DH82A Tiger Moth, G-AOES

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Aircraft Type and Registration:	DH82A Tiger Moth, G-AOES
No & Type of Engines:	1 De Havilland Gipsy Major 1 piston engine
Year of Manufacture:	1941
Date & Time (UTC):	26 September 1999 at 1610 hrs
Location:	Charity Farm Airstrip, Baxterley, Warwickshire
Type of Flight:	Private
Persons on Board:	Crew - 1 - Passengers - None
Injuries:	Crew - Serious - Passengers - N/A
Nature of Damage:	Aircraft severely damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	915 hours (of which 360 were on type) Last 90 days - 26 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB inquiries

History of the flight

The aircraft was being flown by the pilot from the rear cockpit, with the front cockpit vacant. During the course of the local flight a number of aerobatic manoeuvres were conducted, including barrel rolls, a loop, a wing-over and steep turns. A friend of the pilot had taken off from the same airfield in another aircraft and was flying in the vicinity at the time, with the two aircraft remaining in radio contact. On returning to the airfield, G-AOES positioned low downwind to allow a model aircraft to land. However, as the pilot was levelling from his descent, he suddenly realised that his controls had jammed. The aircraft was just above tree top height at this point. He informed the other aircraft of his jammed controls, but his next recollection was of being in a dazed condition with the aircraft on the ground. The pilot of the other aircraft called the Birmingham Approach controller who alerted the emergency services. The pilot, who had been wearing a military helmet, suffered facial cuts from contact with the lower edge of the visor which he, in retrospect, considered was 'very sharp'. After the arrival of the police and emergency services on site, he was

taken to hospital where he was later diagnosed to be suffering from a cracked vertebra and internal bruising to his groin.

Examination of the aircraft

The aircraft had come to rest beside a hedge and ditch bordering the airfield. The engine bay and the front cockpit had been severely crushed in the impact.

The control columns in the front and rear cockpits of the Tiger Moth are connected together by the aileron torque tube and the elevator push rod. These are enclosed in a wooden compartment built onto the fuselage floor. The top of the compartment is covered with a sheet of plywood, which has two circular holes cut into it for the control columns. Leather gaiters are attached between the base of each column and the upper surface of the compartment in order to prevent loose objects from falling through the circular holes.

On this aircraft, the front control column and gaiter had been removed previously in order to facilitate the egress of a parachutist who was sometimes carried in the aircraft; the rear gaiter was torn. The 'stub' tube, into which the front column had fitted, protruded slightly above the level of the plywood 'decking' of the flying controls compartment.

The rear control column had been pushed forward by the pilot as he had been thrown forward during the impact. The front column stub fitting was found in a similarly forward position. The front closure member of the flying controls compartment, together with a section of the plywood decking that included part of the circular cut-out, had been pushed off the front of the compartment. It was considered that this could have occurred as a result of an object, such as the harness Quick Release Fitting (QRF), becoming trapped between the edge of the cut-out and the stub fitting as the latter moved forwards in the impact (see later description of type of harness fitted). Some potentially corroborative evidence was observed in the form of crushed wood fibres on the internal edge of the forward left arc of the cut-out. It was noted that in the event of the front harness lap straps falling off the seat onto the cockpit floor, it was possible for the QRF attached to one of the straps to become lodged in the gap between the control column stub fitting and the edge of the circular cut-out in the plywood. Depending on the exact position of the QRF relative to the stub fitting, ie forward, rearward or to the side of the fitting, it would impede operation of the elevators and/or the ailerons.

The pilot subsequently considered that he became aware of the jam as he had attempted to level out from the descent downwind. This would imply that the QRF may have initially fallen into the aft side of the circular aperture, against the aft side of the stub fitting, and may have subsequently moved around as the control column was 'stirred' by the pilot as he attempted to clear the control restriction. Photographs of the relevant areas of both cockpits are shown at Figures 1 and 2.

Potential restriction of control column

The pilot subsequently commented that even with the front cockpit lap straps fastened, there is insufficient adjustment on the shoulder harness to keep the QRF clear of the base of the control column. He recalled that he had secured the front harness by tying the shoulder straps around the lap straps; however the 'slippery nature' of the webbing may have led to this becoming undone. He suggested that a restraint, such as an elasticated luggage strap, could be used to secure the harness when the front seat is unoccupied. BAE Systems stated that the certificated basic build standard of DH 82A Tiger Moth aircraft included a hinged control box cover part no H 19901 (Standard and

Mk 11) to prevent possible loose articles causing control restrictions when a control column is removed. BAE Systems have not approved any modification to remove such covers. The pilot additionally commented that even with the control column gaiter in place, the slack in the gaiter leather that permits column movement could still permit loose objects to fall into the gaiter folds between the stick base and the aperture, impeding control column movement.

Survivability issues

The aircraft was equipped with 'Z type' harnesses, of the type found in de Havilland Chipmunk aircraft. These used the existing attachment points for the Sutton harnesses which were originally fitted to Tiger Moth aircraft at manufacture. The Z type harness shoulder straps of the rear seat harness were attached at a single point, as was the original Sutton shoulder harness, to a transverse cable which was attached by brackets bolted to the ends of the fuselage longerons behind the pilot's head/shoulders. This cable had failed due to overload during the impact, allowing the pilot's head to contact the instrument panel.

The harness itself, together with the remaining attachments to the aircraft, had held in the impact. On this occasion, the pilot had been wearing a (non approved) lap strap on top of the harness, which he considered provided additional security during aerobatic manoeuvres. (The original Sutton harnesses were designed to be used in conjunction with a military seat-type parachute and were apparently not designed to provide crash restraint. If used without a parachute, the Sutton harnesses do not meet the original Air Ministry requirements. The lap straps are attached to the cockpit floor in such a position that the lap straps are routed over the pilot's thighs. A modification fitted to Australian registered Moth aircraft moves the attachment points to provide improved harness geometry. Sutton harnesses have been prohibited on Australian registered Tiger Moths for approximately 30 years).

The impact parameters, in terms of speed and attitude, appeared similar to those associated with a previous Tiger Moth accident which occurred to G-AOBJ on 20 August 1997 (AAIB Bulletin 6/98). It was therefore considered probable that the impact forces were similar for the pilots of both aircraft.

The transverse cable attaching the pilot's shoulder harness on G-AOBJ had failed in a similar manner to that on G-AOES. BAE Systems stated that modification 143, which increased the strength of the cable from 15 cwt to 20 cwt (ie 1 ton), was raised at the request of the RAF when the Tiger Moth was in military service. However, this requirement for an increased strength transverse cable was subsequently cancelled by the RAF in February 1948.

G-AOBJ had been equipped with Sutton harnesses, which were made from canvas webbing reinforced locally with leather. The pilot's lap strap had failed, causing him to be effectively unrestrained. The age of the harness was not established, but it was probable that the webbing had suffered considerable age related deterioration, with an accompanying reduction in strength. Following that accident, Safety Recommendation No 98-40 was made to the CAA). This recommended that mandatory action be taken to equip de Havilland Moth series aircraft with improved modern harnesses. The CAA accepted this recommendation, stating that they would require the Type Design Authority to issue a Service Bulletin that either limited the life of Sutton harnesses or introduced improved modern harnesses.

The outcome of this was that BAE Systems issued, in March 1999, Technical News Sheet (TNS) CT (Moth) No 33 Issue 1. This consolidated other TNS requirements affecting harness installation.

The 'Accomplishment' instructions detailed the annual inspection requirements for the harness and attachments, and additionally introduced a lifing policy, effective from the date of issue of the TNS. This called for an installed life of 9 years from the date of initial fitment. If it was not possible to determine the initial fitment date, the harnesses were required to be replaced not later than 150 flying hours or 3 years from the TNS issue date.

The 'Compliance' section of this TNS contains the following;

> 'The Type Design Authority notes that the safety harness fails to meet the requirements of Air Ministry Design Leaflet E3 when military seat parachutes are not used. It is strongly recommended that owners or operators consider fitting their aircraft with a harness of improved design made from modern materials meeting the requirements of Air Ministry Design Leaflet E3.'

Any new design of harness would require CAA approval. There have been a number of proposals for a new design of harness and the de Havilland Moth Club has taken an active interest in at least one of these proposals which envisages a three part modification, with Part 1 introducing a repair and overhaul scheme for Sutton harnesses fitted to de Havilland Moth aircraft; Part 2 introducing a replacement 'period style' Sutton harness made from modern materials; and Part 3 introducing an improved design of attachment and geometry for the Tiger Moth restraint system.

Discussion

The accident occurred following reported jamming of the flying controls at a low height. The evidence strongly suggested that the jam had occurred as a result of the QRF of the unsecured front harness in the empty front cockpit (from which the column had been removed) having fallen into the gap between the front control column base stub fitting and the surrounding aperture, from which the protective leather gaiter had been removed previously.

The accident appeared similar in impact parameters to another Tiger Moth accident which had involved G-AOBJ in 1997 (AAIB Bulletin 6/98), in which the pilot in the rear cockpit suffered serious injuries and subsequently died, and which led to AAIB Safety Recommendation No 98-40, which stated:

> 'In order to avoid unnecessary injury to the occupants of vintage aircraft during accidents, and since most Sutton harnesses currently fitted to such aircraft in service are likely to be in a deteriorated condition, it is recommended that all affected aircraft, including the de Havilland Moth series, be the subject of mandatory action by the CAA to equip them with improved modern harnesses.'

The resulting TNS CT (Moth) No 33 Issue 1 which was produced by BAE Systems, the Type Design Authority, was mandated by the CAA. This allowed Sutton harnesses to continue in service for 9 years from the date of fitment, where the date could be verified, or up to 3 years before replacement was required where the date of fitment could not be determined. At the end of these permitted respective periods (unless variations or exemptions are allowed) modification of such aircraft with improved harnesses manufactured from modern materials will require CAA approval. In addition, TNS 33 Issue 1 superceded TNS 12 in all respects. TNS 12 had required the fitment of high tensile strength (HTS) bolts to the front cockpit transverse cable attachments only. The rear cockpit transverse cable attachments had been fitted originally with HTS bolts as part of the basic

build standard. TNS 33 Issue 1 required inspection of the transverse cable attachment bolts for both cockpits and installation, if necessary, of HTS bolts at all four attachment positions.

However, whilst the above action should improve the harnesses on such aircraft in the future, there remains the further related aspect of the shoulder strap attachment cable on Tiger Moth aircraft. Although the pilot's Z type harness shoulder straps did not fail in this accident, the transverse cable to which the shoulder straps were attached did fail due to impact load overstressing, and in a similar manner to the failure of the pilot's shoulder straps attachment cable in the accident to G-AOBJ. The weakness of this cable was recognised some 50 years ago when the Tiger Moth was in RAF training service and an increased strength restraint cable design was made available at that time, although this modification was never adopted by the RAF. Replacement of the current 15 cwt shoulder strap attachment cable with a higher strength cable would be a relatively simple undertaking which could provide additional and potentially critical protection to occupants in future accidents.

Safety recommendation

In view of the above findings arising from this accident, and whilst it is acknowledged that the DH 82A Tiger Moth seat harness was not designed originally as a crash restraint, in order to avoid injury to the occupants of such aircraft in future accidents due to overload failure of the shoulder strap transverse attachment cable, the following Safety Recommendation has been made to the CAA:

Recommendation 2000-38

In order to avoid unnecessary and potentially serious injury to the occupants of de Havilland DH 82A Tiger Moth aircraft during accidents due to overstressing failure of the shoulder strap attachment cable, it is recommended that the CAA should take mandatory action to require Tiger Moth aircraft to be fitted with shoulder strap attachment cables of suitably increased strength.