ACCIDENT

Aircraft Type and Registration:	DH-82A Tiger Moth, N54556	
No & Type of Engines:	1 De Havilland Gipsy Major 1H piston engine	
Year of Manufacture:	N/K (Serial no: T-6392RO)	
Date & Time (UTC):	21 July 2019 at 1304 hrs	
Location:	Private airstrip near Hythe, Kent	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Fatal)	Passengers - 1 (Serious)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	51 years	
Commander's Flying Experience:	523 hours (of which 77 were on type) Last 90 days - 10 hours Last 28 days - 3 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The owner of the aircraft and his passenger, who was a professional pilot, were to carry out a flight to familiarise the passenger with the Tiger Moth. The owner occupied the front cockpit with the passenger in the rear cockpit, from which the aircraft is flown when solo. They completed a first sortie, which comprised general handling and circuits and was followed by a short break. They agreed to do some more circuits with the passenger flying the aircraft. After the first landing, the owner took control and performed a rolling takeoff and made an early right turn, estimated by the passenger to be at about 20-30 ft agl. The passenger noticed that the aircraft was becoming increasingly cross-controlled with full right rudder and left control stick, which resulted in the aircraft rolling into a steeply banked turn to the right and striking the surface of a crop field in a steep nose-down attitude. The pilot, in the front cockpit, was fatally injured and the passenger was seriously injured but able to release himself from the wreckage and drag himself clear.

The accident occurred because the increasing amount of right rudder was not reduced and left roll control stick reached the limit of its travel causing the aircraft to enter a descending, steepening turn to the right, and possibly to enter an incipient spin, before striking the ground. The reason for the loss of control was not determined, but the possibility that the pilot became incapacitated could not be excluded.

History of the flight

Background information

The passenger was an experienced commercial pilot who had decided to take up flying General Aviation (GA) aircraft again for recreational purposes. He did some revision with a training organisation and renewed his Single Engine Piston (SEP) rating on his Irish and UK ATPLs. About a month before the accident, he went to Pent Farm and met the owner of N54556 and it was agreed that they would go flying together at a later date. Subsequently, following an exchange of text messages, they agreed to meet at Pent Farm at 1000 hrs on 21 July 2019, the day of the accident.

The accident flight

The pilot and passenger pushed out N54556 from its hangar and discussed the aircraft. The passenger was not aware of the owner's qualifications but had no intention of flying the aircraft solo or logging the flight time.

The owner showed the passenger how to enter the rear cockpit and strap in. He was given a headset in a fabric helmet and was shown how to plug it into a battery powered intercom system but was told it would be difficult to communicate when flying. The owner hand swung the propeller to start the engine and removed the wheel chocks before climbing into the front cockpit, and they tested the intercom which was just acceptable.

The weather was good with no low cloud and with visibility in excess of 10 km. They taxied onto Runway 25, with the wind directly down the runway at about 10 kt, and the passenger carried out some taxiing before backtracking to the runway threshold. They lined up and the owner briefed the passenger on the takeoff technique before carrying out a power and magneto check. They commenced the takeoff run using full power, and the passenger felt the owner help him on the controls to lift the tail before the aircraft became airborne at about 55 kt. They climbed the aircraft at 70 kt, turning to the left before heading north.

The passenger carried out some turns before the owner, using hand signals because the poor intercom made communication difficult at higher power settings, directed him back towards Pent Farm. He also raised both hands to confirm to the passenger that he was not on the controls. They did the pre-landing checks, which included unlocking the slots and setting the trim lever just aft of the neutral position, before adopting the approach airspeed of 60-70 kt. The passenger felt the owner assisting on the controls, but without saying he was doing so, down to the landing. Following a backtrack, they carried out a further two circuits at 800 ft aal, before stopping for a break and returning to the parking area outside the hangar. The passenger had flown the last of the circuits unassisted by the pilot.

They discussed the flight and took some photographs before the passenger asked if they could do a couple more circuits. The owner happily agreed but mentioned he had to catch a train back to Belgium at 1600 hrs. The passenger had eaten a sandwich before the first flight but had not seen the owner eat anything, although he looked fit and well.

They went through the same start procedure and ensured the trim was set fully forward with the slots locked for takeoff. They did an engine power and magneto check and, when lined up, the owner warned the passenger about the proximity of a tree which was close to the right side of the runway. They made a normal right hand circuit with the passenger flying and he unlocked the slots and set the trim for landing. The passenger offset the approach slightly to the right to give him a better view of the runway. The landing appeared normal and he did not expect any intervention, but after touchdown the owner said "I have control" and applied full power. The passenger released the control stick but followed through lightly on the rudder pedals and, during the takeoff roll he locked the slots.

As soon as the aircraft became airborne, it started a right turn, much earlier than before, at about 20-30 ft agl. A few seconds later, with the aircraft in about a 20° bank to the right, the passenger noticed increasing application of right rudder, along with left control stick to counter the resulting tendency to roll to the right. The aircraft became severely cross-controlled, with the slip needle indicating fully left. The passenger asked the pilot what he was doing but received no audible reply, and he thought the pilot was demonstrating some manoeuvre without saying what he was doing.

The aircraft continued its roll to the right and the nose dropped with the roll and nose-down pitch increasing rapidly, although the passenger thought that the aircraft probably did not pass through the inverted, before it struck the ground in a nose-down but nearly wings level roll attitude. As the ground rushed up, the passenger shouted but there was no response from the owner. The engine stopped immediately on impact, and the passenger was aware of fuel leaking onto him and the pilot. He pushed the broken instrument panel and cockpit coaming clear and released the fire extinguisher and placed it outside. He released his harness and after several attempts was able to free his damaged legs and crawl away from the aircraft. A bystander, who had heard and seen the aircraft in difficulties, arrived at the site and assisted the passenger until the emergency services arrived and airlifted him to hospital.

The pilot received fatal injuries during the accident.

Accident site and wreckage examination

The aircraft struck the ground in an area of arable farmland containing a tall, dense and mature crop (Figure 1). At the time of the impact, the aircraft was complete. It was erect, in a steep nose-down attitude, with low forward speed and a significant descent rate, and was rotating to the right about a vertical axis. One blade of the wooden propeller was shattered with debris projected forwards. Fuel was recovered from the tank. Objects of only limited mass were present in the locker, which was not disrupted by the impact. After impact, the tail of the aircraft settled onto the ground, as shown in the image. The crop was flattened by first responders, not the aircraft.

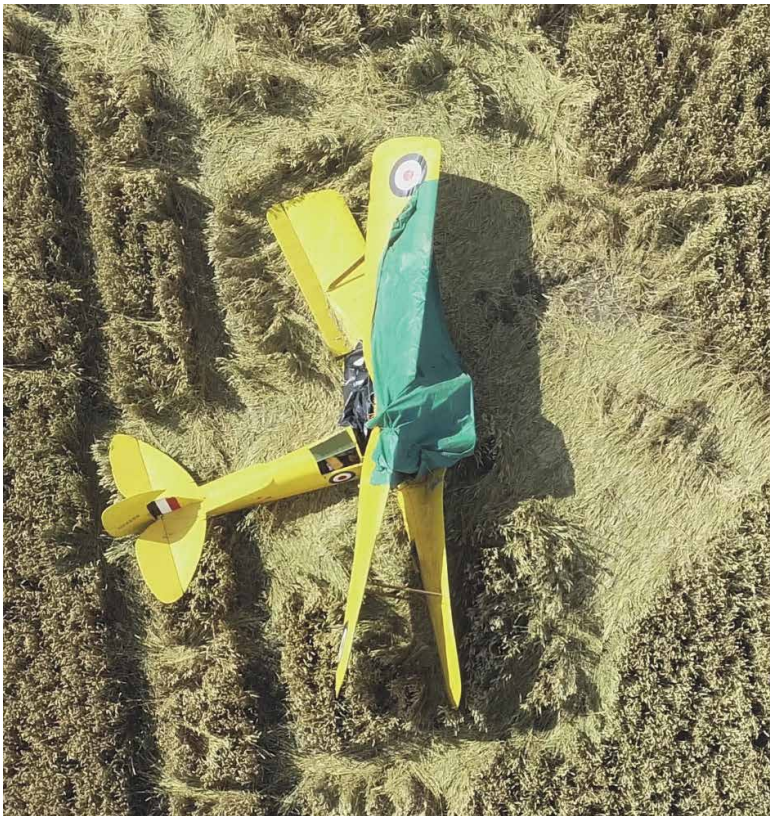

Figure 1
The aircraft in the field

Examination of the flying controls revealed no evidence of pre-impact failure. In particular, the connecting rod between the front and rear cockpit rudder pedals was found attached at both ends; it was bent in two places but unbroken. A strip examination of the engine similarly revealed no evidence of pre-impact mechanical failure. The area containing the front seat was severely disrupted, whilst the area containing the rear seat was much less disrupted.

The features of the accident site and the degree and location of the aircraft damage were consistent with the aircraft being in an incipient or developed spin to the right at impact. The condition of the engine components, found on strip examination, coupled with the condition of the propeller, were consistent with the engine operating normally. Because the propeller was wooden, the amount of power being developed at impact could not be determined.

Aircraft information

The only documentation relating to maintenance that was recovered consisted of an airframe and an engine logbook. Entries in those logbooks stated that the earlier logbooks were lost or stolen, but at the time the replacement logbooks were raised, the estimated airframe and engine time in service was 3,500 hours and 1,500 hours respectively. The aircraft appeared to have been in the USA at that time.

Thereafter, the airframe logbook indicated that control surface and structural inspections commenced on 10 September 1979 and took place progressively until 30 August 1984, enabling each component to be covered in Ceconite 102. Because the original Tiger Moth aircraft utilised stitched and doped cotton fabric, fitment of the Ceconite covering was carried out in accordance with US Supplementary Type Certificate number SA2666WL.

The record stated that the aircraft was rigged in accordance with the De Havilland Maintenance Manual, inspected and found airworthy on 24 October 1984. A test flight was performed on 28 October 1984.

The logbooks did not record any flights after 6 July 2016 by which time the aircraft had completed a notional 3,753.8 hours and the engine 1,753.8 hours. It was presumed the aircraft was still in the USA on that date. Further logbook entries indicated that an annual inspection was completed on 5 January 2018. The location of the aircraft at that time was not determined and no records were found of the aircraft flying in the UK or Europe before the accident.

Maintenance providers reported that considerable detailed differences can be routinely found between examples of DH-82 Tiger Moth aircraft. A Test Pilot with considerable experience of the type reported that, notwithstanding such detailed differences, handling qualities did not significantly differ across a range of examples of DH-82 aircraft.

Weight and balance

The current weight and balance schedule for the aircraft was not located by the investigation. The passenger had noticed that the fuel tank contents indicator was showing between a half and two thirds full. As an indication only, the weight and moment arm for another Tiger Moth was used to estimate the weight and CG position for the accident aircraft. From a basic weight of 1,212 lbs and a moment arm of 8.9 inches aft of datum, a weight of 1,742 lbs and a CG position of 13.7 inches aft were calculated using the weights of the fuel on board, pilot, passenger and small items in the locker behind the rear seat occupant. The maximum permitted All Up Weight for the aircraft is 1,825 lbs with an aft CG limit with spin strakes fitted of 15.3 inches. It is probable that the accident aircraft was within its safe weight and CG operating envelope.

Airfield information

Pent Farm is a private airstrip 2.5 nm north-north-west of Hythe, Kent, with an elevation of 240 ft amsl. It has a single grass runway orientated 070°/250°, 1,000 m long and 25 m wide. There are high tension powerlines and 70 ft high pylons approximately 450 m to the north of and running parallel to the runway. There is high ground rising to 550 ft to the northeast and powerlines 25 ft high close to the Runway 25 threshold. Circuits are flown to the north, to the right from Runway 25, at 1,000 ft amsl. The village of Stanford on the extended centreline of Runway 25 is treated as an avoidance area. There is also a property to the north of Stanford to the west of the Runway 07 threshold which, although not part of the avoidance area, has horses and it would be normal to avoid overflying it, especially at a low height. The airfield and immediate surrounding area are shown at Figure 2.

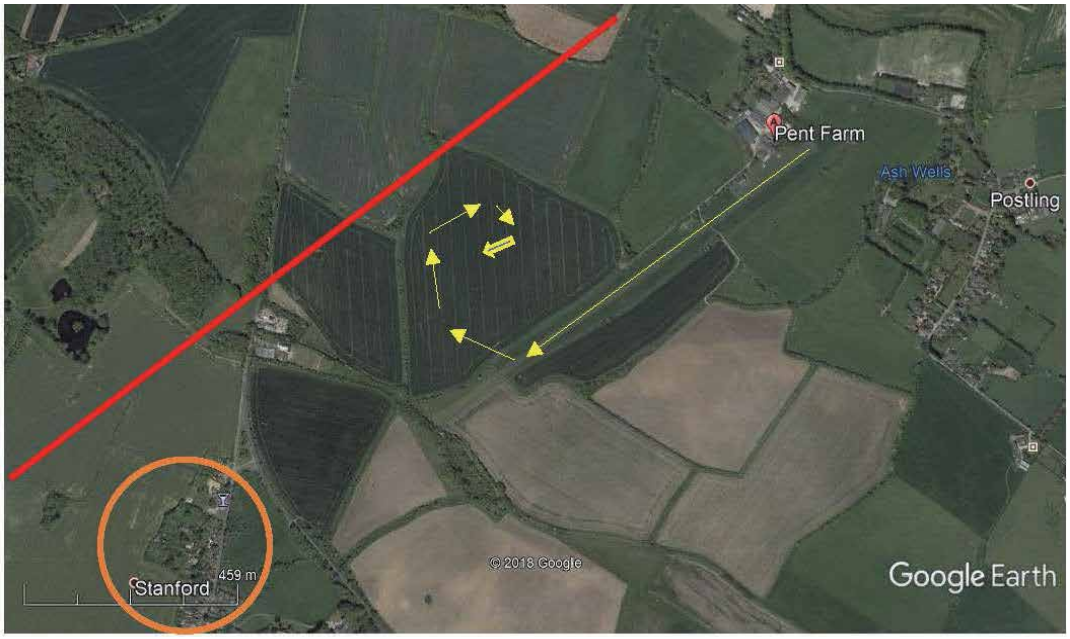

Figure 2

Pent Farm airfield showing the avoidance area of Stanford, estimated aircraft track and accident site in yellow, with pylon wires in red

Personnel

The owner and pilot of the Tiger Moth N54556

The pilot commenced flying whilst serving as an aircraft mechanic in his National Armed Forces between 1984 and 1995, during which time he obtained a National PPL and a civilian aircraft engineer's licence. After leaving the Armed Forces, he worked as an aircraft engineer and built up his own aircraft maintenance and restoration company whilst continuing his private flying. In 1999, the company expanded, and he added a flying school and larger hangar facilities. In 2017 he sold the company and focussed on purchasing and renovating Tiger Moths whilst working in the UK using his FAA Inspector's Licence, working for maintenance organisations on, and inspecting work carried out on FAA registered aircraft.

His FAA pilot's licence, which permitted him to fly N-registered aircraft, was based on him holding a current National PPL and Aircrew Medical Certificate, both of which were valid at the time of the accident flight.

His pilot's logbook was completed up to 30 June 2019, although he was believed to have flown since that date, but the investigation was unable to establish how many hours he had flown in that time.

The passenger

The passenger held an Airline Transport Pilot's Licence (ATPL) with a current SEP rating. He started flying in 1988 and during his career had been a Flying Instructor before gaining his ATPL. He had been employed flying a variety of commercial aircraft types including Boeing 737-800, BAe RJ100 and Embraer EMB 170/190 aircraft.

Medical and pathological information

At the time that this report was completed, no medical history or post-mortem report for the pilot had been seen by the investigation.

The pilot's medical history was requested from his National Aviation Authority but was not made available because of local confidentiality laws. A prescription medication and herbal supplement were found in his personal property and these were made known to the pathologist carrying out the post-mortem examination.

Tests and research

Two flight trials were carried out using a similar Tiger Moth to the accident aircraft, flown by a Test Pilot (TP) who was a graduate of the Empire Test Pilots' School (ETPS) and had a long history of experimental test flying.

The first flight was to assess the aircraft's handling qualities and performance, particularly with respect to rudder versus aileron authority, dihedral, and pressure errors and handling in steady heading sideslips (SHS). The testing was conducted using standard EASA Certification Specification (CS) 23 test techniques. The aircraft was instrumented with GPS-fed data loggers that recorded the flight path and altitude of the aircraft. Additionally, GoPro image recording cameras were worn by the pilot and fitted to the airframe to record the testing.

All testing was conducted with the wing slots locked closed as per the accident aircraft, the takeoff weight was 1,790 lbs (Maximum All Up Weight = 1,825 lbs), and the CG was 13.7 inches aft of the reference datum. Testing consisted of a series of right rudder inputs of increasing size opposed by up to full left aileron. Power was varied from idle power, through power for level flight to full climb power, and the airspeed indications were observed as sideslip was applied.

Initially, the aircraft was set up in level flight at 1,950 rpm and 60 KIAS. Right rudder was applied and then the subsequent roll (away from the generated sideslip) opposed with left aileron. The magnitude of the inputs was increased for subsequent test points. The force required to apply rudder was "very light" requiring minimal effort. When the applied force was released and the rudder was free, it very slowly returned to neutral. A right rudder input of approximately 50-60% required full left aileron to prevent the aircraft rolling to the right. Approximately 30° angle of bank to the left was achieved in this limiting sideslip, which provided very strong "seat-of-the-pants" cues. It was noticed that the aileron control response was most effective around neutral and decreased slightly towards full travel. The control inputs were of the same magnitude with both idle power and full power applied.

In the second sortie, additional rudder was applied having already applied full left aileron. On applying a step input of right rudder, the aircraft promptly rolled right and pitched gently nose-down. The roll rate achieved was in the order of 20° per second which was "uncomfortable". However, it was easy to recover the aircraft by centralising the rudder and rolling the wings level with aileron. It was evident that if full rudder was applied, the resulting

sideslip and the aircraft's lateral stability would produce a powerful rolling moment to the right that could not be stopped even with the application of full opposite aileron.

Both rudder and ailerons tended to float towards neutral when released from modest inputs. However, beyond 70% right rudder travel, the rudder would remain applied with no tendency to centralise without the pilot's intervention. Additionally, with the rudder free to move and climb power applied, the rudder would gently migrate towards full right rudder deflection without any assistance from the pilot.

It was noted that with full power applied, at 60 KIAS the aircraft would normally achieve approximately 500 ft/min rate of climb. However, with full left aileron and 50-60% right rudder applied, the aircraft only achieved level flight in SHS. Evidently, the drag created by such aggressive sideslip manoeuvres was enough to reduce the aircraft's rate of climb to zero.

The airspeed indications were monitored as sideslip was applied and very little change in indicated airspeed was observed in level flight, less than 2 KIAS, even in extreme sideslips. The TP considered that: *'It was unlikely that pressure errors due to sideslip would have contributed to the accident'*. Additionally, the small windscreens in the open cockpits only provide protection from the slipstream with zero sideslip. As soon as 2-3° or more of sideslip was applied, there was considerable wind noise and buffet of the pilot's head. It would not have been possible to fly with large angles of sideslip without noticing it.

The owner of the accident aircraft normally flew it from the rear seat but on the accident flight he occupied the front seat. Although the field of view is similar, the view from the rear cockpit includes much more of the aircraft nose and structure making it easier to discern yaw and pitch attitudes. Additionally, the rear seat is further behind the main wheels, which makes the detection of swing (yaw) on the ground easier and allows better judgement of takeoff and landing attitudes.

The TP concluded that the Tiger Moth aircraft was easy to fly, with the open cockpit providing the pilot with good audio and buffet cues of airspeed and sideslip. Given these cues of extreme attitude and airflow, the TP found it hard to imagine how a pilot could put the aircraft into an extreme sideslip accidently. It was equally hard to understand in the circumstances surrounding the accident why applying any amount of sideslip during the climbing turn after takeoff would be helpful.

Analysis

The aircraft had flown immediately prior to the accident flight and had operated normally. No technical faults or pre-accident failures were identified that may have contributed to the accident (see *Loss of controllability*).

The pilot was properly licensed to operate the Tiger Moth and was experienced in flying it, but normally from the rear and not the front cockpit. Weight and Balance calculations for a similar aircraft showed that the accident aircraft was probably within its safe weight and balance envelope.

It was difficult to understand why the pilot would fly the aircraft in the extreme cross-controlled condition described by the passenger and not take corrective action when the limit of aileron control was approached. The following areas were considered:

- Incapacitation
- Loss of controllability
- Aircraft manoeuvring

Incapacitation

The pilot's medical history was not available to the investigation, but from those persons who knew him he appeared to be in good health and to be enjoying life. On the earlier flight and during the earlier conversations with the passenger, he had also appeared to be in good health.

The fact that the pilot did not respond to the questions from the passenger as the aircraft was developing the cross-controlled condition may have been due to some form of incapacitation.

The control stick was seen by the passenger to move to the extreme left position as the yaw developed but he was not touching or following through on that control. This movement was probably due to an input from the pilot, suggesting that he was not totally incapacitated at this time.

It was the continued forward movement of the right rudder pedal, beyond the point at which aileron control could prevent the secondary roll to the right, which led to the high angle of bank, nose-down pitch and rapidly increasing rate of turn to the right to the point of impact. By moving the left rudder pedal forward, the aircraft could easily have been brought back to normal controlled flight. This would have been a simple and natural action for the pilot to perform and not doing so supported the possibility that there was some lack of cognitive or physical ability on his part.

At the time of writing, the investigation had seen no medical evidence to support the possibility of incapacitation. Should the post-mortem report become available and provide relevant evidence, an addendum to this report will be issued.

Loss of controllability

It was possible that the pilot made a corrective rudder input but it had no effect. For this to have been the case, the rod linking the front rudder bar with the rear would have to have broken or become disconnected at one end before impact. The rod was found connected at both ends and, although it was bent during the impact sequence, it remained unbroken. It was concluded that there was effective control of the rudder from the front seat before impact.

Aircraft manoeuvring

Having taken control and commenced what the passenger described as a low and early turn, it is possible that the pilot had planned to fly an abbreviated low-level circuit or was

simply avoiding the property with the horses. Whether an abbreviated or normal circuit was to be flown, the usual coordinated, balanced turn control inputs should have been made. With the pylon lines ahead and the aircraft in a nose-up climbing attitude, the pilot may have yawed the nose to the right to improve forward visibility, but this would not have required the extreme level of cross-controlled flight described by the passenger. It would also have significantly reduced the rate of climb at a time when gaining height was important.

The accident manoeuvre did not bear any relationship to conventional aerobatic manoeuvres and, given the height and airspeed of the aircraft, aerobatic manoeuvres would not have been possible.

Summary

At full power with the right rudder pedal above 70% of its travel, the pedal will migrate forward to full deflection, as reported by the passenger who was lightly "following through" on the rudder pedals. As the aircraft yawed and rolled to the right, the pilot may have made inputs on the control stick to limit the roll. In these circumstances, unless he was in some way partially incapacitated, it is probable that he would also have acted to prevent the very uncomfortable cross-controlled condition before, or as they reached, the point where the rapid roll to the right and, possibly, incipient spin resulted.

It was not possible to state conclusively why the cross-controlled flight condition was allowed to develop to the point where the rapid roll to the right occurred, although the possibility of incapacitation could not be excluded. If the pilot was not incapacitated, then he had the experience and ability to correct the situation by centralising the rudder and rolling wings level but did not do so. If he had not experienced this situation before, the rapid roll to the right may have surprised him, delaying corrective action.

Conclusion

The cause of the accident was the large amount of right rudder applied at high power beyond the limit of full left aileron control. This resulted in a steepening rolling turn to the right with the associated large nose-down pitch attitude and, possibly, an incipient spin.

No corrective action to address the situation appears to have been taken, and some of the evidence is consistent with the pilot becoming incapacitated. Without conclusive evidence of incapacitation, however, it was not possible to determine why the cross-controlled flight condition was allowed to develop to the point where it caused a rapid roll to the right.

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