ACCIDENT

Aircraft Type and Registration:	Cessna FR172E, G-OMAC
No & Type of Engines:	1 Continental Motors IO-360-D piston engine
Year of Manufacture:	1969
Date & Time (UTC):	7 August 2005 at 1717 hrs
Location:	Bracklesham Bay, West Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence with Instrument Rating
Commander's Age:	25 years
Commander's Flying Experience:	373 hours (of which 170 were on type) Last 90 days - 127 hours Last 28 days - 69 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot and aircraft had been involved in two consecutive days of banner-towing operations. The accident occurred on a positioning flight towards the end of the second day. Shortly after takeoff the aircraft was seen to turn left, with an increasing angle of bank, until it stalled and impacted the ground after turning through approximately 310º. Although the banner hook installation showed evidence of interference with the rudder, it was considered that this was not a factor in the accident. The most likely cause was a stall following the turn to the left with an increasing bank angle. This may have resulted from an attempt to maintain visual contact with a point on the ground, and would have been exacerbated by an increasing tailwind. It was also considered that the pilot may have been affected by fatigue after the two intensive days of banner-towing. Recommendations have been made relating to the banner hook installation and on fatigue associated with banner-towing operations.

Background to flight

The pilot involved in the accident had started flying for a banner-towing company in May 2005. The company had one aircraft and two pilots involved in the operation. The owner of the company, who was the other pilot, had flown with the pilot involved in this accident on several occasions, including banner-towing flights. He considered the pilot to be safe and conscientious.

Several banner flights had been contracted for the weekend of 6/7 August 2005 and the pilot involved in this accident had agreed to operate them. He left his

home at approximately 0500 hrs on 6 August to drive to an airstrip in Kent where G-OMAC was based. He took off at 0746 hrs and flew to Compton Abbas Airfield. Subsequently, he flew a further five flights during the day. His total flying for the day was approximately 5 hours 20 minutes, including three sessions of banner-towing. He landed back at Compton Abbas at 1730 hrs and spent the night at a local hotel.

History of flight

On 7 August, the pilot took off from Compton Abbas Airfield at 0808 hrs for a positioning flight to a private airstrip at Bracklesham Bay. Once there, he completed a banner-towing flight before returning to Compton Abbas for refuelling. He then carried out a further banner-towing flight from Compton before returning to Bracklesham Bay for the final banner-towing flight of the day. He took a passenger on this flight, who later confirmed that the pilot had made no comment about any problems with the aircraft. The passenger had met the pilot before and also confirmed that he appeared his normal self. After takeoff the pilot had made a left turn to position the aircraft for the banner uplift. At the end of the flight, the pilot had completed 6 flights totalling 4 hrs 12 minutes during the day.

Following this final banner-towing flight, the pilot loaded his equipment into G-OMAC and had a cup of tea before boarding the aircraft for the flight back to Kent. There were several witnesses to the subsequent takeoff. The previous passenger watched the aircraft start up and taxi to the eastern end of the airstrip for a takeoff in a westerly direction. One other witness on the airstrip, who was a pilot, also saw the aircraft use the full length of the airstrip for takeoff. He recalled that he heard the pilot do his magneto checks and exercise the propeller control. He also recalled that there appeared to be about 15º of flap selected on the aircraft and that the engine note increased before brake release. This witness had seen the aircraft operate many times from the airstrip and considered that lift off appeared to be at the usual position. One other witness, who was positioned about 100 to 150 m to the north of the airstrip, also heard the magneto checks being done, saw that there was some flap selected and also had the impression that the pilot did a control check.

Shortly after takeoff the aircraft turned to the left, with what appeared to be an increasing bank angle, until the aircraft was heading back towards the start of the airstrip. By now the bank appeared to be close to 90º and all three witnesses saw the nose of the aircraft come down. One witness lost sight of the aircraft behind a hangar, but the other two saw the aircraft impact the ground with the nose and left wing simultaneously. The witnesses alerted the emergency services and two of them ran immediately towards the crash scene. Once there, one witness checked the pilot for signs of life but could not detect any.

One of the witnesses subsequently stated that she had not been aware of any change in engine noise during the accident flight. The other two witnesses considered that the engine noise remained constant until shortly before impact when the engine noise seemed to reduce.

Other witnesses were located on a caravan site positioned to the west of the airstrip. One of these saw the aircraft airborne and approaching his position. He saw the aircraft do a “sharp left turn” and then lost sight of it for a short time behind some vegetation. When he saw it again, it began to descend quickly and impacted the ground. He later recalled that the engine went quiet at some stage in the turn.

The emergency services recorded the initial call at 1724 hrs and the first fire vehicle arrived at the scene at 1740 hrs.

Aircraft description and history

G-OMAC was a Reims Cessna FR172E with a TCM IO-360-D fuel injected, six cylinder, wet sump, horizontally opposed, air-cooled engine driving a constant speed MacCauley propeller. The aircraft was constructed in 1969 and had accumulated around 4,029 hours at the time of the accident; the engine was fitted in November 1998 and had completed 1,149 hours since a zero time rebuild at the factory. A 50 hour inspection had been completed on 29 July 2005. There were no outstanding maintenance issues.

Wreckage examination

The aircraft had initially impacted the ground in a 20-30º nose down attitude and approximately wings level on a heading of 320º M. The general disposition of the wreckage suggested a low speed impact, with a degree of sideslip to the right. The impact position was located approximately 170 m south of the centre point of the airstrip. It was established that the aircraft was intact prior to impact.

There was evidence of some chordwise scoring on the propeller, suggesting at least some engine power. The propeller had remained attached to the engine crank shaft during the impact. However, during the recovery it became detached. It was subsequently found that the crankshaft had failed in torsion, consistent with there having been some power from the engine and the propeller having stopped very quickly in the impact.

Approximately 100 litres of fuel, with the visual appearance and odour of Avgas, were recovered from both wing fuel tanks. There was no fire.

The fuselage structure had been disrupted in the impact. However continuity of the elevator, aileron and rudder control systems was confirmed and there was no evidence of any pre-impact failures.

Engine examination

Strip inspection of the engine showed that it had been mechanically sound before the accident and could still be turned by hand. The combustion chambers had normal amounts of combustion deposits and the cylinder bores were mostly free from scoring and other damage. However, the No 3 cylinder did show evidence of some scoring from the piston pin, although this was not excessive. This wear was confirmed by a small amount of metallic contamination in the oil filter.

The accessory gearbox was intact; all the gear teeth were undamaged, lubricated, and exhibited normal operating wear. The oil sump was intact and the oil recovered appeared to be in satisfactory condition.

Both magnetos were tested and found to function satisfactorily. The spark plugs were in a serviceable condition; the electrodes were clean with only light deposits.

The throttle position on the fuel metering unit was found approximately $^{1}/_{3}$ open, which was consistent with the position of the throttle lever in the cockpit.

The engine-driven fuel pump was free to rotate and the drive was intact. The pump was tested and showed low flow figures at high rpm. There were no leaks and, following adjustment, fully met the specification. The fuel injection system manifold and nozzles were tested and were found to meet the flow requirements. The throttle body was checked in accordance with the maintenance manual; this showed fuel flows higher

than the specification, suggesting the throttle had been adjusted to counter the low fuel flow from the fuel pump.

Flaps

The wing flaps were electrically operated. When the flap switch was selected, electrical power was supplied to a motor located in the right wing. This powered an actuator which transmitted the movement to both flap surfaces via a system of drive pulleys, cables and push-pull rods. The position of the flap was sensed by a potentiometer and transmitted to a cockpit gauge located on the right hand side of the instrument panel. In order to select a flap setting the pilot must hold the flap switch until the desired position is indicated on the gauge and then release the switch. There were no detented positions. However the Flight Manual quotes positions 0º, 10º, 20º, 30º and fully down 40º.

Measurement of the exposed threaded portion of the flap actuator indicated that the flaps were at a position of approximately 25º, which was consistent with the found position of the flap surfaces themselves.

Modification for banner towing

In 1985 the aircraft had been approved by the CAA for use in banner towing. The modification used a standard Cessna supplied hook with the addition of a subsidiary base plate to prevent the assembly rotating. This main hook was attached to the rear tie down fitting at the rearmost point of the main fuselage, and operated by a flexible cable located on the cockpit roof. In addition a grapnel hook was fitted on the aircraft underside forward of the main hook, surrounded by a container designed to stow the grapnel cable. The grapnel release was actuated by an upward pull on a Tee-handle located on the cockpit floor.

To prepare for banner towing, the aircraft would take off with the cable attached to the main hook but stowed within the grapnel container. The cable would then be released by operating the grapnel hook Tee-handle on the cockpit floor and the cable would stream behind the aircraft from the main hook. Having collected the banner and completed the task, both the banner and cable would be dropped from the aircraft prior to landing. This would have been accomplished by operating the main hook release mechanism in the cockpit roof. The release of the hook mechanism latch allows the hook itself to spring rearwards contacting the lower rudder surface. Once the hook has released the banner cable, the hook would be free to float and gravity would allow it to return to its 'normal' vertical position against the latch.

Evidence of repeated operation was apparent on G-OMAC by long term damage to the base of the rudder (see Figure 1). There was a possibility that the hook could become lodged within the rudder. However, given the lightweight fibreglass structure it is likely that rudder pedal pressure would liberate the hook and allow the rudder to move freely again.

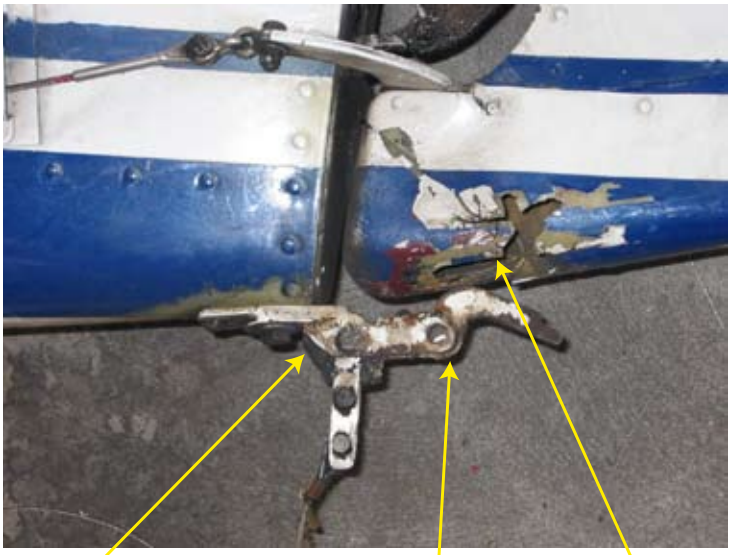

Figure 1

Cessna stated they have not had any experience of these types of tow hooks interfering or jamming the flight controls, although damage such as found on G-OMAC is not uncommon.

Recorder information

The aircraft had a Skyforce SkyMap IIIc GPS mounted in the instrument panel. The unit was removed and downloaded for interpretation. It had recorded samples of latitude, longitude, altitude, magnetic track and ground speed every 30 seconds. The start and finish of a flight was automatic with the first point being recorded at 24 kt (approximately 27 mph). This was the only data point recorded for the accident flight. This position was compared to previous recordings of takeoffs by G-OMAC from Bracklesham Bay that day and the positions were close indicating no abnormalities in the takeoff at that point.

Downloaded information was reviewed to confirm previous aircraft flights. Records were available for all flights from 3 August 2005 up to the accident flight. This confirmed the aircraft movements on 6 and 7 August showing that the aircraft had flown 6 flights on 6 August and 7 flights, including the accident flight, on 7 August. Total flight time on 7 August was 4 hours 12 minutes. The flight time for 6 August could not be determined accurately because the unit stopped prematurely on 5 of the flights but totalled approximately 5 hours 20 minutes.

Weather information

An aftercast from the Met Office at Exeter showed the synoptic situation at 1800 hrs on 7 August 2005. There was a ridge of high pressure over the British Isles with a light northerly flow over Sussex and Hampshire. It was estimated that the surface visibility was 30 km, cloud was FEW/ SCT with a base at 6,000 ft amsl, the surface wind was 350º/ 07 kt and the air temperature was 21ºC with a dew point of 9ºC. At 500 ft amsl, the wind was estimated to be from 010º/ 05 to 10 kt.

The airstrip operator, who was also a witness to the accident, stated that a portable windsock had been positioned near where the accident flight had commenced takeoff. He also confirmed that the surface wind was from the north and that he had noticed, when he was operating a model aircraft, that the wind speed was slightly stronger at about 100 ft agl, although from the same direction.

Medical information

A Post Mortem examination was carried out on the pilot. It was concluded that the crash had not been survivable and that the pilot had died from multiple injuries consistent with an aircraft crash. There was no evidence of any natural disease, which could have caused or contributed to the accident. Additionally, toxicological examination showed that the pilot was not under the influence of alcohol or drugs at the time of the flight.

The weight of the pilot was approximately 180 lb.

Operational information

Airstrip

Bracklesham Bay Airstrip has a grass surface and a length of some 550 m; at the time of the accident, the grass was dry and short and the surface of the airstrip was firm. The airstrip is orientated east/west and has a grass parking area at the eastern end where there is a small hangar and a caravan. To the west of the airstrip is a caravan site and pilots operating from the airstrip are asked to avoid this site whenever possible. The prevailing wind is generally south-west and the normal procedure used by pilots after takeoff on the westerly runway was to turn left towards the coast.

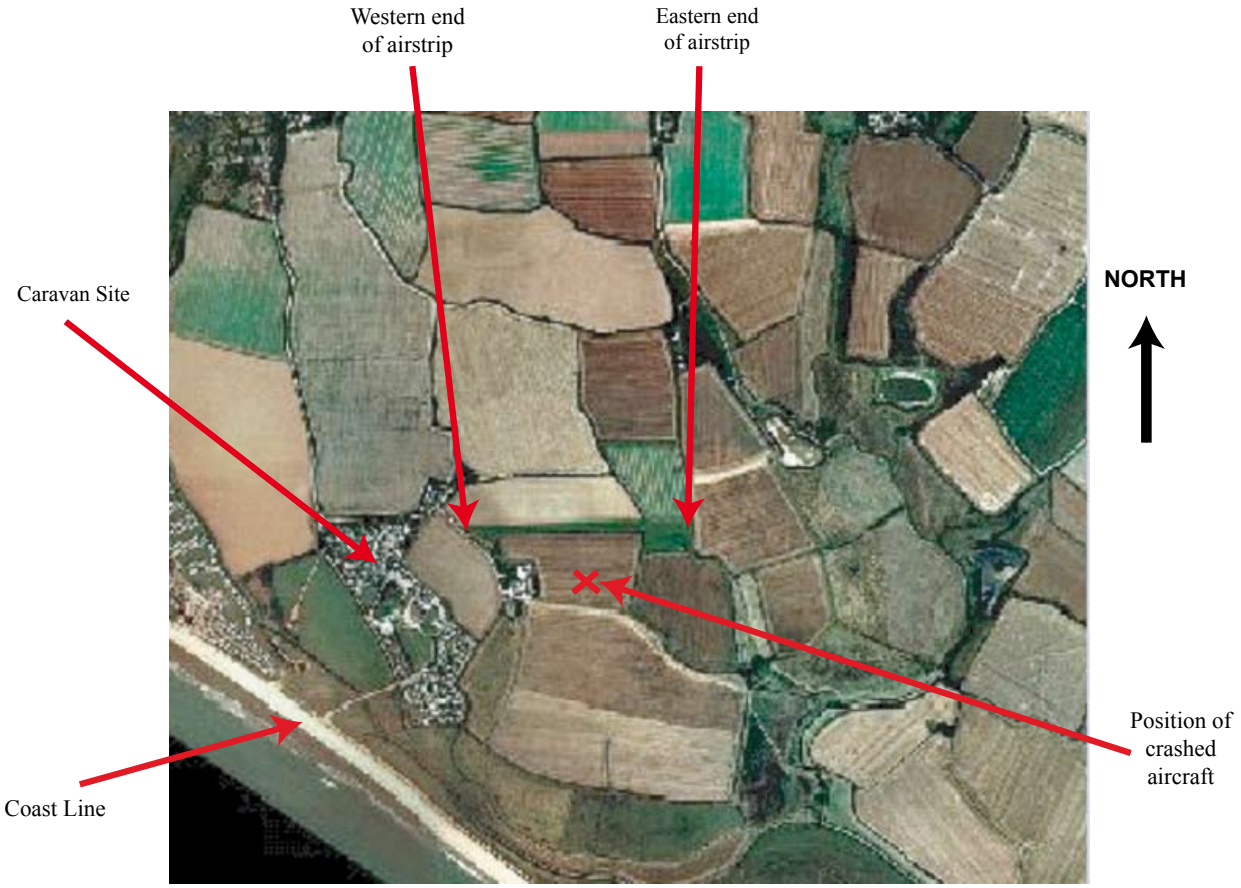

Figure 2

Fuel information

After the accident, a total of some 100 litres of fuel was downloaded from both wing tanks. Enquiries revealed that the aircraft had refuelled on three occasions on 6 August and on one further occasion on 7 August, at approximately 1340 hrs. For the last refuelling, a total of 131.94 litres (approximately 35 USG) was uplifted. With a maximum aircraft fuel load of 52 USG, it was probable that the aircraft was then fully loaded with fuel. Following this final fuel upload, the aircraft completed a further 1 hour 9 minutes of flying prior to the final takeoff. By then, the fuel on board would have totalled approximately 38 USG, based on a fuel flow of approximately 12 USG/hour.

Weight and CG

The aircraft basic weight was 1,561 lb and the total equipment in the aircraft cabin weighed 103 lb. With a pilot weight of 180 lb and a fuel weight of 254 lb, the weight of the aircraft on the final takeoff was estimated as 2,098 lb, which was well below the maximum allowable weight of 2,500 lb.

Calculations also indicated that the aircraft was within normal CG limits for the takeoff on the accident flight. The severity of the impact was such that the original location of the banner-towing equipment in the cabin could not be confirmed but normal practice was to stow it in the rear seats and to the right of the front right seat.

Aircraft performance

The aircraft manual detailed that normal takeoffs should be accomplished with flaps up and that maximum performance takeoffs should be accomplished with 20º flap; soft field takeoffs can be performed with 20º flap. Normal climb speed was 95 mph and maximum performance take-off climb speed was 70 mph.

The aircraft owner's manual detailed the stall speed with zero angle of bank, at maximum weight, flaps 20º and with power off as 58 mph. In the same configuration, the stall speed at 40º angle of bank was 67 mph and at 60º angle of bank was 83 mph. The manufacturer calculated the power off stall at 2,050 lb and 60º angle of bank as 73 mph. Power on stall speeds would be lower than these figures.

The manufacturer also provided an estimate of the aircraft turn performance. This indicated that the turn diameter after a takeoff at 2,050 lb using 20º flap would be 864 ft at a constant 30º angle of bank and 288 ft at 60º angle of bank; the estimates were based on nil wind. The final position of the crashed aircraft was some 558 ft south of the airstrip.

Banner towing regulations

For commercial banner towing, the pilot required a professional licence. The company involved in operating G-OMAC also had a '*Banner Towing Manual*', issued in October 1984, detailing rules and procedures for the operation. There was no reference to duty hours or flight time limitations within the manual. Any aircraft used for banner towing was required to be properly modified and approved by the CAA and to be operated in accordance with a supplement to the aircraft Owner's Manual. G-OMAC had been approved for the operation and the Owner's Manual contained the necessary supplement.

Fatigue

With the number of hours achieved by the pilot over the previous 28 and 90 day periods of 69 hours and 127 hours respectively, it was considered relevant to consult a human factors specialist about the possibility of fatigue being a factor in the accident. The specialist considered the following aspects:

1. Cumulative fatigue as a result of a high work rate over the previous days/weeks. It was concluded that there were periods of high workload during the previous month but also that there were a sufficient number of rest days. There was no indication that the pattern of work would have contributed directly to an accumulation of fatigue.

2. Inadequate sleep prior to the final duty period. The early start on 6 August and a long duty period would have resulted in a tiring day. However, evidence indicated that the pilot was aware of his requirement for sleep and had retired to bed early that night. It was considered that he should have been able to obtain sufficient sleep to overcome most of the deficit from the previous day.

3. Workload leading up to the accident. At the time of the accident the pilot had been at work for almost 10 hours, had flown for over four hours, including nearly 2 hours 40 minutes of banner towing, and was just starting his seventh flight of the day. It was concluded that a fair degree of tiredness would have built up by the end of the day.

It was concluded that the cumulative effect of long hours of work and a heavy workload over two

consecutive days could have resulted in tiredness, which may have increased the likelihood of an error of judgement by the pilot.

Flight time limitations

There are no regulations relating to limitations on flying times for private flights or on duty times for aerial work such as Banner Towing. CAP 393: '*Air Navigation: The Order and the Regulations',* details the following general requirement for pilots:

> *'32 (4): A person shall not be entitled to act as a member of the flight crew of an aircraft registered in the United Kingdom if he knows or suspects that his physical or mental condition renders him temporarily or permanently unfit to perform such functions or to act in such capacity.'*

LASORS 2006, Safety Sense Leaflets 1 '*General Aviation Good Airmanship Guide'* and 24 '*Pilot Health'* provide practical advice on pilot fitness, stress and fatigue. Additionally, CAP 755 '*Recreational Aviation Activities Manual',* published in June 2005, provides guidance to organisations undertaking a recreational aviation activity. It was recommended that such organisations should produce a manual to ensure a satisfactory level of operational safety. Within the manual, there should be an exposition of the company flight and duty time limitation scheme based upon the guidelines contained in CAP 371.

CAP 371 details the duty and flight time limitations for Air Operator Certificate (AOC) holders carrying out public transport operations. In general, a pilot is restricted to 190 duty hours and 100 flying hours in a 28 day period. Annex C of the publication includes requirements for 'Pleasure Flying', which does not place any restriction on the number of flights during the day. It includes a limit on the duty period of 10 hours when carrying passengers but this can be extended to 12 hours to allow the aircraft to be positioned from and to the operator's base.

There was no reference in any publication to 'Banner Towing' operations.

Discussion

The accident occurred after takeoff when the pilot was returning to the aircraft's base. Witnesses saw the aircraft turn left with an increasing bank angle shortly after takeoff. The engine noise was constant until possibly just before impact, which occurred some 558 ft south of the airstrip. At impact, the aircraft had turned left through some 310º from the take-off direction.

Engineering

The aircraft was intact and the engine was producing power at the point of impact. There were two anomalies found during the subsequent engineering investigation.

Firstly, the flaps were found at approximately 25º, which was not a normal take-off configuration. However, the flap system relied on the pilot to hold the switch and judge when the actual flap surface position from the gauge reached the desired setting before releasing it. The location of the gauge on the far side of the instrument panel from the pilot could introduce parallax errors in judging indicated flap position. It is therefore possible that he intended to takeoff with flaps at 20º using the soft field technique, and the difference in the 'as found' position from the actuator could be accounted for by errors in judging the position from the gauge. It was not considered that an additional 5º flap would have had any bearing on the accident.

Secondly, damage had occurred to the rudder surface over time as a result of the banner towing hook springing back as the banner was released. It was considered possible that this could result in a restriction to the normal operation of the rudder system. However, the material in the contact area was frangible and it was considered unlikely that the hook would have remained in a jammed position. Any such restriction would normally only occur after banner release and the accident occurred on takeoff when the hook would have been in the 'normal' vertical position against the latch. In that position, it was considered unlikely that the hook would then make contact with the rudder. There was a slight possibility that, during takeoff on a grass surface, the hook could bounce around its 'normal' position and contact the bottom of the rudder. However, it was considered highly unlikely that this would have resulted in a permanent jam to the rudder system.

The tow hook was supplied by the manufacturer and is fitted to a large number of aircraft. Although there have been no reported instances of flying control restrictions caused by a tow hook, and it is considered unlikely that the banner-towing hook had any bearing on the accident to G-OMAC, any possibility of the hook impinging on a primary flight control is undesirable. The following recommendation is therefore made.

Safety Recommendation 2006-42

It is recommended that the European Aviation Safety Agency review the design of tow hooks fitted to banner-towing aircraft with particular regard to eliminating any possibility of the hook interfering with the aircraft's primary flying control surfaces.

Operational

The weather had been good throughout the day and the pilot was on his fourth takeoff that day from Bracklesham Bay. Prior to takeoff, witnesses were aware of the pilot doing engine checks and probably completing control checks. The completion of these checks, on an aircraft that he had flown 6 times before that day, indicated conscientious behaviour by the pilot. However, one aspect that a pilot would also normally consider was the direction and strength of surface wind. With a takeoff to the west and a northerly wind, the pilot should have been aware that a turn to the south after takeoff would be downwind with a resultant increase in groundspeed.

On the takeoff there was no apparent problem prior to the aircraft becoming airborne when it was seen to enter a left turn and with an increasing bank angle. This was the normal turn direction although a turn to the right was not prohibited and would still have avoided the caravan site, while also having the advantage of turning into wind. With the pilot's intended route being towards the east, the pilot had the option of turning in either direction after takeoff; however, once airborne and turning left with an increasing bank angle, the effect of the tailwind would become more critical. This tailwind, together with a higher stall speed due to the bank angle, could have resulted in the aircraft eventually stalling. The pilot could have recovered the situation by rolling out of the turn and flying wings level. However, this would be dependent on him recognising the developing situation and having the necessary aircraft control authority and altitude to effect the recovery.

It is possible that the pilot was not aware of the developing situation after takeoff. His intended route was to the east and therefore a turn was necessary both to avoid the caravan site and to establish the required heading. This was to be his final flight of the day and it is possible that he intended to fly over the eastern end of the airstrip before setting course towards his home airfield. If this had been his intention, he may have started his turn to

the left after takeoff and then started looking to the left to acquire the airstrip visually. In that situation, it would be difficult to maintain accurate aircraft control and it is possible that the northerly wind resulted in an unintended increase in bank angle as the pilot maintained his planned track over the ground. The final location of the aircraft indicated that the turn after takeoff would have required an average bank angle between 30º and 60º.

If this scenario is correct, the pilot had attempted his intended manoeuvre without a full evaluation of all the relevant factors. All the indications are that he was conscientious in his approach to flying. He went to bed early the previous night following a busy day and he appeared to have completed the engine and control checks prior to the accident flight. He would have been aware of the surface wind at Bracklesham Bay, having operated all day from the airstrip but may not have appreciated the significance of it for his intended manoeuvre. This aspect, together with the possibility that he did not continue close monitoring of the aircraft bank and airspeed after takeoff, raises the possibility that fatigue may have been a factor in the accident. It was concluded that the cumulative effect of long hours of work and a heavy workload over two consecutive days could have resulted in tiredness, which may have increased the likelihood of an error of judgement by the pilot.

A review of CAA publications indicated that there was no specific guidance for duty or flying hour limitations for banner-towing operations. The accident to G-OMAC occurred during a private flight and the responsibility for fatigue avoidance remains with the pilot. Nevertheless, the purpose of this private flight was to position the aircraft back to its base after a period of banner-towing operations. Banner towing is an activity generally involving one pilot and requiring a high degree of concentration. The current guidance in CAP 755 only relates to organisations involved in 'recreational activities' and recommends that limitations should be based on CAP 371. With the possibility that the pilot's workload and working hours may have been a factor in this accident, it would seem appropriate to provide more guidance on duty and flying hours during commercial operations such as banner towing. Additionally, no evidence could be found of any studies relating to tiredness/fatigue for operations involving a single pilot and requiring high concentration levels. The following recommendation is therefore made.

Safety Recommendation 2006-43

It is recommended that the Civil Aviation Authority initiate a study into the fatigue aspects associated with flying operations such as banner towing and provide guidance on duty and flying hour's limitations to such operators.

Conclusion

With no conclusive evidence of any technical malfunction it was considered that the accident resulted from a loss of control, possibly whilst positioning to fly over the departure airstrip. It was also considered probable that fatigue may have resulted in an error of judgement by the pilot. Finally, the investigation could not rule out the possibility that the banner hook may have caused a jam of the rudder system.