Cessna 421C Golden Eagle, G-SAIR

Contents

Incident Information

AAIB Bulletin No: 4/2004	**Ref: EW/C2003/03/02**	**Category: 1.2**
Aircraft Type and Registration:	Cessna 421C Golden Eagle, G-SAIR	
No & Type of Engines:	2 Continental Motors GTSIO-520-L piston engines	
Year of Manufacture:	1978	
Date & Time (UTC):	29 March 2003 at 1229 hrs	
Location:	Humberside International Airport, North Lincolnshire	
Type of Flight:	Private	
Persons on Board:	Crew - 3	Passengers - None
Injuries:	Crew -	Passengers - N/A
	1 (Fatal)	
	1 (Serious)	
	1 (Minor)	
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	See Report Text	
Commander's Age:	See Report Text	
Commander's Flying Experience:	See Report Text	
Information Source:	AAIB Field Investigation	

Synopsis

About 50 minutes into the flight, the aircraft returned to Humberside circuit and was cleared by ATC for a touch-and-go landing on Runway 21. The landing was firm but otherwise uneventful and witnesses heard the power being applied as it accelerated for takeoff. Just before rotation two large "puffs of smoke" were seen to come from the vicinity of the mainwheels as both propellers struck the runway. The aircraft then lifted off and almost immediately began to yaw and roll to the left. The left bank reached an estimated maximum of 90° but reduced just before the left wing tip struck the ground. The aircraft then cartwheeled across the grass to the south of the runway and burst into flames. The owner in the left pilot's seat and the pilot in the right pilot's seat escaped from the wreckage, but the flight examiner, who was occupying a seat in the passenger cabin, was unable to vacate the aircraft and subsequently died of injuries sustained in the post impact fire. An engineering investigation found no fault with the aircraft that might have caused the accident. The investigation concluded that the most probable cause was an inadvertent retraction of the landing gear whilst the aircraft was still on the ground.

Background

The Cessna 421C is a light twin-engined transport aircraft designed for single pilot operation. It can be configured to carry a maximum of six passengers and two pilots. The accident aircraft was configured with five passenger seats (two aft facing and three forward facing) behind two pilot seats.

The aircraft had been purchased in late 1988 and had since been operated almost exclusively by the owner. The aircraft was registered in the UK and the owner maintained a UK PPL/IR (Private Pilot's Licence with Instrument Rating), but recently he had decided to place the aircraft on the USA register and to obtain a stand-alone FAA PPL/IR. In mid 2002 the owner successfully sat the required ground examinations for the FAA PPL/IR and he planned to undertake the FAA PPL/IR Practical Tests in 2003.

Before taking a PPL Practical Test the FAA requires the candidate to undergo flight training with a FAA Flight Instructor and to be certified as competent to undertake the test. During the weekend of 22/23 March 2003, the owner flew 11 hours in G-SAIR with an instructor from a Humberside flying school that specialised in training for FAA licences. The owner stated that only one hour was devoted to formal training and that he told the instructor he wanted more formal training. The instructor stated that because the owner's flying was already of a standard to meet the FAA requirements, he did not require any more formal instruction. On completion of these 11 hours of dual flight the instructor certified the owner as competent to undertake the Practical Test. The test, to be flown from Humberside Airport with an FAA Designated Pilot Examiner (DPE), was arranged for 29 March. On 28 March the owner flew from Aberdeen to Humberside arriving at about 1625 hrs in preparation for the test the next day.

The FAA DPE lived overseas and worked for an international airline. He had been granted a 'one-time authorisation' to conduct the test in a Cessna 421 by the FAA's New York International Field Office. In recent years he had been in the habit of flying to the UK to conduct FAA flight examinations at the Humberside flying school.

For the accident flight the owner occupied the left pilot's seat and the instructor who had flown with the owner the previous weekend occupied the right pilot's seat. Although the examiner was an experienced pilot, he was neither in current flying practice on the Cessna 421 nor familiar with the area around Humberside. Consequently, the examiner opted to direct and observe the flight from a seat in the passenger cabin. The instructor and examiner had flown together several times using this arrangement. However, the owner thought the instructor in the right seat was the commander of the aircraft, whilst the instructor described his role only as an "observer and radio operator".

History of the flight

The owner arrived at Humberside Airport at about 0845 hrs on 29 March and carried out an external check of the aircraft, decided on a fuel load for the flight and supervised refuelling. He then made his way to the flying school where he met the examiner. The Practical Test was to consist of an oral test and a flight test, and the examiner and the owner proceeded to a briefing room to carry out the oral test. The owner stated that there was no formal ground briefing for the flight, and that it was his understanding that the examiner would simply direct him to carry out the various elements of the flight test once they were airborne.

After the oral test the owner made his way to the aircraft and was followed some minutes later by the examiner and finally by the instructor. The aircraft was started up and taxied to the runway holding point where the owner gave a comprehensive pre-takeoff briefing, placing emphasis on actions to be taken in the event of an engine failure on takeoff. The owner recollected that during the briefing the instructor stated that, should there be any emergency during the flight, he would take control. Subsequently, the instructor was adamant that no such conversation took place. This was the only pre-flight briefing at which all three of the aircraft occupants were present. The owner remembered nothing more about the flight until just before the final sequence of events leading to the accident.

The instructor recalled that the aircraft took off and departed to the north-west. Most elements of the test were accomplished competently but during steep turns the owner flew outside the test tolerances and the examiner advised him that he would be required to re-fly the turns on another flight. The owner was given the choice of returning to the airfield to land immediately or continuing with the test. He decided to continue and accomplished the remaining upper air manoeuvres without difficulty. About 50 minutes after takeoff the aircraft returned to the airfield to carry out circuit work.

The weather at the airfield was reported as sky clear, visibility 1,800 metres with a light north-easterly wind. Runway 21 was in use and the instructor recalled that they planned to carry out a touch-and-go landing to assess the suitability of the visibility for the remaining circuit work. The aircraft was cleared by ATC to join on a right base leg for a touch-and-go landing.

The ATC controller recalled that the approach was slightly steeper than normal but the landing was uneventful about 1,000 feet along the runway. Shortly after touchdown the controller began to watch the aircraft through his binoculars and remembered noticing that the flaps did not move during the time he observed the ground roll. The controller put the binoculars down and almost immediately saw two large "puffs of grey smoke" appear from the area of the mainwheels; he recalled making a minor exclamation at the sight. The controller's assistant did not watch the aircraft's approach, but her attention was drawn to the area of the runway by the controller's exclamation. She too noticed the two "puffs of grey smoke".

A third witness was refuelling an aircraft on the apron to the north of Runway 21. He watched the touchdown and saw the right mainwheel touchdown first followed by the left; he saw smoke from both tyres and heard the screech of rubber hitting the runway surface. The aircraft bounced and touched down again, initially on its mainwheels but followed shortly afterwards by the nosewheel. The witness saw the aircraft continue along the runway for a few seconds before he heard the engines increase in power consistent with a touch-and-go. The witness discussed the landing with the pilot of the aircraft that was being refuelled and both agreed that the landing had "been a bit rough" but nothing worse than they had seen before.

All three eyewitnesses saw the aircraft become airborne and shortly thereafter begin rolling to the left. The ATC controller also noted that the aircraft yawed sharply to the left just after becoming airborne and before the roll began to develop. The aircraft was seen to climb slowly to about 50 feet above the ground and the bank to increase to about 90°. At this point the ATC controller looked away to activate the crash alarm, but the controller's assistant and the refueller continued to watch. Both described seeing the nose drop and the aircraft impact the ground left wing first before it cartwheeled across the grass adjacent to the runway. The ATC assistant thought that the bank had reduced just before the wing tip struck the ground.

The two surviving pilots have different recollections of the final moments of the flight. The owner remembered nothing between the first takeoff and a point just about the time the aircraft became airborne on the touch-and-go. His first recollection was of a sinking feeling with the aircraft in a wings level, slightly nose up attitude followed by a "loud clattering noise and vibration" which he took to be the propellers striking the runway. At this point he decided that the safest course of action was to close the throttles and come to a halt ahead, if possible on the grass to the left of the runway, to minimise the possibility of fire. However, before he could take any action, the instructor pushed his hands from the throttles and said, "I have got it". The owner removed his hands from the controls and the aircraft rotated nose-up and began to climb and yaw to the left.

The instructor, on the other hand, remembered all of the flight. He described the landing as "hard but safe" and remembered that the owner applied power very soon after touchdown. He considered that the owner's actions after the landing were somewhat rushed, but his concentration was outside the cockpit, and he could not recall seeing the owner manipulating the controls. He remembered the aircraft apparently leaving the ground and then sinking to "brush" the runway surface again. Immediately after the "brush" the nose came up and the aircraft started a continuous roll to the left.

The instructor did not recall hearing any unusual sounds or feeling any vibrations. Moreover, he was unaware that the propellers had struck the runway, and since the owner seemed to be taking no action to correct the roll, he said "you are losing the left engine" to which the owner responded "it's not the engine". The owner had no recollection of this exchange. In view of the instructor's perception that the owner was not correcting the increasing angle of bank, the instructor decided to take control. He placed his hands on the throttles, over those of the owner, and checked that the throttles were fully forward. He applied full right rudder and full right aileron and managed to arrest and reverse the left roll, but he could not prevent the left wing tip, followed by the nose, striking the ground. Both pilots were adamant that they had not touched the landing gear switch after the aircraft left the runway.

As the aircraft cartwheeled across the grass it burst into flames and eventually came to a halt to the south of the runway, pointing in the opposite direction to which it was travelling and resting on its underside. The owner was thrown on to his right side and on top of the instructor, who seemed to have been knocked unconscious by the impact. Although suffering from a broken shoulder, the owner managed to arouse the instructor and then made his way aft through the remains of the fuselage to the main access door just aft of the left wing. He noticed the examiner still in his seat opposite the door and slumped forward over his seat belt. The door consisted of two parts; the upper part opened without difficulty but the lower part was jammed and required a considerable amount of kicking to release. At this stage the aircraft was burning fiercely and the right side of the aircraft in particular was badly aflame. Before making his exit, the owner tried to release the examiner from his seat, but the examiner was a large man and the owner was unable to lift his upper torso to release his seatbelt. Flames then erupted along the left side of the fuselage and the owner, followed by the instructor, made their escape through the main door. The owner recalled that he tried again to assist the examiner but he was beaten back by the heat and flames. The instructor stated that he did not notice the examiner and was unaware that he was trapped in the aircraft.

Crew flying experience

Some crew records were in the aircraft and damaged by fire during the accident. The following represents a guide to crew experience:

The owner, aged 59, started flying in 1988 and had a total of about 2,250 hours of which about 1,850 hours were on type. He was in current flying practice, maintained a UK PPL/IR and had undertaken recurrent training in the USA since completing his initial training.

The 62 years old instructor had approximately 20,000 hours of which 500 to 600 hours were on type. He was in current flying practice and maintained an FAA Airline Transport Pilot Licence with Flight Instructor Rating. He also held a UK Basic Commercial Pilot's Licence and Flying Instructor Rating. The instructor's UK medical certificate was not current but his FAA Class 2 medical certificate was valid for commercial operations.

The examiner, aged 52, was a current airline pilot and maintained an FAA Airline Transport Pilot Licence. He was an FAA Designated Pilot Examiner for the Cessna 421. He had 8,860 hours flying experience on civil passenger jets and an unknown number of hours on piston-engined aircraft types.

Crew roles and responsibilities

The accident flight was flown in a UK registered aircraft in UK airspace and was therefore subject to UK regulations. The Practical Test was for an FAA Licence and therefore the content and conduct of the test should have been in accordance with USA Federal Aviation Regulations (FARs) and guidance issued to examiners in the FAA Designated Examiners' Handbook.

Various FARs applied to the flight. FAR 61.45a2 permits practical tests to be conducted in foreign registered aircraft subject to various requirements which had been met. FAR 61.47 states that the examiner is not normally to be Pilot in Command (PIC) during the test unless there has been prior agreement with the applicant or other person who would normally be acting as PIC.

The Designated Examiners' Handbook provides detailed guidance on how practical tests should be conducted. Paragraph 25 states:

> *"The examiner shall conduct a preflight briefing on safety procedures, the duties of the safety pilot, and each participant's responsibilities and duties before the flight portion of each practical test."*

Paragraph 9C of the Handbook states:

> *"During practical tests given on aircraft requiring two crew or more, the examiner should give the practical test from a designated jump seat or place in the cabin from which the flight can be adequately observed".*

Neither FARs nor the Handbook make reference to practical tests on 'single pilot' aircraft being conducted from the cabin or a jump seat, but it is understood from the FAA that whilst the practice is not encouraged, it is not forbidden.

Paragraph 25 A of the Handbook requires that whenever a test is conducted by an examiner from a position other than a pilots' seat, a qualified pilot must occupy a pilot seat during the test to act as safety pilot. The reference continues to describe the duties of the safety pilot which are:

> *(1) "The safety pilot physically intervenes on the flight controls before a maneuver or procedure deteriorates to an unsafe level".*
>
> *(2) "The safety pilot protects the overall safety of the flight to whatever extent necessary and ensures that all maneuvers, procedures, and/or alternate courses of action are performed safely".*
>
> *(3) "The examiner, when not occupying a pilot station, must rely on the safety pilot to interfere and override any decision by the examiner, the applicant or other person, if safety requirements demand that action".*

Pilot's Operating Handbook procedures

The Pilot's Operating Handbook (POH) for the Cessna 421C does not contain a procedure for carrying out a touch-and-go landing, but the Cessna Pilot Safety and Warning Supplements contain the following comments on the use of landing gear and flaps in the circuit area:

> *....wheels up landings have been attributed to.....not leaving the landing gear extended while performing several landings while remaining in the traffic pattern.*

The Supplement, therefore, recommends that the landing gear is left extended during consecutive landings.

The Practical Test required the test candidate to carry out a number of different takeoffs and landings but there was no requirement for a touch-and-go landing. The owner had not carried out a touch-and-go since his last check flight some months previously. However, the procedure he recalled using on previous flights required the flaps to be raised shortly after touchdown, power to be applied and rotation to be made at blue line speed (111 KIAS).

Although the POH makes no reference to a touch-and-go procedure, the Balked Landing (go around) procedure contains the following initial steps which are similar to the above touch-and-go procedure:

1. *Increase propeller speed to 2235 RPM and apply full throttle if necessary.*
2. *Balked Landing Transition Speed - 100 KIAS*
3. *Landing gear-RETRACT.....*
4. *Wing Flap 15°.*

Aircraft systems description

Landing gear. The retractable tricycle landing gear is electrically controlled and hydraulically actuated. The individual landing gear actuators incorporate an internal lock to hold the landing gear in the extended position. The landing gear is held in the retracted position by mechanical uplocks that are released hydraulically during gear extension. The landing gear completes the retraction cycle in approximately 4.5 seconds at maximum engine RPM. During ground operation, accidental gear retraction, regardless of gear switch position, is prevented by a Weight-On-Wheels (WOW) safety switch located on the left landing gear shock strut. The gear switch is shaped like a small wheel and is located to the left of the central throttle quadrant.

Flap system. The aircraft type is equipped with four split flaps (two per wing). Each flap is attached to the wing rear spar lower surface and is actuated by two push-pull rods attached to bell cranks in the wing. An electric motor in the fuselage centre section controls the flap actuation via cables and push-pull rods. The wing flap position switch in the cockpit incorporates a pre-select feature that allows the pilot to select the amount of flap extension desired. When a flap position is selected, the flap motor is electrically actuated and drives the flaps toward the selected position. As the flaps move, an intermediate cable feeds position information back to the pre-select assembly. The flaps can be set to the 0°, 15°, 30°, 45° detent positions or to an intermediate position between any of the detents. The flap selector lever is shaped like a horizontal tab and is located to the right of the central throttle quadrant.

Gear warning horn. The aircraft type is equipped with a landing gear warning horn which sounds from a speaker to the left of the left seat pilot. The horn sound, which is not transmitted over the aircraft intercom system, will produce an intermittent warning under any of the following conditions:

- throttle retarded below 15.0 inches Hg (mercury) manifold pressure with landing gear retracted.
- wing flaps extended beyond 15° position with the landing gear in any position other than down and locked.
- landing gear switch selected to 'UP' position while the WOW safety switch is indicating weight on the left main gear.

Powerplant. The aircraft type is powered by two 6-cylinder piston engines, each rated at 375 horsepower at 2,235 RPM and 39.0 inches Hg manifold pressure. Each engine drives a McCauley C501 three-bladed, fully-feathering, constant-speed propeller. The propeller control lever controls the propeller governor. Oil pressure from the propeller governor drives the blades toward fine pitch (increasing RPM) while a spring and counterweights drive the blades toward coarse pitch (decreasing RPM) when the oil pressure is reduced. In the event of an engine failure the propeller can be feathered (full coarse pitch to reduce drag) by moving the propeller control lever to the feathered position.

Maintenance history

Between September 2002 and January 2003 extensive work was carried out on the aircraft including an annual inspection. The outer wings were removed to install an inspection service kit. Sealant was applied to the wire connections on the WOW microswitch on the left main gear. Heatshrink insulation was applied to the gear and stall warning horns. Landing gear rigging and functional checks were carried out. The aircraft received a number of avionics upgrades, a new interior and was re-painted. The last maintenance carried out on the aircraft was the installation of a new right vacuum pump on 28 March 2003. At the time of the accident the aircraft had logged approximately 3,720 hours and the engines had logged approximately 550 hours. Both propellers had been overhauled in January 2003.

Accident site examination

The initial impact point was located in the grass area 75 metres to the left (east) of the Runway 21 centreline, abeam a position approximately 1,170 metres (3,825 feet) along the length of Runway 21 (see Figure 1). Following initial impact on a track of 165°(M), the main cabin had travelled a distance of 42 metres before coming to rest facing opposite to the direction of travel. The aircraft and surrounding area had been engulfed in fire. The wreckage trail was strewn with items from the nose section baggage compartment. The left wing had separated from the aircraft and lay inverted near the main cabin. A fragment of the left wing tip strobe light was found close to the initial impact mark. The nose gear and nose gear strut lay in the wreckage trail leading to the main cabin. All three propeller tips from the right powerplant and two propeller tips from the left powerplant were bent backwards. One propeller tip from the left powerplant was bent forwards.

It was apparent from the accident site features that the aircraft had impacted in a steep left bank, causing the left wing and left aileron to separate from the aircraft. The aircraft had then cartwheeled, striking the ground on its nose (shedding the contents of the baggage compartment) and then striking the ground with its right wing and aft fuselage. The scrape marks on the bent propeller tips were consistent with impact with a hard surface rather than soil.

The aircraft was recovered to the AAIB for further detailed examination.

Examination of the propeller strike marks on the runway

A number of propeller strike marks were found on the runway approximately 330 metres from the initial impact point (see Figure 1).

Figure 1 - Accident site location

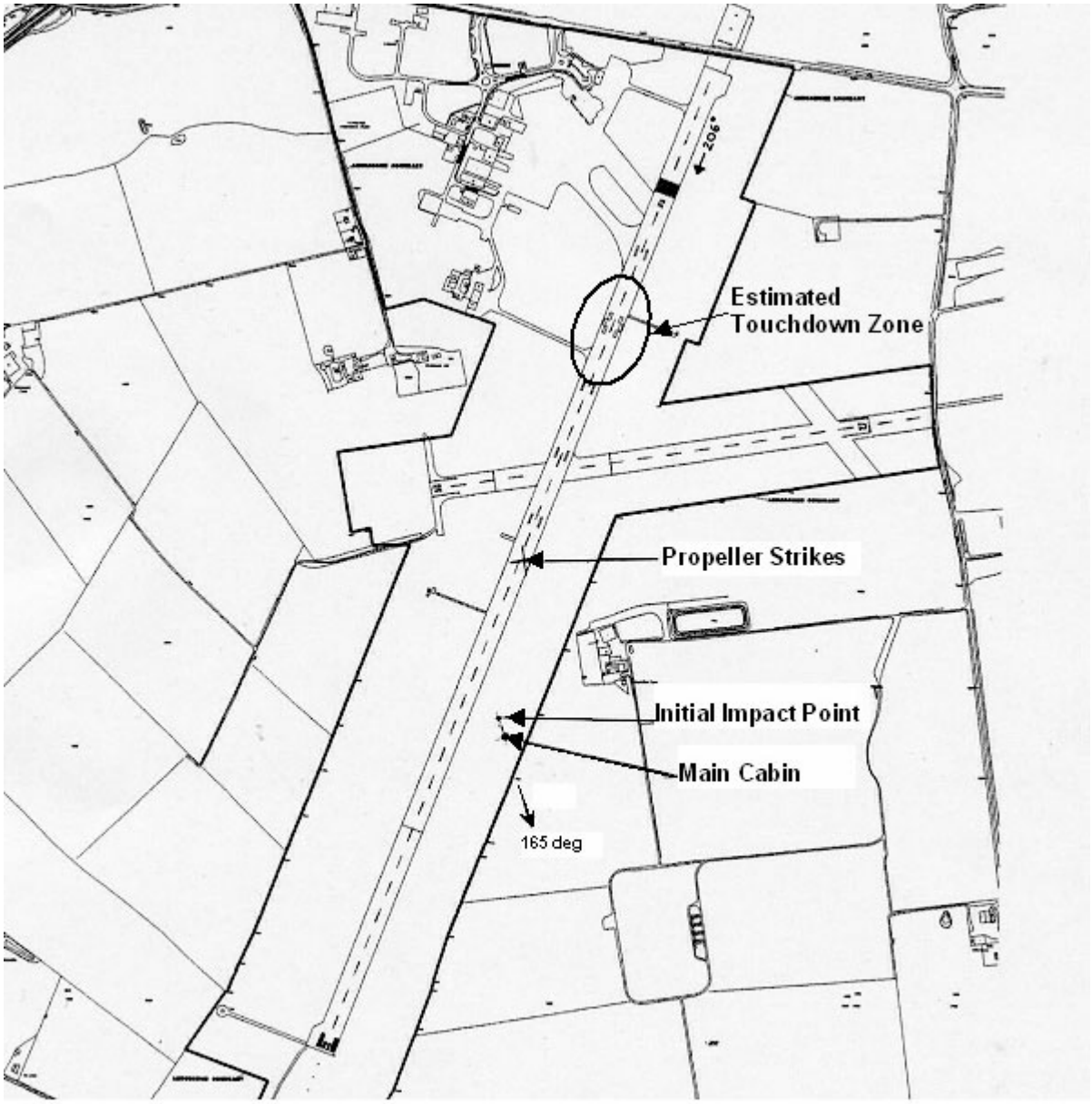

Figure 1 - Accident Site Location

There were two sets of propeller strike marks running parallel to each other slightly offset to the left of the runway centreline (see Figure 2) indicating that the aircraft was in a near wings-level attitude when the strikes occurred. The right propeller had produced a set of 26 propeller strikes with an initial minimum spacing of 54 cm and a final maximum spacing of 68 cm. The left propeller had produced a set of 20 propeller strikes with an initial minimum spacing of 56 cm and a final maximum spacing of 87 cm. The left propeller strikes started 2.8 metres further along the runway than the strikes on the right but ended in approximately the same abeam location. The first six strikes on each side caused deep gouges in the runway surface while subsequent strikes caused lighter marks.

Figure 2 - Propeller strike marks on the runway

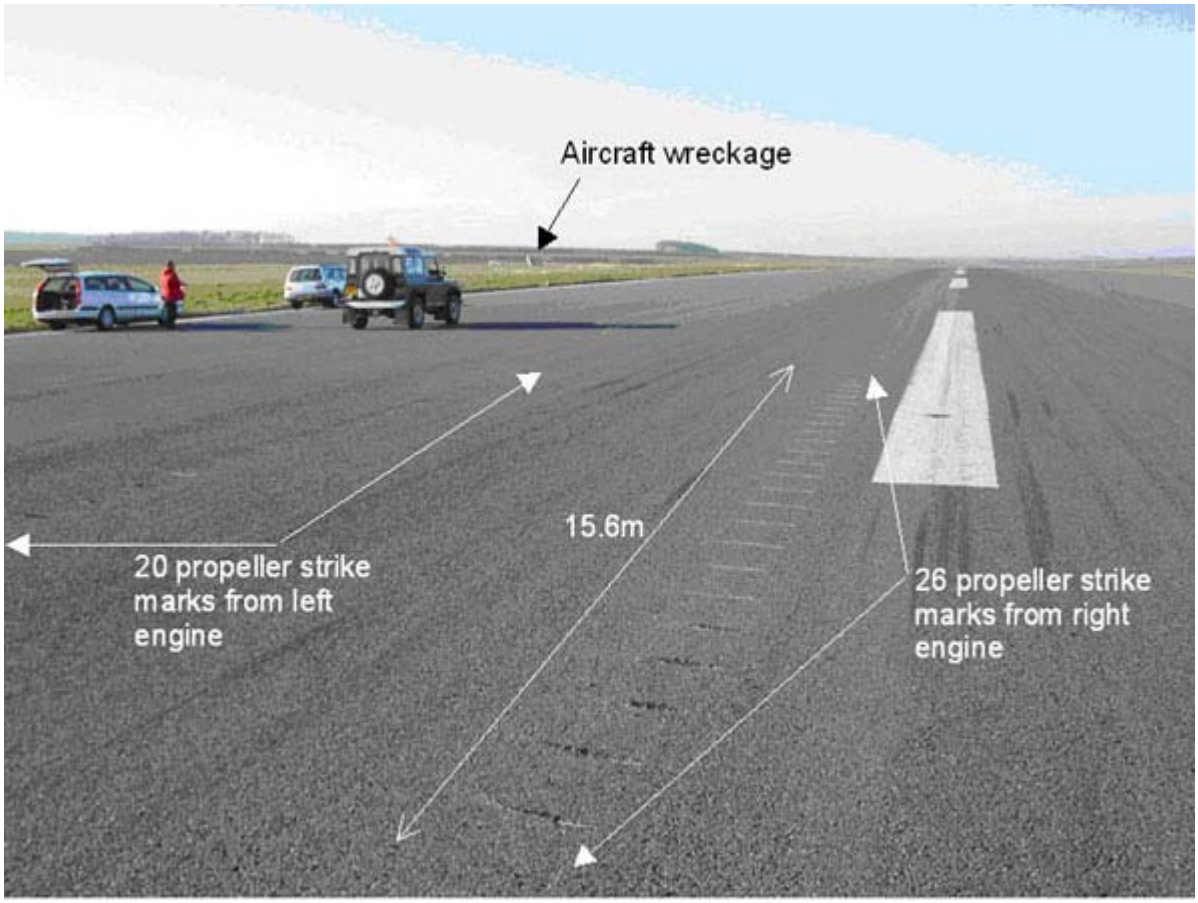

Figure 2 - Propeller strike marks on runway

If the propellers were operating at their maximum RPM for takeoff (2,235 RPM) when the right propeller struck, then based on the spacing of the runway strikes, the aircraft's ground speed was approximately 116 ± 4 kt. With a reported tailwind of 3 kt the aircraft's airspeed was approximately 113 ± 4 KIAS (pilot's normal rotation speed was 111 KIAS). The increasing spacing of the propeller strikes indicated that the propellers were slowing down as a result of the strikes. Assuming a constant ground speed of 116 kt during the strikes, the final RPM on the right propeller when the strikes ended was approximately 1,750 and the final RPM on the left propeller was approximately 1,350. The total time duration of the propeller strikes was approximately 0.26 seconds. Given the short duration of the strikes, it is reasonable to assume that the aircraft's ground speed remained approximately constant during that period. Alternatively, if the propellers had been left at the cruise/landing setting of 1,900 RPM then the aircraft's ground speed when the propellers struck would have been approximately 100 ± 4 kt (97± 4 KIAS).

The angle of each propeller strike mark - apart from one - was approximately the same: between 10° and 17° relative to a line perpendicular to the direction of travel. However, the sixth strike on the left side left a deep gouge at an angle of 26°.

Propeller examination

The damaged propeller blades and hubs were taken to the propeller manufacturer to be stripped and examined in more detail. The blade bending, twisting and overall propeller damage was similar for each propeller and consistent with both powerplants producing symmetrical power at the first impact point on the runway. The main difference between the two propellers was in the tip damage. The blade tips on all three blades on the right propeller were bent backwards with chordwise scratches. Two of the blades on the left propeller had also been bent backwards and had chordwise scratches but

one blade of the left propeller (blade No 3) had been bent forwards with spanwise scratches (see Figure 3).

Figure 3 - Spanwise scratches propeller blade (left) versus chordwise scratches (right)

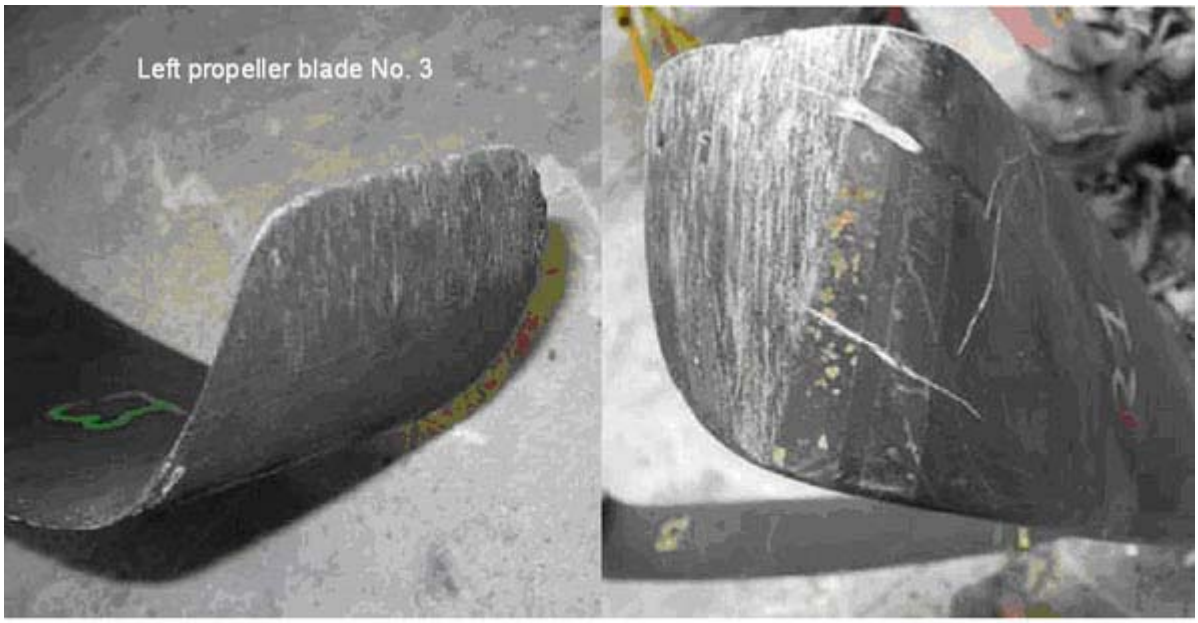

Figure 3 - Spanwise scratches propeller blade (left) versus chordwise scratches (right)

Internal inspection of the left propeller hub revealed that the actuating pin on the blade root of the No 3 blade had disconnected from the pitch change link allowing it to rotate freely to any pitch angle. Due to the counterweights on the propeller blade roots, the inertial forces due to rotation would cause a disconnected blade to rotate towards the feathered position. This would explain why the No 3 left propeller blade appears to have struck in a near-feathered position creating the spanwise scratches. It is also probable that the left No 3 blade created the unusual left propeller strike mark with an angle of 26°.

Examination of the witness marks inside and outside the propeller hub revealed that both propellers were operating in the fine pitch range when the initial runway strikes occurred but the exact amount of power being produced could not be determined. The damage to the blade tips on the right propeller would have reduced the thrust being produced but no data existed for determining the degree of thrust reduction. The damage to the left propeller would have had a more significant effect on the thrust being produced. The disconnected No 3 blade, in a coarse near-feather position, would have produced significant drag and slowed the rotation of the left engine. As the rotation slowed, the other two propeller blades would have rotated to a finer position (in an attempt by the governor to re-establish the set RPM) thus reducing the thrust being produced by those two blades. The net effect on thrust could not be quantified but it is possible that the left engine slowed sufficiently to a point where it was producing little thrust or perhaps, due to disturbed airflow created by the No 3 blade, no thrust and only drag.

Engines examination

Both engines were too badly damaged by impact and fire to be tested. However, there were no external signs of any pre-impact damage.

Landing gear examination

The left main gear was found in the up and locked position. The right main gear was up but not locked up. The right main gear uplock had cracked indicating that the right main gear may have been locked prior to impact and then unlocked during the impact sequence. The nose gear strut and nosewheel had separated from the aircraft during the impact. The nose gear uplock hook was bent in the same direction as the hook attachment on the nose gear leg, which was consistent with the nose gear having been up and locked at impact. The nose gear actuator was radiographed (x-ray) and then disassembled; no fault was found with the internal down-lock mechanism. There was no visible evidence to suggest a collapse of either the main landing gear or the nose gear but the spring-loaded landing gear actuation switch in the cockpit was found in the 'UP' position.

Flap system examination

The inboard split flaps on both wings had folded forwards underneath the wing. The outboard flaps had suffered major ground fire damage. If the flaps had been retracted it would have been difficult for the impact forces, as the aircraft fuselage slid backwards, to fold the flaps forward. It was therefore apparent that the flaps must have been extended during impact. An examination of the position of the electric flap motor by the aircraft manufacturer indicated that the flaps were probably set to somewhere between 13° and 23°. The flap lever in the cockpit was found set in the region between the 15° and 30° detents and the flap position indicator was in the same vertical location as the flap lever. From the combined evidence it was clear that the flaps were extended at impact but their actual position could not be determined within the range of 13° to 30°.

WOW safety switch examination

The WOW safety switch prevents electrical power from reaching the gear actuator when the left landing gear shock strut is compressed. When the weight of the aircraft is supported by the wings the shock strut extends and the safety switch closes, enabling actuation of the gear. The WOW safety switch was tested in-situ and operated correctly as the strut was manually compressed and extended. The safety switch triggered when the strut was within 0.55 inches of full extension (the total stroke of the strut was measured at 1.2 inches). The service manual states that the switch should be adjusted such that it triggers when the strut is within 0.63 to 0.75 inches of full extension. The safety switch on this aircraft was therefore outside the tolerance but it was rigged on the side of safety since more weight needed to be removed from the left strut before the gear could be retracted. The possibility of water ingress inside the switch causing an electrical short could not be ruled out although the switch had recently been re-sealed during the aircraft's annual maintenance.

Landing gear warning horn examination

The operation of the landing gear warning horn was described in the aircraft description section of this bulletin. The gear warning horn along with the resistor and flasher that formed part of the gear warning horn circuit were removed from the aircraft and tested with a 28V power supply. The horn produced a loud intermittent sound in accordance with its design.

Aircraft performance

The aircraft's single engine climb performance was calculated from the POH. The aircraft's weight was approximately 7,000 lb at the time of the accident. The temperature and pressure altitude were +14°C and 66 feet respectively. The single engine climb rate at the recommended speed of 110 KIAS with the gear up was as follows:

Table 1 Single engine climb rate at 110 KIAS

Inoperative Powerplant	Flap (deg)	Climb Rate (feet/min)
Feathered	0	450
Windmilling	0	50
Feathered	15	250
Windmilling	15	-150
Feathered	40	-1250
Windmilling	40	-1650

Assuming the flap configuration did not change between lift-off and impact, the flap position was probably between 13° and 30°. The left powerplant, although still operating, would not have been producing much thrust and would probably have more closely represented a windmilling powerplant rather than a feathered powerplant. The performance of the right powerplant would also have been degraded due to the bent propeller tips. Therefore, from Table 1 it can be seen that the aircraft would probably have had a negative climb rate at the recommended climb speed. Although airspeed could have been exchanged for altitude, a sustained climb would not have been achievable. The aircraft's published air minimum control speed (V_{MCA}) was 73 KIAS (optional vortex generators were fitted). The power-off stall speed (assuming flap 15°) was 73 KIAS wings level, rising to 104 KIAS in a 60°bank. The aircraft's approximate speed at the time of the propeller strikes was 97 ± 4 KIAS if the propellers were at 1900 RPM or 113 ± 4 KIAS if the propellers were at maximum RPM (based on distance between strike marks).

Flight tests and research

A flight test on an aircraft of the same type was carried out in order to determine its handling characteristics during touch-and-go landings, its response to sudden engine failure and the audibility of the landing gear warning horn. The weight and balance of the test aircraft was adjusted to replicate as closely as possible that of the accident aircraft. The test results cannot be taken as an exact replication of what may have occurred during the accident flight because of variables such as longitudinal trim setting, wind conditions and pilot input. Nevertheless they give an indication of the likely reaction of the aircraft to the various configurations and simulated failures.

A normal takeoff was carried out with flaps at 0°, and a number of touch-and-go landings were conducted with various flap settings between 13° and 45°. For each event the aircraft was accelerated on the ground towards the accident aircraft's maximum calculated airspeed of 117 KIAS (113 ± 4 KIAS). The elevator trim setting was set to the middle of the take-off range for the first takeoff. For the touch-and-go landings, the aircraft was trimmed on approach at 100 KIAS with flap 45° extended and the landing gear down, and the trim was kept at this setting throughout the touch-and-go. In practice, the elevator trim setting varied very little, and for both the takeoff and the touch-and-go landings was in the middle of the take-off range.

During the normal takeoff with flaps at 0° the pilot needed to apply a small push force to keep the aircraft on the ground above about 115 KIAS. During the touch-and-go landings with various flap settings the aircraft became light on its oleos at speeds below 117 KIAS and, without pilot intervention, became airborne in a level attitude as the aircraft continued to accelerate. The exact speeds at which these events took place varied with the amount of flap extended. In general, the tendency to become light on the oleos before becoming airborne was more noticeable with the lesser flaps settings than at the higher flap settings when the aircraft became airborne more abruptly.

A simulated engine failure at 120 KIAS with both engines at maximum power was conducted at 5,000 feet. The aircraft reacted immediately as engine power was reduced and almost simultaneously

yawed and rolled toward the failed engine. This test was not entirely representative of the situation that applied to the accident aircraft since the damage to the propellers could not be replicated and the altitude and temperature at which the test was conducted would have resulted in less thrust from the operating powerplant. However, the test showed that, without appropriate pilot intervention, the aircraft rolls and yaws toward the failed powerplant.

Tests of the landing gear warning horn audibility were carried out. The pilot carrying out the test wore a Direct Noise Cancelling headset of the type used by the owner, but he was seated in the right pilot's seat. The tests indicated that the horn was clearly audible during cruise flight but, as expected, audibility reduced during a full power go around or with other noise present. Critically, the pilot carrying out the test was of the opinion that the volume of the horn might be insufficient to penetrate an operating pilot's awareness in a highly stressful situation.

Lastly the view of the cockpit from the seat occupied by the examiner was assessed. The view was restricted by the shoulders and arms of the two pilots. Specifically, several of the flight instruments and a number of the controls were not visible without moving well forward in the seat. The seat was not designed as a 'jump seat'.

Medical and pathological information

A post mortem examination carried out on the FAA examiner's body revealed that he died from severe burns.

The aircraft owner held a UK and a USA Class 2 Medical certificate both of which required the holder to have available corrective lenses. The instructor had a US Class 2 Medical Certificate which required that the 'holder possess glasses to correct for near vision'. In October 2001 the instructor advised the CAA of a loss of hearing acuity and in response, the CAA required that he should undergo a "cockpit hearing test". This was not carried out prior to the accident. However, the instructor obtained a FAA Medical Certificate Second Class on 13 May 2002, about 10 months before the accident. Since the accident, the instructor has undertaken and passed the cockpit hearing test and his CAA medical has been renewed with a requirement for him to undergo an annual audiogram.

The owner and instructor both volunteered to provide blood samples for investigation. In the case of the instructor the analysis revealed nothing of any significance that could have contributed to the accident. However, in the case of the owner, promethazine at a level of 0.004 micrograms per millilitre was discovered. Tablets of Phenergan, a trade name for promethazine, were found in the owner's flight bag. Some months after the accident, when questioned about the possible source of promethazine in his blood, the owner was unable to recall taking Phenergan before the flight. However, his General Practitioner had prescribed Phenergan for him as an aid to sleep and he thought it possible that he had taken a tablet the night before the accident.

The Senior Medical Information Officer for the manufacturers of promethazine stated "The mean plasma half-life of promethazine is seven to 14 hours. The duration of action may be up to 12 hours, patients should therefore be advised that if they feel drowsy they should not drive or operate heavy machinery".

The Department of Aviation Pathology at the RAF Centre of Aviation Medicine was asked to comment on the toxicological findings. Their report stated that the level of promethazine discovered probably represented ingestion at a therapeutic dose by the aircraft owner between 6 and 18 hours before the blood sample was taken. The report continued:

> *'Promethazine is a sedative antihistamine used in a number of preparations to treat allergic conditions such as hay fever and allergic rhinitis. In Britain all preparations containing promethazine carry the warning label "Warning: May cause drowsiness. If affected do not drive or operative machinery. Avoid alcoholic drink."*
>
> *The use of "first generation" antihistamines such as promethazine is often associated with a number of unwanted and undesirable central side effects, the most troublesome of which is*

sedation. The term "sedation" usually describes a wide range of subjective experiences described as drowsiness, loss of alertness, decreased concentration and somnolence. In fact, sedation reflects the measurable impairment of superior cognitive functions such as attention, memory, co-ordination and psychomotor performance which can severely impair daytime activities such as school performance, car driving ability and many other tasks where concentration and a high degree of alertness and skill are required. With regard to these functions there are papers in medical literature describing impairment of the following higher cognitive functions: continuous tracking, visuo-motor co-ordination, choice reaction time and information processing.'

The Department of Aviation Pathology also consulted a national medical expert on the use of antihistamines in aviation. In the expert's opinion, an individual's response to promethazine is extremely variable and it cannot be judged from the blood level because there is no correlation between blood level and clinical response. Moreover, the duration of promethazine action may be very variable and some individuals are slow metabolisers of promethazine.

The Civil Aviation Authority issued safety advice on the subject of medication and flying in Aeronautical Information Circular (AIC) 58/2000 (Pink 4) entitled Medication, Alcohol and Flying. Paragraph 2 (also published in LASORs, Operating Requirements and Safety, Section A) states:

'The following are some of the more widely used medicines which are normally considered incompatible with flying.

(d) Antihistamines can cause drowsiness. They are widely used in "cold cures" and in the treatment of hayfever, asthma and allergic rashes. ... in many cases the condition itself may preclude flying, so that if treatment is necessary, advice from an Aviation Medicine Specialist should be sought so that modern drugs, which do not degrade human performance, can be prescribed'

The AIC goes on to state in paragraph 6:

'If you are ill and need treatment it is vitally important that the doctor whom you consult knows that you are a member of air crew...'

In addition to the above, the CAA publishes Safety Sense Leaflet 24 *Pilot Health* (also reproduced in LASORS) which provides further advice on medication and flying.

Survival aspects

Both front seat pilots were wearing lap and shoulder harnesses whilst the examiner, seated opposite the main exit facing forward, had only a lap belt. The post mortem did not reveal injuries that would have prevented the examiner from exiting the aircraft, but evidence from the owner and the fire crews indicated that that the examiner may have been unconscious or badly dazed after the aircraft's initial impact. The owner tried to release the examiner from his seat but was prevented from doing so by the examiner being slumped forward over his lap belt latch. The fire crews eventually rescued the examiner from the aircraft using breathing apparatus.

Analysis

Propeller strikes

Eyewitness reports of "puffs of grey smoke" from the vicinity of the mainwheels together with witness marks on the runway indicate that the first identified event in the sequence that led to this accident was both propellers striking the runway during the take-off portion of a touch-and-go. This analysis will begin by assessing the cause of the propeller strikes and then discuss the other issues that could have led to the loss of control of the aircraft.

Study of the aircraft's geometry (see Figure 4), and advice given by the manufacturer, indicate that there are only four means by which both propellers can strike the ground simultaneously: (1) collapse of the nose gear, (2) collapse of both main gear, (3) collapse of all the landing gear, or (4) retraction of all the landing gear.

Figure 4 - Cessna 421C geometry

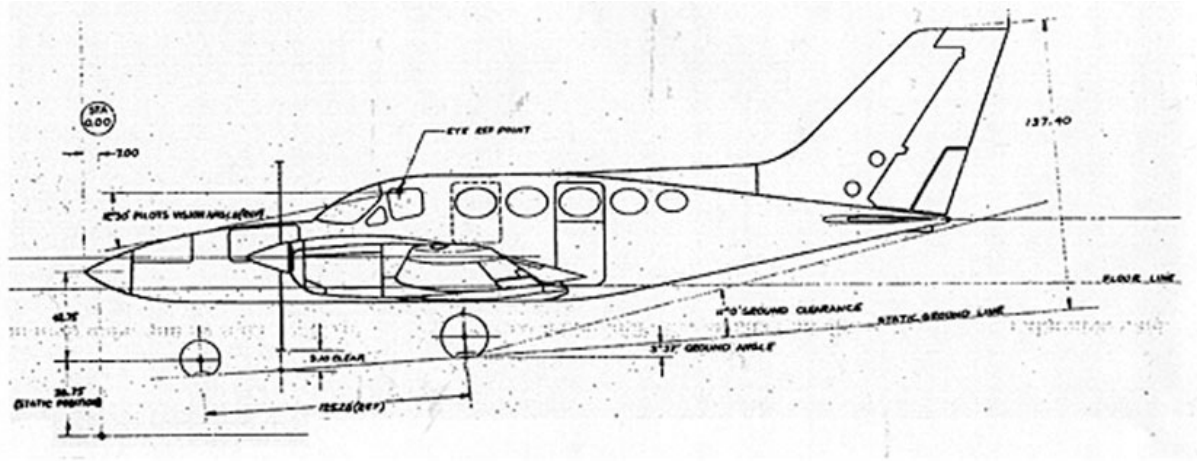

Figure 4 - Cessna 421C geometry

(1) Collapse of the nose gear would result in the aircraft pitching nose down but the owner recalled that the aircraft was in a "slightly nose up attitude" when the propellers struck. No fault was found with the nose gear downlock mechanism and there were physical indications that the nose gear was up and locked at impact. Furthermore it seems improbable that the nose gear would have collapsed 8-10 seconds after the initial touchdown.

(2) Collapse of both main gear would have resulted in a large nose up attitude before the propeller tips could have struck. No such pitch up was observed or reported. A main gear collapse would also probably have resulted in the aircraft's rear fuselage striking the ground before the propeller tips and no evidence of a fuselage strike was found on the runway.

(3) Collapse of all the landing gear caused by a heavy landing appears unlikely because the aircraft rolled along the runway normally for 8-10 seconds after the initial touchdown. Neither the eyewitnesses nor the instructor thought that the landing was unsafe, and no physical evidence was found to indicate a failure of the landing gear. A simultaneous collapse of all the landing gear therefore seems improbable.

(4) Retraction of the landing gear remains a possibility. The landing gear selector was found in the 'UP' position and the physical evidence was consistent with both the main landing gear

and the nose gear being up and locked at impact. The POH gives the landing gear retraction time at maximum engine RPM as 4.5 seconds and the estimated airborne time of the aircraft was approximately 6 to 7 seconds. There was sufficient time for the gear to retract and given the evidence of landing gear position at impact, the landing gear was most probably retracted before the aircraft struck the ground. The instructor is adamant that he did not touch the landing gear or flap controls during the flight and the owner is certain that he did not touch the landing gear selector after the propellers struck the ground. It therefore appears likely that the gear 'UP' selection was made during the touch-and-go landing whilst the aircraft was still on the runway.

Retraction of the landing gear whilst the aircraft is on the ground is normally inhibited by a WOW switch on the left landing gear shock strut; the switch was found to be serviceable and so retraction should have been prevented. However, examination of the wreckage showed that the flaps were at least partially extended when the aircraft struck the ground, and flight tests revealed that the aircraft, with flap extended, became light on its oleos before the normal flaps-up rotate speed. It is therefore possible that, as the aircraft accelerated along the runway, the landing gear shock strut extended sufficiently to close the WOW switch and enable actuation of the gear. With the gear selector 'UP', the landing gear would have begun to retract with the wheels still in contact with the ground. At this stage most but not all of the aircraft's weight would have been supported by the wings. As the gear retracted, the aircraft would have begun to settle resulting in the propellers striking the runway. Another explanation for the aircraft's settling could have been a nose down control application by the owner to keep the aircraft on the ground until his normal rotation speed but the owner could not remember anything about this stage of the touch-and-go. A third explanation would be gear retraction during or immediately after takeoff followed by some form of engine power loss. However, the symmetry of the blade angles seen in both sets of runway propeller marks (except for one mark which accounted for failure of the left propeller's No 3 blade pitch-change link) suggests that any such power loss must have affected both engines equally. However, there was no physical evidence or logical explanation for a sudden, symmetric power loss.

The landing gear warning horn should have activated if the landing gear selector was placed to 'UP' on the ground. Moreover, if the flaps were greater than 15°, it should have continued to sound with the landing gear up once the aircraft became airborne. However, although the horn appeared to be serviceable, neither pilot recalled hearing the horn during the accident but the instructor had degraded hearing and both pilots were wearing noise-cancelling headsets. Whilst these factors might help to explain why neither pilot heard the horn, it has been established that the human auditory function is one of the first faculties to degrade in highly stressful situations. The explanation might therefore be that the horn operated normally but did not penetrate either pilot's consciousness. It may also explain why the instructor did not hear the propellers striking the runway.

Since the owner cannot remember the touch-and-go prior to his sinking feeling which preceded the propeller strikes, and the instructor was focussing his attention outside the aircraft, it has not been possible to determine what might have led to an inadvertent landing gear 'UP' selection on the ground. The POH does not contain a published procedure for a touch-and-go landing, the owner did not recall having accomplished a touch-and-go landing recently and he was not briefed to expect a touch-and-go landing during the test. Although he had not practised flying the manoeuvre, he had recently carried out a number of 'Balked Landing' (go-around) procedures. The initial actions in the Balked Landing checklist are to apply power followed by retraction of the landing gear and then the flaps, and it is possible that the owner simply substituted the actions for a Balked Landing with those required for a touch-and-go landing. Alternatively, the selection might have been the result of a mental slip caused by the effects of stress, rushed procedures, high workload or the similar principle of the landing gear and flap switches operation. (Raising the flaps and raising the landing gear both require upward movement of a control switch located beside the throttle quadrant.)

Loss of control

Each of the pilots had different recollections of the events that followed the propeller strikes which, given the trauma of the accident, is not surprising. It has therefore not been possible to determine with certainty the reasons for the loss of control. The damage to the left propeller No 3 blade probably accounts for the aircraft roll and yaw to the left, which the instructor diagnosed as a left engine failure. The runway propeller marks suggest that the aircraft was either at approximately 97 KIAS or 113 KIAS when the propellers struck, speeds which are above the V_{MCA} of 73 KIAS. However, the aircraft's climb performance would have suffered considerably as a result of the propeller strikes. The left powerplant may not have been producing any thrust and the right powerplant would have been producing less than maximum thrust due to its propeller tip damage. Moreover, the extended flaps would have caused an additional reduction in climb performance. Without the ability to sustain a climb, the aircraft's speed would have bled off rapidly and the effectiveness of the controls to counter the left yaw and roll would have reduced. Once the bank angle had increased beyond a critical amount, recovery without further loss of altitude would have been impossible.

A full understanding of the events is further complicated by the differing appreciation that each pilot had of the problems that faced them and of their roles during the flight. The owner knew that the propellers had struck the runway and later stated that he had wanted to land straight ahead, whilst the instructor was unaware of the propeller strikes and reacted only to an apparent engine failure. There is disagreement over the verbal exchanges, if any, that took place after the propellers struck the runway and in any event, there was very little time for a discussion. The owner thought that the instructor was in command of the aircraft and bore the responsibility for the overall safety of the flight whereas the instructor considered himself only to be an observer and radio operator. He thought that since the owner already held a UK PPL and had many hours on type, the owner was commander of the flight.

Conclusions

The confusion over individual roles would have been resolved if the examiner had given a pre-flight briefing in line with the guidance contained in the FAA Designated Examiners' Handbook, but both pilots have stated that this briefing did not take place. In any event, the FAA Handbook and FARs are unclear on who should be the commander of the flight although FAR 61.47 states the examiner is not normally to be the Pilot in Command except by prior agreement with the applicant or other person who would normally be acting as Pilot in Command. Nevertheless, it is clear that the instructor should have been briefed that he was fulfilling the safety pilot role and was responsible for *"protect(ing) the overall safety of the flight to whatever extent is necessary"*. If the instructor had clearly understood this responsibility, he might have monitored the owner's actions more closely during the touch-and-go and might have intervened earlier.

Notwithstanding the confusion, the instructor took control when he considered that the owner was not taking appropriate action to control the aircraft, although the actual moment that he took control is in dispute. Given the owner's belief that the instructor was the commander and that the instructor was in any case by far the more experienced pilot, it is not surprising that he relinquished control even though, unknowingly, he had a more complete understanding of the aircraft's predicament. The flight time from the propeller strikes to the next ground impact was only a few seconds. Once the aircraft became airborne with a significant amount of power applied and a badly damaged left propeller, the situation was well beyond any emergency for which either pilot might have trained. The options for action were very limited and would have required a full appreciation of the circumstances, plus extremely rapid analysis and reactions if those actions were to be successful.

Safety recommendations

Conduct of the flight

This flight was relatively unusual in that it was a PPL Practical Test in a multi-engine rather than a single-engine aircraft and the candidate was not only already qualified on type but had many flying hours of experience. Furthermore, although the aircraft was certified for single pilot operations, the examiner chose to conduct the flight from a rear passenger seat in the mode more frequently used for multi-crew aircraft. The flight test raised questions about the adequacy of the position with regard to observation of the test, and the use of the passenger seat inevitably meant that, to comply with FAA requirements, a safety pilot would be required. The role of the safety pilot was an important one and required a clear understanding both on the part of the safety pilot and the candidate of the responsibilities of each other. Moreover, operation of the flight was subject to UK aviation regulations and not FAA regulations, so it was the commander's responsibility to give a safety briefing, but the arrangements for the flight did not establish unequivocally the commander's identity in the presence of all the participants. Given the unusual nature of the flight and the presence of a safety pilot, the pre-flight briefing by the examiner was crucial, but the FAA regulations and guidance provided for the examiner were inadequate for this unusual situation. Specifically, there were no mandatory requirements for the examiner to hold the pre-flight briefing in the presence of all the participants and to identify the Pilot in Command (commander). Therefore, it was recommended that:

Safety Recommendation 2003-117

The Federal Aviation Administration should review the relevant Federal Aviation Regulations and guidance material for flight examiners to ensure that:

a. The policy on conducting flight tests from seats other than a pilot's seat in multi-seat aircraft certified for single crew operations is clear and unambiguous.

b. The Pilot in Command on Practical Test flights is clearly defined.

The effects of promethazine

The investigation was not able to establish if the promethazine in the owner's blood had any effect on his flying performance. However, the drug was taken quite innocently the night before the accident as a sleeping pill. The owner had been taking promethazine for some time with no apparent effects on his performance the next day and some 12 hours had elapsed between his taking the tablet and the accident. Therefore, it seems unlikely that the owner's performance was affected by the residual promethazine in his blood whilst he was flying. Nevertheless, given the wide variation of individuals' responses to promethazine, the possibility that treatment with promethazine slightly impaired the owner's ability to fly the aircraft cannot be totally excluded.

It is therefore recommended that:

Safety Recommendation 2003-118

The Civil Aviation Authority should take action to publish more information that re-emphasises the dangers of piloting an aircraft after taking medication.

Safety action by the FAA

On 10 February 2004 the Federal Aviation Administration (FAA) wrote to the AAIB accepting Safety Recommendation 2003-117. The FAA's response was as follows:

'The FAA intends to revise Order 8710, 3C, chapter 5, to ensure that FAA's policy concerning the conduct of practical tests by DPE from other than a cockpit seat in aircraft certificated for only a single pilot crewmember is clear and unambiguous as to the "command" status or

responsibility of those on board and will allow the examiner to fully assess the command ability of the candidate and the assisting crewmember during a practical test conducted in this manner. Further, in the interest of improving safety, the FAA will provide additional emphasis and information on FAA policy concerning this matter to DPE who attend Examiner Standardization courses in the future.'