Avid Speedwing (Modified), G-FOLD

AAIB Bulletin No: 8/2003	**Ref: EW/C2002/08/02**	**Category: 1.3**
Aircraft Type and Registration:	Avid Speedwing (Modified), G-FOLD	
No & Type of Engines:	1 Rotax 582 piston engine	
Year of Manufacture:	1994	
Date & Time (UTC):	22 August 2002 at 1630 hrs	
Location:	Otherton Airfield, Staffordshire	
Type of Flight:	Private	
Persons on Board:	Crew -1	Passengers - None
Injuries:	Crew - 1 (Serious)	Passengers - N/A
Nature of Damage:	Damaged beyond economic repair	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	46 years	
Commander's Flying Experience:	414 hours (of which none were on type) Last 90 days - 93 hours Last 28 days - 28 hours	
Information Source:	AAIB Field Investigation	

History of the flight

On the day prior to the accident, the aircraft had been flight tested by a PFA inspector following a wing span extension modification. The inspector completed the test flight and was satisfied with the aircraft's performance. This type of aircraft requires a Permit to Fly to be issued by the CAA, on the recommendation of the Popular Flying Association (PFA), before any other flight may be conducted. However, at the time of this accident, the Permit to Fly had not yet been issued, but there was no reason to suggest that it would not have been issued in due course.

As the owners were not qualified pilots, they intended to let a member of the local flying club familiarise himself with the aircraft before flying with them. This pilot had not flown the Avid Speedwing before but owned and regularly flew a Kitfox aircraft, which is similar. The day following the test flight, the pilot visually checked the aircraft and made several high-speed taxi runs. With the owner's assistance, the aircraft was refuelled and the pilot commenced his solo familiarisation flight. During his pre take-off checks, the pilot verified that the controls were moving freely and in the correct sense. As he accelerated down the grass Runway 34, he felt a 'bump' and heard a distinct 'crack' at approximately 65 mph. The takeoff was continued and, as the aircraft became airborne, there began an uncommanded gentle roll to the left. A witness on the ground observed a short period of level flight before the roll commenced. Application of right roll demand failed to correct the roll and the pilot reported that the left bank increased as he applied right stick input, but at no time did he feel any restriction to movement of the control stick.

At approximately 100 feet agl and 85 mph, the aircraft began to descend with an increasing angle of bank. The pilot reduced power momentarily, which increased the nose down attitude. Full power and full up elevator were applied. Just prior to impact, the pilot applied full left rudder in order that the right side of the aircraft would take the full force of the impact. A witness stated that the aircraft appeared to be turning back towards the airfield as if to make an emergency landing. Further witness and pilot reports suggested that the aircraft struck the ground initially with the left wing or landing gear and rapidly rolled onto the right wing, with the aircraft slewing through 90° to the left before coming to a halt. The pilot was able to extricate himself from the wreckage without assistance, but subsequently required hospital treatment.

Aircraft Description

The Avid Speedwing is a high wing kit plane, with a maximum take-off weight of 463 kg. It has a side-by-side two seat configuration. The aircraft can be 'trailered' for transport by road and has folding wings that rotate backwards about the aft spar pickup. The fuselage is constructed from a steel tube rigid joint truss structure. The fuselage and wings are covered in dope sealed Dacron fabric. The standard wing has a span of 24 feet, although the accident aircraft had been recently modified to increase the wing span to 30 feet. The kit can be built in either a tailwheel or a tricycle gear configuration. The accident aircraft originally had a tricycle gear configuration, but in May 2000 it was converted to a tailwheel configuration. The aircraft had a flaps-up stall speed of 50 mph at maximum take-off weight.

The Avid's lateral control system is unusual in that it consists of two full span flaperons. The flaperons can be deflected symmetrically downwards to act as flaps and can also be deflected asymmetrically via the control stick to act as ailerons to control bank angle. The flaperon is actuated via a vertical control rod attached to the inboard leading edge of the flaperon. The vertical control rod is connected to a mechanical mixer behind the pilot's seat that takes flap input from the flap lever and lateral control input from the control stick.

Wreckage and Impact Examination

The impact marks in the ploughed field indicated that the aircraft had struck the ground in a left wing low attitude, with approximately 20 to 30 degree left bank. The aircraft had then yawed to the left and impacted travelling sideways. The sideways motion caused the right wheel to collapse underneath the fuselage and it had formed a track in the field along the direction of travel (see Figure 1). The direction of travel of the right wheel track was 151°M. The aircraft is estimated to have impacted at a speed of between 50 kt to 70 kt and travelled a distance of 25 metres along the ground. The right wing appeared to have dug into the soil, collapsing the wing tip, and absorbing some of the impact energy. Fortunately, the vertical impact was not sufficient to cause any spinal injury to the pilot. The tailwheel had bent to the left and dragged through the soil producing another track. The left wing was undamaged apart from slight rub and soil marks where the left wing tip had grazed the soil. The left wing aft lift strut threaded rod attachment had fractured. The left wing struts had also buckled forwards. The left flaperon had detached from the wing, but was still attached to its control rod - it was probably torn off when the left wing tip touched the ground. The right flaperon had detached and was buckled. It had separated from its control rod as the right wing had dug into the ground.

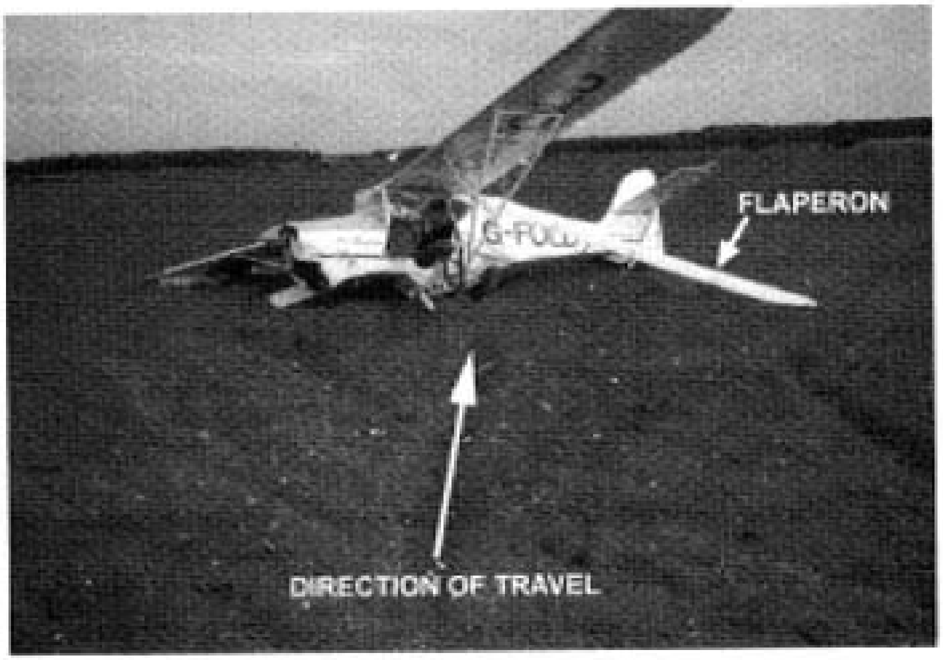

Figure 1 Accident Site

Two of the carbon-fibre composite propeller blades of the three-bladed propeller had delaminated and cracked. Due to the left yaw prior to impact, the nose of the aircraft and engine compartment sustained relatively little damage. The engine was not examined in any detail as the pilot reported that the engine was operating normally right up to initial impact.

Flight Control System Examination

The control stick was free to move in both axes. The elevator control rod had been bent, but forceful application of full fore and aft stick caused the elevator to move to its full up and down travel. No evidence of any pre-impact damage to the rudder control system was found. The rudder was operated by cables that connected the rudder directly to the rudder pedals - these cables were intact. Sideways movement of the control stick moved a bell crank that was connected to a rod that operated the flaperon mixer mechanism behind the pilot's seat. The bell crank was bent and the connecting rod was also slightly bent. The stick moved the vertical flaperon control rods freely but the bent bell crank restricted the degree of down left flaperon available. When the bell crank was disconnected from the rod, the flaperon control rods operated to their full travel in both directions.

It was possible to jam aft movement of the 'mixer to bell crank' connecting rod by rotating the pilot's left seat belt attachment plate downwards. However, with the seat belt secured, as it was in this accident, the plate would not have been able to jam the control rod. Older versions of the Avid had a flaperon control rod that passed directly underneath the seat - a design that enabled a collapsed seat to jam the control rod. The Avid in this accident was equipped with a modified control rod that passed along the left side of the fuselage, clear of the seat base.

Airframe Examination

The most extensive damage to the fuselage structure was to the landing gear truss as shown in Figure 2. The upper cross tube had fractured as a result of the sideways load on the right gear forcing the gear to fold underneath the fuselage. The cross tube is normally hollow but the fracture revealed that two steel rods had been inserted. There was also evidence of a weld repair to the cross tube. It became apparent that, on a previous occasion, this cross tube had probably been bent during a hard landing and that it had been straightened and steel rods inserted during the repair. No entry regarding this repair was found in the aircraft logbook and it was ascertained that it was not a PFA-approved repair scheme.

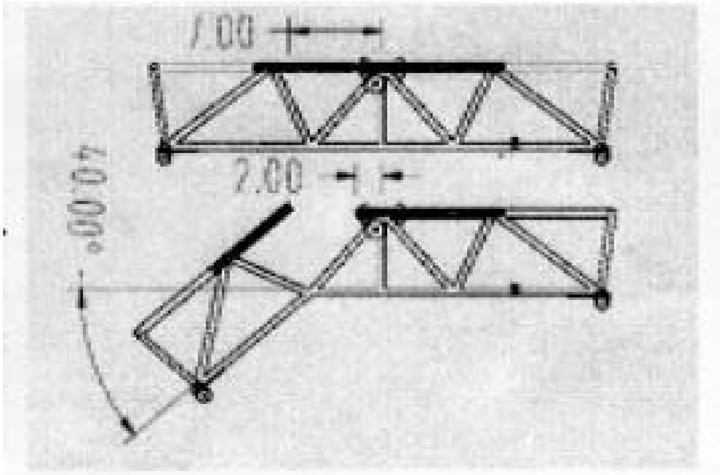

Figure 2 Diagram of truss with steel rod insert (looking aft)

The tail structure of the aircraft was relatively undamaged, apart from the right aft corner of the elevator that was bent on impact. The right wing tip was extensively damaged as it had dug into the soil on impact. The right wing forward spar pickup had also fractured allowing the wing to sweep forwards. The right wing lift struts were undamaged. Although the left wing, apart from the flaperon, was not damaged the left wing aft lift strut had detached and both struts had buckled (see Figure 3).

The left wing aft lift strut is attached to the wing via a threaded rod and an adjustable eye end (see Figure 4). The strut had fractured at the threaded portion of the steel rod (see Figure 5).

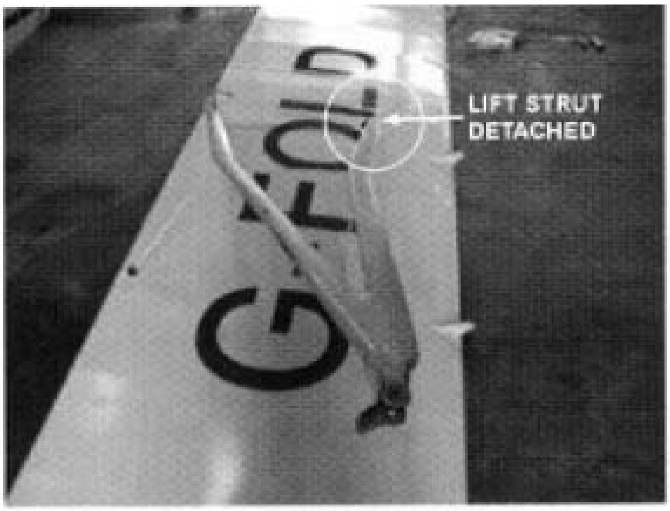

Figure 3 Buckled Left Wing Struts (aft strut has detached at wing end)

The left wing aft lift strut is attached to the wing via a threaded rod and an adjustable eye end (see Figure 4). The strut had fractured at the threaded portion of the steel rod (see Figure 5).

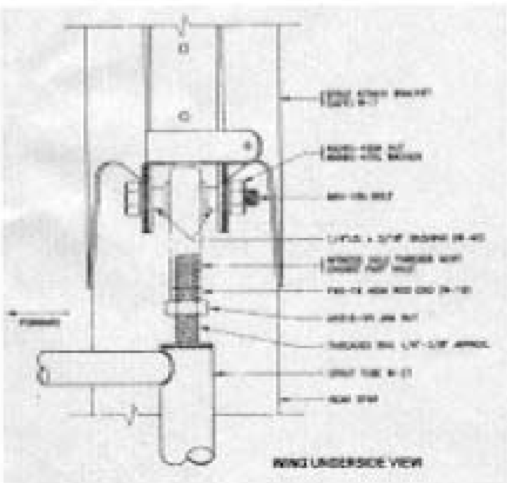

Figure 4 Left Wing Aft Lift Strut Attachment

Figure 5 Fractured left wing aft strut

The lift strut attachment design permits the wing twist to be adjusted after the aircraft has been built to eliminate any lateral asymmetry. The right wing aft lift strut does not have an adjustable rod end. It was not readily apparent that this failure had been caused during the impact and therefore the fractured rod was sent to a metallurgist for examination.

Metallurgical Examination of Fractured Rod End

The metallurgist concluded that the fracture had occurred as a consequence of overload bending and that this had resulted from the application of high compressive loads. He also noted that the threaded rod had bent plastically and that vibratory loads had been applied during the bending, thus causing cyclic changes in the rate of separation. However, he ruled out fatigue and corrosion as possible causes of this fracture. Further examination showed that the rod had been manufactured from low carbon rolled steel bar and that the threads had been cut, rather than rolled. A Vickers hardness test gave a value of approximately 300 HV(10), which corresponds to an approximate tensile strength of

925 Newtons (N) per square millimetre, which is typical for this type of material. Figure 6 shows a close-up of the fracture at the wing attachment end. The rod had bent inwards towards the fuselage.

Figure 6 Close-up of bend in fractured rod (bend is inwards towards fuselage)

The lift strut is effectively pin-jointed at both ends. Therefore, the flight loads can only induce either a tensile or a compressive load in the threaded rod. However, this rod had failed in bending. The rod had therefore either failed due to impact loads or it was bent prior to flight. If the rod had been bent prior to flight, then a compressive load acting during the takeoff roll could have caused the rod end to buckle, resulting in a bending failure.

Aerodynamic Effect of a Separated Aft Lift Strut

Under normal flight loads, the aft lift strut is in tension and is working to prevent the aft portion of the wing from lifting. If the aft lift strut were to fail at the wing attachment point, then an upward lift force would cause the trailing edge of the wing to lift up. The wing would still be restrained by the forward strut and the jury strut would take more of the aft wing loading. The net effect would be for the wing to twist in the nose down direction, with more twist outboard than inboard. This wing twist would result in a reduction of lift on the failed side that would cause the aircraft to roll. Failure of the left wing aft lift strut on takeoff would produce a left roll. If the pilot were then to counter this roll by applying right stick, the left flaperon would deflect downwards. On an unrestrained wing the left flaperon would act like a trim tab and cause the wing to twist even more nose down and thus cause more left roll, ie in the opposite direction of that commanded.

Load Required to Bend Aft Lift Strut Rod End

As stated previously, flight loads could only induce a compressive or a tensile load in the strut. The threaded rod had a tensile strength of approximately 925 N per square millimetre. Based on the cross sectional area of the threaded rod, the maximum tensile or compressive load that the rod could have sustained prior to failure was approximately 31,600 N (equivalent to a 3,200 kg load). The aircraft only weighed approximately 400 kg and, therefore, it would not have been possible for a compressive or tensile load to fail an undamaged threaded rod during takeoff. However, if the threaded rod was bent prior to takeoff, then a small compressive load, perhaps induced by an uneven runway surface, could have been sufficient to buckle the rod and hence cause it to fail in bending.

The threaded rod was not very strong in bending. The fracture point of the rod was offset 44.8 mm from the eye-end attachment point. An estimated load of 75 kg applied at a right angle to the rod at this point, possibly during ground handling, would have been sufficient to bend the rod.

Avid Accident in the USA

On 20 August 2000, an accident occurred to an Avid Hauler in Trinidad, Colorado, USA. The Avid Hauler is a very similar aircraft to the Avid Speedwing - one of the main differences is that the Hauler has a more cambered wing. The Hauler in this accident had a wing span of 30 feet. The aircraft had been cruising for approximately an hour at 1,000 feet agl when the aircraft began to bank left. The pilot was unable to control the bank with full right stick. The pilot also reported losing elevator control and rudder control. The pilot adjusted the throttle until the aircraft was established in a slight left bank at 65 mph. The aircraft continued to spiral down until it hit the ground. The pilot was seriously injured. The National Transportation Safety Board determined that the probable cause of the accident was *the failure of the left wing lift strut attachment rod for an unknown reason, which resulted in a loss of aircraft control*. The threaded rod was sent to the AAIB for examination. The metallurgist determined that the rod had failed in overload bending in the same manner as the rod from G-FOLD.

Discussion

The accident was caused by the inability of the pilot to regain full control of the aircraft after it began to roll to the left after takeoff. Among the possible causes of the left roll were: (a) aircraft stall or spin; (b) control restriction; (c) control detachment; and (d) structural failure of the left lift strut. Each of these possibilities is evaluated in turn:

(a) Aircraft stall or spin

The accident flight was the pilot's first flight in an Avid Speedwing. It is possible that the aircraft stalled after lift off or that it stalled and then entered an incipient spin to the left. The pilot had logged more than 250 hours in a Kitfox aircraft that he owned, which is a very similar design to the Avid. One witness reported that he believed the aircraft was turning back to land, which is not consistent with the onset of a stall or a spin which usually involve sudden pitch and/or bank angle changes. The impact evidence suggested that the aircraft struck the ground in a relatively flat pitch attitude. A stall or a spin from 100 feet agl would have resulted in a significantly steeper impact.

(b) Control restriction

It is possible that a control restriction prevented the flaperons from being deflected during attempts to correct the left bank. The bell crank which connected the stick to the flaperon controls was found bent, which limited the degree of left flaperon down travel available. The design of the lateral control system is such that any restriction or jam in the control linkage would be felt through the stick. The pilot reported that he did not feel any restriction to movement while he was applying right stick during his attempts to counter the left roll. It is unlikely that the pilot bent the bell crank without noticing it. The bell crank was probably bent on impact as a result of the flaperons being ripped off and forcing the stick against the pilot's leg.

(c) Control detachment

Neither flaperon had become detached in flight, as they were both found with the wreckage. Examination of the control system showed that all linkages were continuous apart from the right flaperon which had separated from its control rod. The right flaperon had sustained significant damage and had buckled on impact and, therefore, it is likely that it had separated from its control rod during impact. In addition, if the right flaperon had become disconnected in flight, some degree of lateral control response would have been maintained by the left flaperon alone.

(d) Structural failure of the left lift strut

If the left wing lift strut threaded attachment rod had failed during takeoff, it would have caused the left wing to twist nose down, which would have resulted in a left roll. A right stick input would subsequently have increased the left bank - a symptom that the pilot reported experiencing. The pilot also reported hearing a distinct 'crack' during the take-off run. It is possible that the compressive force on the strut, from bouncing over an uneven surface, could have failed an already-bent lift strut threaded attachment rod. The compressive force would not have been sufficient to fail an undamaged rod. Metallurgical examination of the rod did not reveal any evidence of fatigue or corrosion. The rod had failed in bending due to a compressive load. Calculations indicated that an estimated load of only 75 kg applied perpendicular to the threaded rod could have been sufficient to plastically deform the rod prior to flight.

There are a number of ways that the rod could have been bent during ground handling. It is possible that the rod was bent during a previous hard landing and evidence from the fractured truss suggested that the aircraft had experienced a hard landing sometime in its past. However, due to the light weight of the aircraft, the shock load from a hard landing was probably insufficient to exceed the compressive yield strength of the strut.

It is also possible that, at some point in the past, the aircraft was tied down using a rope passing around the rod. However, tie-down rings are provided on the forward lift strut and the owners of the aircraft reported only ever using the forward rings as tie-downs. It is also possible that the rod may have been bent by a force applied as a result of *trailering* the aircraft on the road (the aircraft was towed by its tail with the main wheels on the road). However, the owners of the aircraft were of the opinion that the rod was undamaged prior to flight.

From the available evidence it was not possible to determine a definite cause of this accident. However, given that a left lift strut failure was a possible cause it was suggested to the Popular Flying Association that the lift strut threaded attachment rods on all Avid Aircraft should be inspected.

Safety Action

As a result of the investigation into this accident, the Popular Flying Association (PFA) issued an Airworthiness Information Leaflet (MOD/189/007) on 26 September 2002. This leaflet required that the lift strut threaded attachment rods on all Avid aircraft be inspected within five flying hours from receipt of the leaflet, or at permit renewal, whichever was soonest. The PFA has also promulgated this information to the Experimental Aircraft Association (EAA) in the USA.