attention was fixed ahead and slightly to the left of the nose. The turn was flown with approximately 50° to 60° of bank with left rudder applied throughout. During the turn, the airbrakes were selected out momentarily four times, although they were fully extended only once, and they were selected out once more immediately before impact. When the aircraft stalled, indicated by a distinct drop in the nose attitude, sideslip was present and the aircraft departed controlled flight, impacting the ground two seconds later.

Information from the team leader

The team leader stated that the glider had a stall warning system but that Swift pilots often chose not to turn it on (it was not on during the accident flight). He considered that a minimum cloud base of 500 ft was required in order for the team to fly their low level display profile, and he believed the tug and glider combination to be a single aircraft for the purposes of CAP 403 and display flying.

Following a previous display flight where the aerotow rope broke leaving the glider in a similar position to the accident flight, the team leader reviewed the safety of the display and concluded that, following the launch phase, the glider could glide back to the airfield for a safe landing from any point in the display. The low level part of the display was flown approximately 25 kt above approach speed giving the glider more energy and increasing the safety margins.

The team leader stated that glide range is determined by assessing angles, particularly in the circuit, and that the progress of a glide (whether the glider will overshoot or undershoot the intended landing point) is determined by observing changes in those angles. He stated that pilots could not pre-plan circuits using ground reference points because of the variation caused by even small differences in height, speed and wind speed.

Glider handling

When nearing the ground, pilots are likely to gain an impression of a glider's groundspeed by the flow of objects in their peripheral vision and, if landing downwind, the groundspeed is likely to be higher than normal. If a pilot does not monitor the ASI when landing downwind, he or she might reduce the indicated airspeed inadvertently in order to achieve the same impression of groundspeed as that experienced during normal into-wind landings. The pilot was aware of this phenomenon and had experienced it previously. The tailwind at the time of the accident was approximately 5 kt.

The manufacturer of Swift S-1's stated that its stalling speed is 39 kt, but during a final turn flown with a bank angle between 50° and 60°, such as in the accident flight, this would increase to between 49 kt and 55 kt[3]. If the final turn was flown at 50° angle of bank, the wing tip would have been 4.86 m (16 ft) below the centreline of the glider[4]. If the turn was started at a height of 40 ft aal, the wing tip clearance from the ground would have been 24 ft.

In his book *Gliding Safety*[5], Derek Piggott discussed spin related accidents and handling in low level final turns. He wrote that many spin accidents:

Footnote

3 The level flight stalling speed increases by the square root of the load factor in the turn. The load factor in the turn is given by the secant of the bank angle.
4 The wingspan is 12.68 m.
5 Piggott D (1991) *Gliding Safety* London: A & C Black Ltd.

> *'are caused by poor planning, which leads to situations involving difficult manoeuvring near the ground, putting pilots under stress so that they make mistakes or fly badly enough to stall and spin in.'*

In addition, he wrote that, when a glider is very low, pilots often use too much rudder in an effort to complete the final turn.

> *'Over-ruddering during the final turn creates extra drag and height loss, and helps to cause the nose to drop. If the pilot stops the nose from dropping by easing back on the stick instinctively, the speed will decrease further.'*

Civil Aviation Publication (CAP) 403

CAP 403 – '*Flying Displays and Special Events: A Guide to Safety and Administrative Arrangements'* is intended to be a code of practice to ensure the safety of participants and spectators at air shows. It states that:

> *'The minima and standards quoted* [in this manual] *should be treated as almost absolute unless sound logic demands otherwise.'*

CAP 403 states that minimum weather conditions for displays must be determined in advance and strictly observed. The recommended minima relevant to this investigation are shown in Table 2.

The stalling speeds of the Swift and the Twisters quoted by their manufacturers were below 50 kt. For such aircraft flying solo or in formation, a full aerobatic display required no significant cloud below 800 ft and a flypast required no significant cloud below 500 ft. CAP 403 does not specify separate criteria for flat aerobatic displays by aircraft in this category.

			Weather minima	
Type of aircraft	**Type of display**		**Cloud ceiling[6] or significant cloud (4/8 or more)**	**Visibility**
V/STOL aircraft, rotorcraft and other aircraft with a stalling speed below 50 kt	Flypasts	Solo aircraft	500 ft	1,500 m
		Formations	500 ft	3,000 m
	Full aerobatic displays	Solo aircraft	800 ft	3,000 m
		Formations	800 ft	5 km
Flying displays by other aircraft	Flypasts or flat aerobatic displays	Solo aircraft	500 ft	3,000 m
		Formations	800 ft	5 km

Table 2

CAP 403 weather limits

Footnote

[6] CAP 393 *Air Navigation: The Order and the Regulations* defines cloud ceiling as '*the vertical distance from the elevation of the aerodrome to the lowest part of any cloud visible from the aerodrome which is sufficient to obscure more than one-half of the sky so visible*'.

Shoreham flying display instructions

The flying display instructions issued to participants in the air show stated that:

> *'Display weather minima will be in accordance with and as set out in CAP 403.'*

The minima applicable to this accident shown in the display instructions are reproduced in Table 3. There were differences from CAP 403, which are shown in bold italics.

The display instructions allowed flat aerobatic displays by aircraft such as the Swift or Twister flown solo or in formation providing there was no significant cloud below 500 ft. The instructions also allowed full aerobatic displays from solo aircraft providing there was no significant cloud below 500 ft.

CAP 393 '*Air Navigation: The Order and the Regulations*'

For the purpose of avoiding aerial collisions, CAP 393 states that:

> *'A glider and a flying machine which is towing it shall be considered to be a single aircraft under the commander of the flying machine.'*

CAP 403 does not explain whether or not this interpretation applies when considering a glider and tug combination at an air show.

Glider certification

The Polish CAA certificated the Swift S-1 in August 1992 to requirements contained in *JAR-22 Sailplanes and Powered Sailplanes*. In June 2005, airworthiness oversight for the type transferred to EASA and the original Polish Type Certification Data Sheet (TCDS) was replaced with EASA TCDS A.038. Design requirement JAR 22.561 refers to emergency landing conditions and states that:

			Weather minima	
Type of aircraft	**Type of display**		**Cloud ceiling or significant cloud (4/8 or more)**	**Visibility**
V/STOL aircraft, rotorcraft and other aircraft with a stalling speed below 50 kt	Flypasts ***or flat aerobatic displays***	Solo aircraft	500 ft	1,500 m
		Formations	500 ft	3,000 m
	Full aerobatic displays	Solo aircraft	***500*** ft	3,000 m
		Formations	800 ft	5 km
Flying displays by other aircraft	Flypasts or flat aerobatic displays	Solo aircraft	500 ft	3,000 m
		Formations	800 ft	5 km

Table 3

Display instruction weather limits

> *'The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a crash landing when proper use is made of belts and harnesses provided for in the design, in the following conditions:*
>
> *An ultimate load of 6 times the weight of the sailplane acting rearward and upwards at an angle of 45° to the longitudinal axis of the sailplane acts on the forward portion of the fuselage at the foremost point(s) suitable for the application of such a load.'*

The EASA TCDS for the Swift S-1 contains an exemption from this part of the certification basis stating:

> *'Fuselage structure verified up to 77% of emergency landing ultimate loads.'*

Although airworthiness of the Swift S-1 was not reassessed by EASA when the type was transitioned to its oversight, EASA commented that an exemption was probably justified by the nature of operation of this aerobatic glider: it would not normally be operated using winch launches or for cross-country flights, and was expected to perform standard approaches after local flights.

The TCDS also contains an exemption from JAR 22.207, a requirement which states that:

> *'The stall warning must begin at a speed between 1.05 and 1.10 V_{S1} and must continue until the stall occurs.'*

The exemption states that the stall warning is outside the required limit. In order to comply with JAR 22.207, the TCDS includes in the minimum equipment list for the Swift S-1 a stall warning device that is required to be turned on during flight.

The current certification requirements for gliders are given in EASA document CS-22 *Certification Specifications for Sailplanes and Powered Sailplanes*. Certification Specification (CS) 22.561 for the emergency landing condition increases the ultimate load requirement within JAR 22.561 (above) from six to nine times the weight of the sailplane. In the Acceptable Means of Compliance (AMC) section of EASA document CS-22, AMC 22.561 discusses the emergency landing situation and notes:

> *'Energy-absorbing seats, seat cushions or seat mountings constitute another means of improving safety by reducing the load on the occupant's head and spine in a crash.'*

Analysis

Glider handling

The evidence showed that the glider stalled in the final turn with rudder applied and with sideslip present, leading to a departure from controlled flight at too low a height to allow recovery. The video evidence suggested that the pilot did not look at the ASI for 8 seconds before the aircraft stalled. It is possible, therefore, that he inadvertently allowed the glider's airspeed to reduce as he tried to achieve, while attempting to land downwind, the more usual impression of groundspeed gained from landing into wind. It was also possible that the pilot began the final turn below the target speed of 65 kt and with a wing tip clearance of approximately 24 ft. Rudder applied during the turn, and the momentary selection of airbrakes, would have increased the drag on the glider and, if the pilot eased back on the control column to prevent the nose from dropping, the speed would have decreased further.

The glider's stalling speed would have increased in the turn to approximately 55 kt, reducing further the margin above stalling speed. Eventually the margin was completely eroded and the aircraft stalled. The investigation did not determine whether a functioning stall warning system would have activated in sufficient time for the pilot to prevent the stall and complete the landing safely.

During the turn away from the tug aircraft, the pilot used small rudder inputs and appeared to scan the glider's attitude, airspeed and flightpath. During the final turn, however, rudder was applied throughout, airbrake was selected intermittently, the pilot's scan was limited to ahead and slightly left of the nose and he did not look at the airspeed. It is probable that the alarm experienced by the pilot, along with the fact that he had to fly the final turn so close to the ground, induced stress that affected his ability to fly within the safety margins available. It is also possible that the aircraft had insufficient energy to complete the turn safely.

During his safety review, the team leader established that the glider had sufficient energy to land safely from any point in the display but G-IZII had too much, rather than too little, energy to turn directly to the launch point and land safely. For glider pilots to use changes in angles to judge their approach, they must be able to see the point at which they intend to land. The launch point was behind the pilot of G-IZII, so it would have been very difficult for him to use this technique to judge the earliest position from which he could turn towards the launch point and not have too much energy to land safely. Although when flying a circuit ground features might not be useful, in this case using a pre-planned ground reference point might have prevented the pilot from turning away from the tug and entering the circuit too early. Therefore:

Safety Recommendation 2011-031

It is recommended that the Swift Aerobatic Display Team assess prior to each display the conditions required for the glider to land safely when it releases from the tug.

CAP 403 weather minima

Before the team took off, ATC reported cloud scattered at 600 ft and broken at 800 ft. CAP 403 defines significant cloud cover as being 4/8 or more; cloud reported as "scattered" implies cover of either 3/8 or 4/8. Therefore, a report of "scattered" cloud contains insufficient information to determine if cloud cover is "significant" in the context of display weather minima, making it difficult to judge before takeoff whether a particular type of display is permitted.

Display minima recommended in CAP 403 implied that a full aerobatic display was permitted if the "scattered" cloud at 600 ft provided cover of less than 4/8. Otherwise, the display should be limited to flypasts. The display instruction, however, whose limits were to be strictly observed, permitted a flat aerobatic display of aircraft in formation or the full aerobatic display of a solo aircraft, if there was no "significant" cloud below 500 ft. These limits were lower than those in CAP 403 because of an oversight, rather than as a result of a considered decision, but it was the 500 ft limit that was used by the team in deciding whether they were permitted to display.

Once airborne, pilots rely on their own judgement to decide whether to begin or continue a display and, in this case, the Twister pilot decided to cancel part of his display because he considered the weather unsuitable. Nevertheless, weather information available to pilots at air shows should be unambiguous. Accordingly, the following safety actions have been taken:

Safety action

The Civil Aviation Authority agreed to consider, in its ongoing review of CAP 403, the circumstances in which cloud should be considered significant.

The display organisers agreed to review their display instructions to ensure that they are in accordance with CAP 403 in the future.

Crashworthiness

G-IZII was designed as an aerobatic glider that would normally be landed in a conventional way following a local flight and it was only verified to 77% of the emergency landing ultimate load requirement of JAR 22.561. This accident was survivable but gliders designed to meet the emergency landing requirements of CS 22, and using energy absorbing materials in the seat structure, cushions or mountings, should reduce the level of injury suffered by pilots in similar accidents in the future.