INCIDENT

Aircraft Type and Registration:	Slingsby T67M260, G-EFSM
No & Type of Engines:	1 Lycoming AEIO-540-D4A5 piston engine
Year of Manufacture:	1989
Date & Time (UTC):	23 November 2006 at 0945 hrs
Location:	Near Cambridge Airport, Bedfordshire
Type of Flight:	Public Transport (Training)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Possible cracking of the cockpit floor
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	36 years
Commander's Flying Experience:	2,000 hours (of which 300 were on type) Last 90 days - 38 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, information from the maintenance organisation and manufacturer and AAIB examination of the aircraft

Synopsis

Whilst attempting to recover from a spin during an aerobatic training flight, the instructor was initially unable to move the rudder pedals from their fully pro-spin position. He managed to free the pedals by applying a high pedal force and was then able to recover from the spin. The restriction delayed recovery by an estimated two and a half turns. The restriction had probably been caused when one of the pedals contacted a fixed bracket, probably due to a relatively small lateral displacement of the rudder pedal mechanism. The displacement could have been due to wear in the rudder pedal mechanism, deformation of a bracket supporting the mechanism and/or displacement of the bracket because of cracking of the floor structure to which it was mounted.

Adequate checks aimed at ensuring sufficient clearance had not been specified, but detailed repetitive inspections mandated following the incident may be effective in detecting progressive deterioration of the mechanism. The inspection programme would not preclude the possibility of damage to the support bracket or its mountings (potentially allowing interference to free movement of the pedals) from remaining undetected until a subsequent inspection. Two Safety Recommendations have been made.

History of the flight

The incident occurred during a dual aerobatic training flight. The student pilot, who held a Private Pilot's

Licence, was undergoing training aimed at obtaining an Aerobatic Certificate from the Aircraft Owners and Pilots Association (AOPA). The purpose of the flight was to teach the student spin recognition and recovery, at both the incipient and fully developed stages. The instructor was seated in the left seat and the student in the right seat, each wearing a full harness. The weather was good, with no cloud.

The instructor reported that he carried out a demonstration spin to the left and recovery and the student repeated this, without incident. The third spin to the left was also an instructor demonstration, initiated and maintained with full left rudder. Following one turn for entry and stabilisation, the spin was allowed to continue for three turns. When the instructor initiated recovery, by first attempting to apply full anti-spin rudder, he found that he was unable to move the right pedal. After two attempts, the rudder remained fully deflected to the left. On his third attempt the instructor applied considerable force to the right pedal and it freed with a loud crack noise. He immediately applied full right rudder and made a normal recovery from the spin, in the usual one and a half turns. The instructor estimated that the control difficulties delayed the recovery by two and a half turns.

The aircraft was flown back to its base at Cambridge Airport, Bedfordshire, and landed without further incident.

Aircraft description

The Slingsby T67 Firefly is a single-engined low-winged monoplane, designed to be fully aerobatic (Figure 1). It is constructed principally of glass reinforced plastic (GRP). Two side-by-side seats are provided. The Firefly was first certificated in 1983, as the T67M, and a number of other versions were subsequently developed, including the 260 shp T67M260. In total, 280 aircraft have been built. Maximum takeoff weight of the T67M260 is 2,550 lb (1,157 kg).

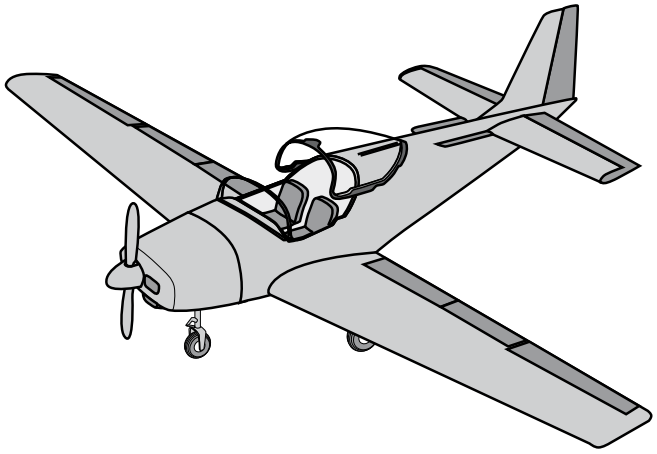

Figure 1

Primary flight controls are conventional, operated by dual cockpit controls. Rudder pedal assemblies are numbered from 1 to 4 across the aircraft from left to right (Figure 2). The pedals are mounted on two rotatable cross-shafts in the cockpit, known as rudder bars, with the left pedal of each pair (Nos 1 and 3) fixed to the left bar and the right pedals (Nos 2 and 4) fixed to the right bar. A crank arm on each bar is connected to rudder operating levers by a cable-fairlead system. Thus, a forward displacement of the No 1 pedal, for example, rotates the left bar and moves the No 3 pedal forward in unison, while the connection through the cable loop causes the right bar to rotate in the opposite direction and displace the Nos 2 and 4 pedals aft.

Each rudder bar is supported on two rotation bearings, each mounted on a bracket bolted to the cockpit floor structure. The support bracket bolts pass through the floor panel into captive nuts fixed to the underside of the GRP structure. Rudder bar end-float can be adjusted by fitting packing washers of varying thickness between the brackets and the ends of the bar.

Rotation of the rudder bars also steers the nosewheel, via

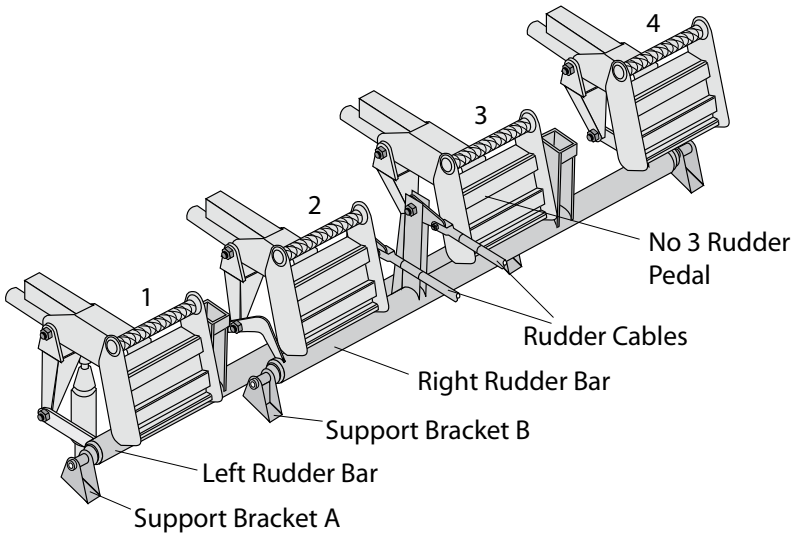

Figure 2

a control rod driven by a crank arm fixed to the right bar. Each pedal can be pivoted, by pushing a brake bar at the top of the pedal, to apply the brake on the respective main wheel. A slider mounting mechanism allows each pedal to be individually adjusted fore and aft to cater for variation in pilot leg length and then locked by a pin that locates in one of four holes in the slider.

Two adjustable stops fixed to the floor structure limit the forward rotation of the two rudder bars (ie the forward travel of the associated pedals). The rearward rotation of each rudder bar is limited by bottoming of the piston in the respective brake cylinder. These limitations constitute the travel stops for both the rudder and nose wheel steering systems.

The Pilot's Notes for the T67M260 provided information about normal spinning which may be summarised as follows: After initiation, the spin progressively stabilizes over about three turns, ending up with about 50º of bank and with the nose about 40º below the horizon. In a normal, developed spin the rate of rotation is about 2 seconds per turn and the height loss about 300 ft per turn, indicating a descent rate of around 7,500 ft min. Following recovery from the spin, the ensuing dive involves a height loss of around 700 ft. The initial flight control input specified for spin recovery is to apply full rudder to oppose the direction of turn.

Aircraft examination

Following the flight, the organisation that normally maintained the aircraft undertook a detailed inspection of the rudder control system, in conjunction with representatives of the aircraft manufacturer. The system was disassembled before the AAIB examination.

The maintenance organisation reported that, after prolonged attempts, it was found possible to produce interference between the No 3 pedal and a fixed bracket supporting engine control cables. With the No 3 pedal adjusted fully forward, pushing the brake bar of this pedal fully forward (thus applying full left rudder and full left wheel brake) positioned the top part of the pedal close to the bracket. If a left side force was simultaneously applied to the No 3 pedal, its edge could contact the bracket (Figure 3). It appeared that the pedal could possibly get caught behind the bracket and that a significant force on the right pedal could be required to clear the foul.

No signs were found that the engine control cable bracket was incorrectly sized or positioned. The aircraft manufacturer reported that, although no witness marks could be found to confirm a positive foul, their inspection showed there was excessive end-float (ie lateral movement) of the left rudder bar, estimated at around 1.5 mm, and that the left support bracket for the left bar (Bracket A in Figure 2) was angled over to the left. After removal of the rudder bars from the aircraft, cracking of the floor beneath Bracket A was found. No

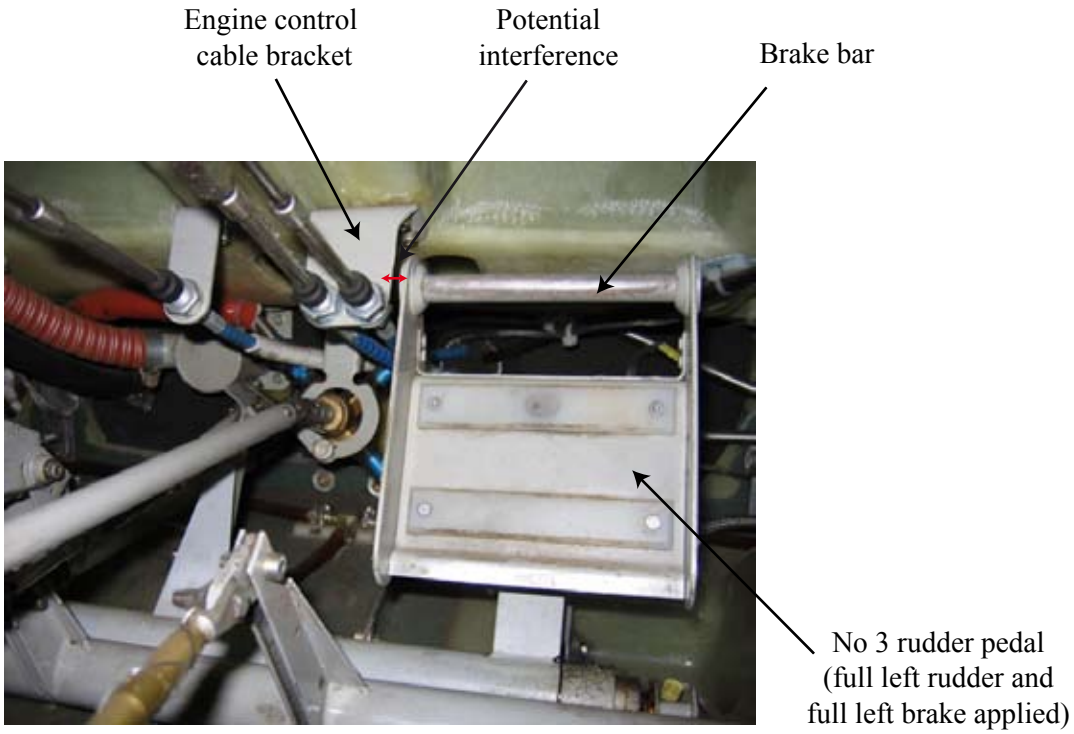

Figure 3

No 3 pedal clearance (similar aircraft)

evidence was available to indicate whether the damage had been present before the incident or had been caused by high forces applied while attempting to free the pedals during the incident. The degree to which the cracking would have allowed lateral movement of the left rudder bar could not be positively determined, but it appeared unlikely that it would have been major.

Background

No evidence was found to indicate that control deficiencies had been a factor in previous T67 accidents. A number of instances of restriction in T67 rudder pedal movement had been experienced. The restrictions reportedly had all been caused by interference between moving parts of the cockpit rudder, wheelbrake and steering mechanism (generally a pedal or brake bar or a pilot's boot) and either other parts of the mechanism or adjacent static parts of the aircraft.

At the time of G-EFSM's incident, procedures aimed at ensuring adequate rudder mechanism clearance were contained in a number of Service Bulletins (SBs) issued by the aircraft manufacturer over the service life of the T67, but were not incorporated in the Aircraft Maintenance Manual.

One of the SBs (SB 88, first issued 30 August 1996) specified an inspection for a potential foul between the No 3 pedal and both the mixture lever and the engine control cable bracket. The SB specified a minimum clearance of 3 mm between the pedal assembly and the bracket when left rudder and left brake were applied together with a left-hand side force sufficient to take up any free play. It was applicable to T67M260 and T67M260-T3A aircraft that did not have Modification M687 incorporated and was classified as Mandatory by the CAA. The inspection was required within 50 flight hours; no repeat inspection was specified.

SB 75 (first issued 8 March 1995) recommended an inspection and set-up procedure aimed at ensuring adequate clearance between the No 2 rudder pedal and a heater distribution box. If the clearance was found to be inadequate, a check of the end-float of both rudder bars was specified. If the clearance was greater than 0.8 mm, packing washers were to be added to achieve this limit. The manufacturer classified the SB as '*Highly Recommended*'. It was applicable to seven T67 aircraft, not including G-EFSM (Works Number 2072). The inspection was recommended to be carried out at the next 50 hour check or within one month of receipt of the SB; repeat inspection was not specified.

Cases of cracking of the GRP structure beneath Bracket A on T67 aircraft had occurred previously, and the manufacturer had issued a Service Bulletin (Slingsby Aviation SB 168, issued 19 September 2000) requiring an inspection of the area. The SB was categorised as '*Recommended*'. It recommended that, if damage were found, the GRP should be repaired and a strengthening doubler fitted. The inspection was recommended to be carried out during the next aircraft Annual Inspection. The aircraft manufacturer noted that a turn outside the permitted limits while towing imposes very high loads on the rudder system which it is not designed to take. Markings are painted on the engine cowl to show the limiting angle for the towbar, which is typically around 2 metres long. An over-travel to the right rotates the right rudder bar, via the nose wheel control rod, until it contacts the forward stop. Simultaneously, the left rudder bar is rotated rearwards, via the rudder cable loop, until the piston in the left brake cylinder bottoms. Over-travel to the left similarly rotates the right rudder bar rearwards, until the piston of the right brake cylinder bottoms. The left pedal is not driven forwards, as the rudder cable loop does not transmit a compression load.

Once the system has reached the stops, any further increase in steering angle is likely to cause overload damage, probably to the rudder bar support brackets or the floor to which they are bolted. The manufacturer noted that it would be impractical to design the system to withstand the high loads that can be generated in this situation.

Post-incident measures

Following the incident to G-EFSM, the manufacturer issued two additional SBs (Slingsby SB 187, for the T67M260 and two T67M200 aircraft, and SB 188, for the T67B, T67C, T67M-Mkll and the other T67M200 aircraft, both issued on 9 March 2007). The manufacturer stated that these SBs aimed to bring together the various check and adjustment procedures for rudder mechanism clearance provided in the previously published SBs. The intention was:

> *'to reinforce the importance of ensuring correct clearances and maintenance of the rudder operating mechanism, mountings and stops to ensure the required clearance for safe operation.'*

EASA Airworthiness Directive (AD) 2007-0132 was issued on 11 May 2007 mandating incorporation of the two SBs. The AD required some of the SB measures to be carried out before further flight and some within the next 50 flight hours and for checks to be repeated at intervals of 300 flight hours or 12 months, whichever occurred first.

Minimum rudder mechanism clearances specified in the SBs were generally in the range 10-20 mm (0.39-0.79 inch) but were considerably less in two areas, including that between the No 2 pedal and the steering arm bolt, specified as 1 mm (0.04 inch). The SBs stated:

'It must be noted that during the clearance checks that the pedals do not necessarily have a direct fore and aft load applied, there will be side loads on the pedal pads deflecting the pedal pad laterally or pivoting the pedal about its slider.'

The magnitude of the lateral load to be applied during the checks was not specified but was intended to take up any free play in the mechanism.

SB 187 and SB 188 also specified a check of the rudder bar end-float and adjustment to a maximum of 0.8 mm for all aircraft, irrespective of pedal clearances. They also required a check that Bracket A was square to the floor, not 'lozenged' (Figure 4) and without deformation to its base. The SBs noted that:

'An identifiable cause for the distortion of the rudder support brackets is ground handling the aircraft with a vehicle, whereby the towing arm has been outside of the limitation markings on the cowling when the aircraft is turned.'

The manufacturer considered that cockpit rudder mechanism clearances, while small in some areas, were adequate, provided the SB measures had been incorporated and the system was correctly adjusted and maintained.

The manufacturer also intended to issue an Advanced Information Leaflet (AIL No 01/2007), intended to clarify the rudder system set-up procedure. It was intended that the AIL would also include a warning against exceeding the towing angle limits and that consideration would be given to revising the Aircraft Maintenance Manual to emphasise the consequences of such an exceedence. The manufacturer also stated the intention of considering the possibility of introducing a towbar weak link or load-limiter device.

Discussion

The available evidence indicated that G-EFSM's rudder restriction had resulted from interference of the engine control cable bracket with the No 3 pedal. This would have required the pedal to have been adjusted fully forward and pushed and rotated fully forward. It appeared that it would be relatively easy to apply wheel brake inadvertently in this way when applying full rudder; this would not normally be of any relevance while airborne. While it appeared that a sufficiently high force applied to the No 2 pedal would be expected to free the mechanism, this could not be positively confirmed and involved the risk of damaging the rudder pedal mechanism or its mountings. The restriction was clearly a highly undesirable occurrence and in this case caused a significant delay in recovery from the spin.

The control restriction apparently resulted from excessive lateral displacement of the No 3 pedal. Such

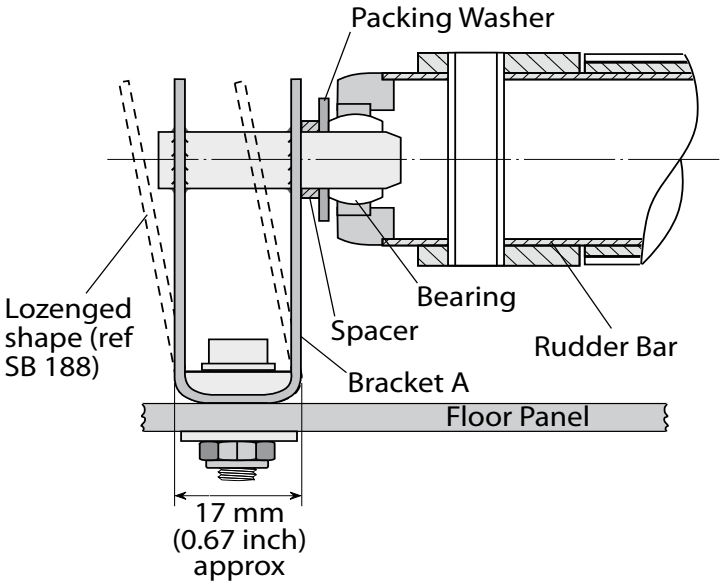

Figure 4

Rudder bar support bracket

displacement could result from wear in the No 3 pedal slider and/or excessive end-float of the left rudder bar. An increase in end-float could be caused by wear, by lozenging distortion of Bracket A and/or by tilting of Bracket A on its mountings.

The reported unloaded end-float in the left rudder bar, which was an estimated 0.7 mm (0.028 inch) outside the manufacturer's limits, should not have been sufficient on its own to result in a foul. However, only a small amount of additional lateral displacement of the No 3 pedal would be needed for interference to occur, given the minimal allowable clearance (3 mm (0.12 inch)) between the pedal and the cable bracket.

Cases of distortion of Bracket A had occurred previously, attributed by the manufacturer to an excessive steering angle during towing. It was noted that, whereas the left mounting bracket for the right rudder bar (Bracket B, Figure 2) had a lateral web member that would increase its resistance to either elastic or permanent lozenging under lateral loads, this feature was not present on Bracket A.

It was also apparent that the base of Bracket A was relatively narrow (Figure 4), and that side loads applied to the bracket would therefore be expected to generate higher loads in the bracket attachments and thus in the local floor structure than if the base were wider. In G-EFSM's case, weakening of the bracket attachment because of floor cracking could possibly have allowed the bracket to tilt and could therefore have contributed to displacement of the No 3 pedal. However, this could not be confirmed as it was unknown whether the floor cracking found had occurred before or as a consequence of the incident.

It was unclear whether loads applied by the pilot could deform the bracket. It was apparent that distortion could be the consequence of an excessive steering angle during towing, which would generate high forces in the rudder system as its travel was limited by stops within the rudder pedal mechanism. Primary stops on the nosewheel oleo would be required to prevent such excessive loads. However, the possibility of finding specific evidence that an excessive steering angle had caused any such distortion would be small. Thus the cause of the distortion found with G-EFSM and in the other cases could not be conclusively determined.

SBs issued some time before the incident had recommended inspection for cracking of the GRP structure beneath Bracket A and required inspection for adequate pedal clearance from the control cable bracket. However, no repeat inspections of these aspects had been specified. A further SB had recommended a one-off inspection and rectification of excessive rudder bar end-float in relation to a different rudder mechanism clearance problem, but had not been applicable to G-EFSM. There appeared to have been an expectation that normal engineering practice would ensure correct rudder bar end-float. Thus the detailed, repeated checks specified in the SBs issued after G-EFSM's incident represented a considerable improvement.

However, the checks, while likely to ensure the detection of wear before it became excessive, could not be expected to detect damage immediately to Bracket A or its attachment. Any deformation of the bracket or weakening of its attachment as the result of floor cracking could well occur suddenly and not necessarily be found until the subsequent scheduled check on the pedal mechanism. This could be up to 300 flights or 12 months later. In view of the small rudder mechanism clearances in a number of areas and the potential hazard of a rudder restriction, the following Safety Recommendations are made:

Safety Recommendation 2007-077

The European Aviation Safety Authority should review the rudder pedal system of the Slingsby T67 aircraft. Consideration should be given to improving both the lateral stiffness and strength of the rudder bar support brackets and the integrity of the attachments for the brackets, in order to prevent possible interference with the free movement of the rudder pedals. Consideration should also be given to requiring means to limit the loads applied to the rudder system during towing.

Safety Recommendation 2007-078

The European Aviation Safety Authority should require changes to the engine control cable bracket on relevant Slingsby T67 aircraft to increase its clearance from the No 3 rudder pedal, in order to prevent possible interference with the free movement of the rudder pedals.