

American CPL holder to come to Europe to familiarise himself with the aircraft and to accompany him on the world flight. Since then, both pilots had based themselves at Cannes and together they had flown around Europe.

The owner had learned to fly in Guernsey, starting in 1997, and gained his Private Pilot's Licence in July 1998. In September 2000, he commenced training in Guernsey for an IMC Rating but did not complete the course. He then went to the USA in October 2000 to train for and acquire an American Instrument Rating. The other pilot in N294TC was the holder of a US CPL with an Instrument Rating. He was also a qualified Flight Instructor and had instructed the owner during the owner's training for his Instrument Rating. He had a total of 1,002 hours flying experience of which 109 hours were on multi-engined aircraft. His first flight in N294TC was on 6 June 2001 and he then flew four more flights, of which one on 13 June was from Southampton to Guernsey. He accompanied the owner during all of these flights in N294TC.

On 15 June 2001, the pilots flew N294TC from Cannes to Southampton Airport. After landing, the aircraft was parked on the apron and refuelled. The recollection of the experienced fuel bowser driver was that the pilot asked for the aircraft to be refuelled to full tanks. He replenished the tanks with 270 litres of AVGAS and before leaving, he checked that both fuel caps were in place. The aircraft remained parked outside for the next three days. During this period, the CPL holder informed friends in the USA that the aircraft had been performing well.

On the morning of 19 June, an acquaintance from Guernsey spoke to the owner by telephone. The owner was reported to have said that, despite not feeling 100% well, he was intending to fly back to France accompanied by the CPL holder. The acquaintance suggested that the owner should route back through Guernsey where a new set of spark plugs could be fitted to the aircraft's engine. This new type of spark plug had been ordered in preparation for the proposed world flight; it had been suggested that the engine "would run better with these new plugs". The owner agreed to return to Cannes via Guernsey.

Southampton Airport

The Airport has a single, asphalt-surfaced runway designated 02/20, with an Apron and Terminal complex to the west of the runway. There is no taxiway between the Apron and the threshold of Runway 20. Taxiway 'Bravo' connects the Apron to the runway at a position 875 metres from the threshold of Runway 20. From this holding point, aircraft enter the runway and 'backtrack' to the threshold of Runway 20.

The Take-Off Run Available from Runway 20 is 1,650 metres. The threshold elevation is 44 feet amsl and the runway has a slight downslope. The M27 Motorway passes about 100 metres to the south of the runway and beneath its level. Beyond the M27, there is rising ground. The elevation of the apex is 207 feet amsl (not including buildings); it is to the left of the extended runway centre-line about 1,750 metres from the end of Runway 20.

History of flight

On the day of the accident, the two pilots arrived at Southampton Airport at about 1100 hrs for the flight to Guernsey. The owner filed a flight plan in the Operations Controller's office and then both pilots left the office to walk the short distance to the aircraft. Some 10 to 15 minutes later the Operations Controller saw the aircraft leave the apron but no one reported having watched the pilots carry out their pre-flight checks.

The owner, who occupied the left pilot's seat, made all the radio calls from N294TC. At 1141 hrs he requested taxi clearance for his VFR flight to Guernsey. The aerodrome controller (call sign Southampton Tower) cleared the aircraft to taxi to holding point 'Bravo 1'. At this location at 1145 hrs, the owner reported that he was "READY FOR DEPARTURE" and was instructed to "HOLD". Then, at 1147 hrs the controller advised him of a new QNH and cleared him to enter and backtrack Runway 20 behind a landing Rallye aircraft which was one mile from the threshold on final approach; this message was correctly acknowledged. At 1149 hrs the pilot of a Seneca aircraft approaching to land from the south asked if he should orbit. The controller replied "ADVISE WHEN YOU ARE READY TO TURN BASE, THE AIRCRAFT WILL BE BACKTRACKING VERY SOON AND HE'LL EXPEDITE". A few seconds later, the controller passed a VFR departure clearance to the pilot of N294TC; this required the pilot to leave the control zone on track and to climb to not above 2,000 feet amsl; it too was correctly acknowledged. When it was on the runway, the landing Rallye aircraft was also instructed to 'expedite' and as soon as it had reported clear of the runway, N294TC was cleared to take off at 1150 hrs. The reported surface wind was "SOUTHERLY AT TEN KNOTS".

The controller watched the aircraft lift off the runway and then turned his attention to the Seneca aircraft that was approaching to land. After the Seneca landed, he heard the following radio call from N294TC: "WE HAVE AN EMERGENCY WE'RE NOT CLIMBING I DON'T KNOW WHY WE'D LIKE TO COME BACK AND LAND". The controller immediately replied "YOU CAN MAKE A LEFT OR RIGHT TURN POSITION DOWNWIND RIGHT". The owner acknowledged the message with "MAKE A RIGHT TURN TANGO CHARLIE DOWNWIND RIGHT" and the controller saw the aircraft bank to the right. He estimated its height as between 300 and 600 feet agl and said that it then seemed to sideslip and lose height until buildings obscured his view of the aircraft. Shortly afterwards the controller saw a plume of black smoke rising from where he had last seen the aircraft and he immediately activated the airport alert procedures and declared an 'Off Airport Accident'. The Airport Fire Service reacted immediately and arrived at the crash scene shortly after the Hampshire Fire Service.

Witnesses

There were numerous witnesses to the accident. In addition to the Air Traffic Controller, some pilots watched the aircraft's departure; these included pilots who were airborne and two in an aircraft holding on the taxiway at 'Bravo 1'. Other witnesses saw and heard the aircraft during its flight and at the crash site. Relevant points from the witnesses' accounts are as follows:

The take-off ground roll appeared unusually long and the initial climb angle seemed very shallow. From his vantage point in the ATC Tower, the controller estimated that the aircraft began its take-off roll from a position close to the threshold of Runway 20 and that it took about two thirds of the runway length to get airborne. Certainly, N294TC was not airborne when it passed the stationary aircraft at 'Bravo 1'. Its crew estimated that N294TC did not get airborne until about three-quarters of the way along the runway. They confirmed that the landing gear of N294TC was retracted shortly after take-off. However, they thought that the climb angle was shallow and they were concerned that the aircraft would not clear rising ground located under the climb-out path. Some of these observers considered that 'smoke or haze' seemed to be coming from the aircraft.

Just after he landed, the Seneca pilot heard the emergency call and looked towards the aircraft; he reported that he saw a streak of bluish smoke, which lasted for between two and three seconds, coming from underneath the aircraft. A witness on the ground, near the Airport perimeter fence, stated that his attention was drawn to the Commander aircraft by the irregular sound of its engine

which seemed to be operating at lower RPM than he would have expected. The aircraft passed him at an estimated height of 40 to 50 feet and well below the minimum of 200 feet he normally expected for a light aircraft. He also stated that, as the aircraft crossed over the M27 motorway, "I saw a thick plume of brown dirty smoke come from the port side of the engine". The low altitude over the motorway was corroborated by a passing motorist who also thought that the aircraft's engine was not running smoothly. As the aircraft passed over him, he saw what he described as a "thin black strip of smoke or oil coming from the left hand side"

When it was about a mile from the Airport, the aircraft was seen to turn to the right, back towards the area of the Airport. The aerodrome controller stated that he could see all of the aircraft's upper side as it sideslipped, indicating that it was steeply banked. Shortly before the accident, the aircraft was seen at a height in the order of 50 to 100 feet, having largely completed its turn back towards the Airport, with the nose high and the rear of the aircraft "moving from side to side". As it approached some trees, it began to climb as if to clear them, which it did by a few feet. However, at about the same time, the aircraft pitched up, rolled to the right and dived almost vertically into the ground. The observers nearby were not aware of any flames or smoke from the aircraft prior to impact but some reported that the engine appeared to be "misfiring" or "spluttering". One witness close to the impact site reported that he heard an increase in engine power just as the aircraft pitched up before the final roll.

The adjacent witnesses, some with fire extinguishers, ran towards the crashed aircraft. It was on fire and the witnesses attempted to contain the fire until the fire service arrived. There was no indication that the occupants had survived the impact.

Weather information

The Southampton weather observation (METAR) at 1150 hrs on 19 June was as follows: surface wind 190°/09kt variable between 140° and 260° M; cloud and visibility OK; temperature 18°C, dew point 9°C; QNH 1027 hPa.

Information on rainfall during the period that N294TC was parked outside at Southampton Airport was sought from The Meteorological Office at Bracknell and rainfall data were obtained from an automatic weather station located near the Airport in Southampton city. On 16 June, there were two periods when high levels of rainfall were recorded; from 0600 to 0700 hrs UTC, 34 mm (1.34 in) of rain fell and from 1600 to 1700 hrs UTC, 16 mm (0.63 in) of rain fell. Over both periods, rainfall was included in the METAR at the Airport.

Weight and balance

The Commander 114TC has an integral fuel tank in each wing with refuelling points on the upper surfaces near the outboard ends of the tanks. The aircraft type's maximum fuel capacity is 341 litres (equivalent to 90 US Gallons) of which 333 litres are useable. The delivery of 270 litres to N294TC would suggest that the aircraft's tanks were probably refuelled to full.

The basic weight of N294TC was 2,429 lb and the Maximum Take-Off Weight (MTOW) was 3,305 lb. The combined weight of the two pilots was 416 lb and the weight of full fuel was 540 lb. This combination would give a take-off weight of 3,385 lb. However, there was additional equipment on board including a liferaft, life jackets, a bag of flight manuals, three small cases and other sundry equipment; a conservative estimate of the weight of this additional equipment was 150 lb. Therefore, the aircraft was some 230 lb overweight for take-off. The Centre of Gravity (CG)

could not be accurately calculated from the Pilot's Operating Handbook as the weight was outside the coverage of the graph. However, using extrapolation, the CG was probably within the limits.

Aircraft performance

The flap setting used for take off could not be determined but the Commander Aircraft Company was asked to provide performance information based on the known weather conditions. The company calculated that, for a take off weight 200 lb above the maximum authorised weight, the expected ground roll for a flaps retracted take-off would be 480 metres and the associated take-off distance to 50 feet would be 840 metres. The use of 10° or 20° flap for take off would have reduced the ground roll distances to 465 and 424 metres respectively, and the take-off distances required to achieve 50 feet in height to 778 and 674 metres respectively.

At maximum authorised weight, the rate of climb with flaps retracted would have been 956 feet/minute. However, the additional weight and the use of air conditioning would have slightly decreased the rate of climb. The Pilot's Operating Handbook gives the best rate of climb speed as 100 kt. It also includes the information that the best angle of climb should be used if a nearby obstruction requires a steeper climb angle; in that case, the best speed is 75 kt. At the aircraft maximum weight of 3,305 lb, the stall speed with flaps up at 0° angle of bank is 68 kt. At bank angles of 30°, 45° and 60°, the respective stall speeds become 73 kt, 81 kt and 96 kt.

Previous incident

During the investigation, a previous incident involving the aircraft and the same pilots was brought to the attention of the investigators. This occurred on 7 June 2001, following a departure from Guernsey at 1038 hrs. The pilot reported to Jersey Air Traffic Control that he was experiencing "A LITTLE BIT OF ROUGH RUNNING" and requested radar vectors back to Guernsey Airport. The aircraft landed safely at Guernsey at 1046 hrs and the pilot apparently cleared the problem on the ground. He then departed for Southampton at 1104 hrs. There was no record of the problem being brought to the attention of the aircraft's maintenance organisation.

Medical Evidence

On the morning of the day of the accident, during a telephone conversation, the owner said that he was suffering from a cold or virus and was not feeling 100% well. However, a consultant pathologist stated that there was no evidence of any pre-existing medical condition, which may have caused or contributed to the accident. Additionally, there was no evidence of any alcohol, carbon monoxide, drugs or other toxic substances that might have caused or contributed to the accident.

The accident site

The accident site was approximately eight metres from the main Southampton to London railway line. The impact position and the area immediately to the south was wooded with a mixture of tall mature trees and medium height trees and bushes. The area immediately to the north was open, rough meadow for about 150 metres beyond which were buildings and a tarmac hardstanding containing a number of boats and trailers. The area to the west was built-up with housing and to the east was the River Itchen. Beyond the river was parkland interspersed with large mature trees.

Examination at the site showed that the aircraft impacted the trees in an almost vertical nose-down attitude, yawed slightly nose to the left and spinning to the right. The impact speed was assessed as being in the region of 60 kt. Following the ground impact, a small fire started within the wreckage which, because of large quantities of aviation fuel leaking from the ruptured fuel tanks, quickly became a large, fierce fire that consumed a substantial amount of the aircraft's structure. The aircraft was complete, that is no parts of the airframe had detached prior to impact and there was no evidence that it had collided with anything prior to striking the trees. The landing gear and wing flaps were retracted and the air conditioning system intake flap was extended, indicating that the system had been selected ON. Examination of the propeller indicated that it was being driven by the engine when the aircraft struck the trees. The engine bay and lower fuselage areas were examined for evidence of an airborne oil leak from the engine or propeller mechanism but none was observed.

Subsequent engineering investigation

A detailed examination of the aircraft's flying control systems showed that there was no pre-impact disconnection and there was no evidence of a restriction or jam. A small fuel sample from a pipeline within the engine compartment was analysed; it was found to be uncontaminated and the correct type for the aircraft. The fuel filter was also examined and found to be clean.

The engine hours accumulated since the aircraft was re-registered on 4 December 2000 could not be determined from the available technical records. However, it was unlikely that it had flown for more than 50 additional hours, resulting in a total running time of not more than 261 hours. The engine was taken to an FAA and CAA approved engine overhaul facility for Lycoming engines where a detailed strip took place and components were examined and tested. The external and internal conditions of the engine were found to be very good and consistent with a nearly new unit. When the six cylinders were removed from the engine's crankcase, it was found that the number 2 cylinder showed extensive black deposits consistent with recent running in a fuel rich condition for a short period. This would have caused a partial loss of power produced by that cylinder and dark coloured exhaust smoke.

The engine's fuel system components were bench tested. The number 2 cylinder fuel injector nozzle, which, as far as could be established was original equipment, was delivering a fuel spray pattern that was very uneven and poorly atomised. Microscopic examination of the fuel nozzle did not reveal the reason for the uneven fuel spray pattern. Following ultrasonic cleaning, the fuel nozzle was re-tested and found to continue producing a very uneven and poorly atomised fuel spray pattern. A fuel flow rate check of all six nozzles was carried out and found satisfactory since the quantity collected from each nozzle was identical. The number 2 fuel nozzle was installed in a similar type engine and an engine run, which included a full power check, was carried out. No faults were observed with the test engine's performance.

A second apparent problem was found in the number 2 cylinder. The inlet manifold, which is where the fuel nozzle was fitted, had a glazed or shellac like appearance. This type of contamination is usually associated with abnormally high cylinder head temperatures for a period of many hours. Moreover, examination of the inlet valve guide within the number 2 cylinder showed evidence to suggest that the inlet valve may have started to stick occasionally. If this valve had been partially but not fully closed during the combustion phase of the cylinder's operation, some loss of compression (and hence power) from this cylinder was likely but there may not have been any associated rough running. A stuck valve would also have allowed hot combustion gasses into the inlet manifold. These gasses could have caused the glazing seen within the manifold.

Consideration was given to poor or reduced air supply to both the fuel nozzle and the inlet manifold. Examination of both systems did not reveal any faults or failures. The spark plugs and magnetos were bench tested and found to function satisfactorily. The two spark plugs from the No 2 cylinder were fitted to an engine that was installed on an engine test bed. No faults were found with this engine (and hence the spark plugs) during two subsequent test runs. Units from the turbo charger system were also bench tested and found to function satisfactorily.

Analysis

The owner acknowledged all the air traffic clearances without difficulty or delay which indicated that he was mentally alert even if he was not feeling '100%' well. On arrival at Southampton, there was no indication of any problem with N294TC but the aircraft crashed on take-off after being parked on the ground for the previous three days. The rich running of the engine's No 2 cylinder could explain the witness evidence of a trail of smoke or haze coming from the aircraft but it would not have caused a gross loss in power output. However, the aircraft's instrument panel was equipped with an electronic display of all six cylinder head temperatures, so if the associated high temperature of number 2 cylinder had been an enduring defect, the owner would have had good reason to have its cause determined, particularly as the engine had some history of rough running. Moreover, if the inlet valve had stuck open once more, there could have been a significant power loss and possibly some associated rough running.

In isolation, these problems should not have resulted in the accident but, during the investigation, other aspects became apparent which, in combination, may have resulted in a situation outside the pilot's experience. In considering these aspects, it should be remembered that there were two qualified pilots in the aircraft. Although the owner was in the left (commander's) seat and made all the radio calls, the pilot in the right seat was a flying instructor and therefore used to flying from that seat. It was not possible to confirm who was handling the controls at any stage during the accident flight. Accordingly, the single term 'pilot' is used in the remainder of this analysis.

Together with the occupants and the equipment, the refuelling to full tanks resulted in the take-off weight exceeding the MTOW by some 230 lb. The additional weight would have had an adverse effect on performance increasing by some 13.6% the take-off distances. Both pilots should have been aware of the weight limitation and a simple calculation would have indicated the maximum fuel quantity that could have been carried to ensure that the weight remained within the limit. The performance would also have been further reduced by some 1.3 % by the air conditioning system, which should not have been operating during take-off. No drag penalty was offered by the aircraft manufacturer for the open air conditioning inlet door on the aft fuselage because this was thought to be insignificant at low airspeeds.

The possibility that water contamination caused the rough running was considered because water might have entered the fuel system during the periods of heavy rainfall when the aircraft was parked outside. Normally, a pilot would check that the fuel was clear of visible water during the pre-flight checks but there was no evidence to indicate whether or not this was done. Nevertheless, the refueller checked that the filler caps were properly fitted and a post-accident fuel sample was free of significant water content. Water contamination was, therefore, an unlikely causal factor, but it was not possible to eliminate it.

The fact that the pilot transmitted that he could not understand why the aircraft was not climbing suggested that there was no obvious reason for the perceived lack of climb performance. Although the engine malfunction, the extra weight and the use of air conditioning would have had a

cumulative effect on the performance of the aircraft, it is possible that the approaching high ground may have given the pilot a visual impression that the aircraft was not climbing. Such an illusion may have accentuated any decrease in aircraft performance but the witness evidence suggested that the performance was already significantly compromised, both on the runway and immediately after take-off, and before the aircraft reached the rising ground.

The evidence from the aerodrome controller suggested that when the pilot commenced a turn to the right, the turn appeared to be at a high bank angle and that the aircraft then started a descent. When the pilot initiated the turn, it would be reasonable to assume that the aircraft was close to the best climb speed. At that speed, particularly with a suspect engine, the aircraft should have been manoeuvred gently using not more than about 10° bank. Any extra bank would have resulted in the possibility of the aircraft stalling. However, the pilot was over a densely populated area in an aircraft that did not seem to be performing normally. In that situation, it would be difficult to concentrate fully on accurate control of the aircraft. It appears likely that some loss of control followed the initial turn and resulted in a rapid loss of altitude.

Witnesses then reported the aircraft at low altitude, indicating that the pilot had regained control. The aircraft's airspeed was probably low and its engine noises suggested a problem. No definite technical reason could be found for the reported noises. However, low altitude and low airspeed are a difficult combination from which to recover, particularly with a problematic engine, and the pilot would have been aware that the aircraft was over an area of dense population. As the aircraft approached a line of trees, the pilots' instinctive reaction would have been to climb to clear the trees. This final manoeuvre may have caused the aircraft to stall resulting in an incipient spin and the accident, although sudden restoration of high engine power might also have induced the incipient spin.

Safety Lesson

Both pilots had taken-off from Southampton the previous week and had landed there on the Thursday before the accident, so both would have been aware of the approximate length of the runway. On take off, the aircraft used not less than 800 metres and possibly as much as 1100 metres ground roll distance. This was significantly more than the calculated 480 metres and unusually long for the aircraft type.

Regardless of the airborne problems subsequently encountered by the pilots, the aircraft did not perform as well it should have done during the take-off roll. General Aviation Safety Sense Leaflet 7B deals with aeroplane performance and recommends that pilots work out a decision point. The Leaflet states that this means a point on the runway at which the pilot can stop the aircraft '*in the event of engine or other malfunctions e.g. low engine rpm, loss of ASI, lack of acceleration or dragging brakes*'. The advice given is '*Do NOT mentally programme yourself in a GO-mode to the exclusion of all else.*' The evidence indicated that the aircraft's take-off ground roll was prolonged to the extent that this 'stop' option should have been exercised before the aircraft became airborne.