# Rockwell Commander 114, G-LIMA, 24 February 2001

| | | |
|---|---|---|
| **AAIB Bulletin No: 4/2002** | **Ref: EW/C2001/2/5** | **Category: 1.3** |
| **Aircraft Type and Registration:** | Rockwell Commander 114, G-LIMA | |
| **No & Type of Engines:** | 1 Lycoming IO-540-T4B5D piston engine | |
| **Year of Manufacture:** | 1978 | |
| **Date & Time (UTC):** | 24 February 2001 at 1425 hrs | |
| **Location:** | Near Sharpthorne, West Sussex | |
| **Type of Flight:** | Private | |
| **Persons on Board:** | Crew - 1 | Passengers - 3 |
| **Injuries:** | Crew 1 (Fatal) | Passengers 3 (Fatal) |
| **Nature of Damage:** | Aircraft destroyed | |
| **Commander's Licence:** | Private Pilots Licence with IMC Rating | |
| **Commander's Age:** | 55 years | |
| **Commander's Flying Experience:** | Estimated 400+ hours | |
| | Last 90 days - Not known | |
| | Last 28 days - Not known | |
| **Information Source:** | AAIB Field Investigation | |

## History of the flight

The pilot, a member of a flying syndicate, booked the aircraft for a return cross-country flight to Shoreham departing from Biggin Hill at 1200 hrs. He had recently completed an IMC revalidation test in a Piper PA 28, and also held a Night Rating which required renewal.

The aircraft was parked in a hangar on the southern side of the airfield. At 0900 hrs on the day of the accident the pilot telephoned the hangar manager enquiring as to the aircraft's fuel state. He was told that the tanks were full but the aircraft was being flown earlier that day by another member of the syndicate. The pilot asked that the aircraft should not be refuelled upon its return as he intended carrying three passengers and did not want full fuel on board. The aircraft landed from its first flight that day at 1145 hrs with its tanks 3/4s full. The pilot operating that first flight subsequently reported that the aircraft was fully serviceable with all systems operating normally.

The aircraft took-off from Biggin Hill at 1247 hrs and arrived at Shoreham, without incident, at 1312 hrs. The pilot and his three passengers left the aircraft parked close to the terminal and entered the airfield restaurant for light refreshments. Having eaten and carried out some pre-flight planning the pilot and passengers boarded the aircraft for the return flight. The passenger, seated in the front right seat next to the pilot, was also a qualified private pilot who had flown with him on previous occasions on flights to the Continent, North Africa and the Middle East.

The aircraft took-off from Shoreham at 1407 hrs to return to Biggin Hill. The pilot was in contact by radio with the Shoreham Approach controller during departure but 5 minutes into the flight he requested to change frequency. There was no record of him subsequently having made contact with any other air traffic unit.

The progress of the flight from Shoreham to Biggin Hill was recorded by the National Air Traffic Services (NATS) radar at Pease Pottage several miles to the south of Gatwick. Only the primary radar returns were recorded as the aircraft's Mode 'C'(height encoding) transponder transmissions were not received.

The aircraft was first detected by radar, at 1407:09 hrs, as it took off from Runway 03 at Shoreham. The aircraft turned right after departure, flying towards Brighton and crossing the coast by Brighton Marina. It flew approximately 0.5 km from the coast until it turned inland close to the Seaford (SFD) VOR. The aircraft then followed a track of approximately 345° passing just to the east of the village of Newick (5 km south-east of Haywards Heath) before turning onto a track of 340° towards Sharpthorne. It approached the southern edge of the Gatwick Control Zone (CTR) (controlled airspace extending from the surface to 2,500 feet amsl) just north of Sharpthorne and was recorded as entering a tight right turn before the radar return disappeared. The last recorded position was at 1424:53 hrs, directly above the Bluebell railway line, 2 km north of Sharpthorne.

There were several eye witnesses to the aircraft's progress just prior to the accident. One witness, positioned east of Sharpthorne, saw the aircraft flying normally on a northerly track with its wings level and the engine sounding normal. The witness, an experienced pilot himself, estimated the aircraft to be at a height of 500 to 800 feet agl (900 to 1,300 feet amsl). He heard the engine noise then increase for 5 to10 seconds before it stopped abruptly. He described the weather at his location as being fine but with a large cumulus cloud in the area. Moments after the engine noise ceased the visibility on the ground reduced to 200 metres in snow that continued to fall for a further 5 to 10 minutes.

One witness saw the aircraft 'enter or fly behind the cloud'. As it did so the engine noise started to rise 'as if aircraft had started a dive without throttling back'. A further witness was also aware of changes in engine noise whilst the aircraft was in the vicinity. As the noise became particularly loud he saw the aircraft 800 metres away from him coming out of a shallow 10° descent, still under power at or below the tree line. He reported that 'it appeared to attempt a level right turn but both wings fluttered, vibrating unnaturally before there was the sound of mechanical failure'. The aircraft continued its turn to straighten on a southerly heading now with the left wing barely attached. The left wing separated from the aircraft which then impacted with the ground. A witness close to the Bluebell Railway line looked up to see the aircraft's left wing break away, the aircraft 'start spinning and spiral into the ground'. Other witnesses described both wings as folding upwards and rearwards prior to impact.

The accident was reported to the police at 1425 hrs. The other emergency services were alerted immediately and arrived on the scene within about ten minutes. The pilot and passengers however had all received fatal injuries in the impact. There were no reports received from the emergency personnel on the scene of any ice or snow adhering to the wreckage.

## Pathology

Post mortem examinations were conducted on all of the aircraft occupants. The results of examinations of the pilot and his front seat passenger showed that there was no evidence of any pre-existing disease which may have caused or contributed to the cause of the accident.

## Weather

An aftercast covering the time of the accident was obtained from the Meteorological Office, Bracknell. It described the synoptic situation at 1200 hrs as a shallow ridge of high pressure across southern England with a moderate, unstable, north-easterly airstream covering the area. The weather comprised slight snow showers, visibility of 20 km with scattered cumulus cloud at 2,500 feet and few stratocumulus clouds at 5,000 feet. The wind at the surface was 030°/10 kt, at 1,000 feet was 040°/22 kt and at 2,000 feet was 050°/25 kt. The mean sea level pressure was 1014 mb. These weather conditions made it suitable for a VFR flight, clear of cloud.

Rainfall radar and satellite imagery showed the isolated nature of the showers in the south-east of England. A witness close to the crash site reported experiencing a moderate snow shower with visibility on the ground reduced to a few hundred metres at the time of the accident.

The 'actual weather' recorded at London Gatwick airport at 1420 hrs was: surface wind 030°/09 to 20 kt, visibility10 km, showers in the vicinity with towering cumulus cloud, few at 3,000 feet, broken at 4,500 feet, temperature +4°C, dewpoint -7°C sea level pressure (QNH) 1014 mb. At 1350 hrs, 35 minutes before the accident, the conditions at Gatwick included a lighter surface wind of 10 kt with a visibility greater than 10 km and broken cloud at 4,000 feet.

The Gatwick Intermediate Director, located in the Terminal Control Room at the London Air Traffic Control Centre (LATCC), saw a primary radar contact approaching the Gatwick Control Area (CTA; an area extending from 1,500 feet to 2,500 feet amsl) from the south south-east. He monitored its progress, by selecting the zone boundary video map on his display, in case it infringed the Control Zone and came into conflict with departing traffic climbing out from Runway 08R at Gatwick. He noticed the radar contact turn away from the zone at a point close to the boundary. He reported that at the time several aircraft departing Gatwick, on the departure route that turns south 2.5 nm from Gatwick and routes west of East Grinstead towards Seaford, asked to delay their turn south to avoid weather in the East Grinstead area.

## Aircraft information

G-LIMA was a model 114 which carried the manufacturer's serial number 14415. It was constructed in 1978, and came on to the UK Civil Register in 1994, having previously been on the US Register. At its last Annual Inspection, in July 2000, it had accumulated 2,777.25 hours total flying time. It was fitted with a Lycoming I0-540 engine and Hartzell two bladed constant speed propeller. The last maintenance task had been a 50 hour check completed in December 2000. According to the maintenance records there had been only minor rectification work required in the last 12 months. The manufacturer's Service Bulletin SB-114-22C, which replaced the Main Landing Gear side brace fittings, was applicable to this aircraft and the requirements of that Service Bulletin were embodied.

The aircraft was certificated to Federal Aviation Requirements (FAR) Part 23, which requires, in the 'Normal' category, a limit load equivalent to 3.8g normal load factor. For certification purposes therefore, the fully factored load was 5.7 g (3.8g x 1.5). During development, the manufacturer had carried out static load tests on a specimen wing, under conditions of maximum Zero Fuel Weight (ZFW) and the most forward permissible Centre of Gravity (CG). In this test, a failure mode was experienced at 2.1 times the limit load (7.98g), well in excess of the requirements of FAR 23. The manufacturer made estimates of the weight and balance at the time of the accident and calculated that under those conditions wing failure would not occur below 2.3 times the limit load, in other words at 8.8 'g' and at a minimum speed of 179.5 knots.

**Weight and balance**

Calculations were made to determine the aircraft's All Up Weight (AUW) and Centre of Gravity (CG) position both at the time of takeoff from Shoreham and at the time of the accident. The weight of both front seat occupants was known but the weight of the two rear seat occupants was unknown, and had to be estimated. The results of calculations for both events showed that the aircraft was probably close to its Maximum Takeoff Weight Authorised (MTOWA), Max ZFW and CG limits.

**Pilot's operating handbook**

The pilot's operating handbook includes the following entries relevant to this accident:

(1) Airspeed Limitations

| Speed | IAS (kt) (Normal Category) | Remarks |
|---|---|---|
| Manoeuvring Speed ($V_A$) | 116 kt | Do not make full or abrupt control movements above this speed |
| Never Exceed ($V_{NE}$) | 187 kt (SL-12,500 ft) | Do not exceed this speed in any operation |
| Maximum Structural Cruising ($V_{NO}$) | 147 kt (SL-12,500 ft) | Do not exceed this speed except in smooth air and then only with caution |

(2) Manoeuvre Limits

**Unauthorised Manoeuvres**
Any other intentional manoeuvre which involves an abrupt change in the airplanes attitude, an abnormal attitude, or abnormal acceleration not necessary for normal flight

(3) Flight Load Factor Limits

Normal Category Limit Load Factor.........................Flaps Retracted: +3.8g to -1.52g

(4) Miscellaneous Emergencies

Inadvertent Icing Encounter
1. Pitot Heat........ON
2. Windshield Defrost - Pull ON
3. Engine RPM - INCREASE

WARNING - Evasive action should be initiated immediately when icing conditions are **first** encountered

4. Altitude - CHANGE to an altitude less conducive to icing.

NOTE - A climb is usually preferred, if practical.

5. Course - ALTER or REVERSE as required, to avoid icing.

NOTE - The likelihood of the induction air system icing is very remote; however, should icing occur, as evidenced by the loss of manifold pressure, the alternate induction air control should be placed in the HOT position.

6. Mixture - ADJUST, as required.

7. Approach Airspeed - INCREASE 5 to 20 KIAS depending on ice accumulation.

It was not possible, from the examination of the wreckage, to identify the pre-impact positions of the pitot heat switch or windshield defrost control.

**Examination of the wreckage**

The aircraft crashed in an open field with the wreckage spread over a distance of 400 feet in a north to south direction. The fuselage heading at impact was easterly. The impact speed was assessed as high, with the aircraft in a steep nose down attitude as it made contact with the ground. It had broken up extensively with the engine buried deep in the ground. Ground marks and relative degrees of damage indicated that the right wing, which had come to rest some 80 feet from the fuselage, was not attached to the fuselage at impact. It was apparent from the limited damage to the right wing that it had finally separated not long before the ground impact. Although several witnesses had stated that the left wing detached in flight, the left wing had travelled with the fuselage to the point of impact even though its major structural attachments were broken.

The main spar of the right wing had separated near the root, with all the breaks inboard of wing station (WS) 26.5 (right hand). The bottom spar cap had fractured at about WS 25 (right hand) in tensile overload, with some twisting. The top spar cap joiner plate on the aircraft centreline had failed in upward bending, reaching an angle (dihedral) of 30° to 40° before fracture. The spar web had collapsed on the left side of the fracture, and torn away on the right side. The left wing top and bottom spar caps had collapsed towards each other and rotated out of plane by about 20 degrees. There was evidence of compression buckling of the right wing top spar cap at WS 26, but this spar cap had not completely collapsed. There was also some compression buckling in the left top spar cap at about WS 8, combined with some bending rearwards at WS 26. Metallurgical examination of the fractures showed that overload conditions had caused the spar caps to break. There was no evidence of fatigue. Material hardness tests carried out on the spar caps and doublers found them to be of normal hardness. No evidence of control surface hinge over-travel was found on either wing, the fin, or the horizontal tail. Hinge cut-outs were not enlarged, and there was no corresponding damage at the edges of the control surfaces. The assembly of the main spar truss 'A' frame had been satisfactory with no pre-impact fretting or free play, and there was no evidence of any initiation of the wing break up from this area of the wing structure. None of the other wing attachments were loose or showed any evidence of relative movement or fretting.

Although the flight instruments were extensively broken up in the impact, it was possible to determine that the artificial horizon and turn and slip gyros had been running, apparently normally, at impact. From an analysis of light bulb filaments, no evidence of electrical power at impact was found, probably due to the system being disrupted in the air.

**Wing failure mode**

Witness observations of the aircraft during the later stages of its descent raised concerns over the wing break up such that a proposed safety recommendation was formulated to review the flutter substantiation of the aircraft. During the consultation phase, however, information that was not previously known was submitted by the manufacturer on previous flutter analyses and test results, and a recent review which they had commissioned through an FAA Designated Engineering Representative (DER). Using this data AAIB commissioned its own review, which concluded that the aircraft is free of wing flutter to speeds well in excess of the requirements. In addition the review showed that major damage to the wing spar and/or attachments was necessary before aeroelastic effects could arise, with divergence becoming the first likely effect, possible only after substantial damage had been incurred.

The manufacturer also submitted data and photographs of the wing upbending destruction test carried out for certification. This data showed that the initial failure mode was a buckling instability failure of the top spar cap inboard of wing stations WS 26.5. Elements of the buckling deformation were in a downward sense at about WS 10 and WS 26, with a reversed, upward element interposed. There was also a degree of rearwards deformation. The test was halted before further failures occurred.

Damage to the top spar cap of G-LIMA showed similar deformation in a downward sense at about WS 8 and WS 26, and similar but greater rearwards deformation. Other damage features within the wing structure were attributed to the fact that the wing on G-LIMA had progressed beyond the buckling instability failure of the top spar cap, to failure of the lower spar cap, the web, and the wing to fuselage attachments. The greater rearwards deflection was attributed to the continuation of the loads in flight. Loading of the wing spar from the centreline truss, imposed after failure of the main spar to fuselage frame joint with the upward movement of the right hand wing, would also produce greater rearward deformation of the spar upper cap.

**Analysis**

The aircraft left Shoreham and after proceeding along the coast turned northwards towards Biggin Hill. Its progress was unremarkable except that its track took it more to the west than might have been expected. If it had continued it would have significantly infringed the Gatwick Control Zone, coming into conflict with aircraft departing from Gatwick Runway 08R. At the Gatwick zone boundary however, G-LIMA carried out a very tight turn to the right. This may have been because of the pilot's late realisation that he was about to infringe controlled airspace. Calculations of bank angle based on radar information showed that a mean bank angle of 59° was required for the aircraft to carry out a level turn consistent with the radius of turn recorded.

Significantly the aircraft had also entered one of the few intense snow shower clouds in the area. The pilot's operating handbook warns of the need the take 'evasive action' should the aircraft inadvertently enter icing conditions. The aircraft had been in the cruise with an OAT of around 0° to -2°C. Thus the airframe may have been cold enough to accumulate ice. Ice accretion rates are normally too low for significant amounts of structural ice to form in the very short time that G-LIMA was in the cloud, however there exists the possibility, supported by anecdotal evidence, that wet snow can accumulate very rapidly in some cases. It is possible that on noticing contamination of the wings the pilot decided to turn steeply to return to more favourable weather.

The aircraft was seen to exit the area of weather a few moments later albeit recovering from a dive at 'treetop height'. Engine noise at that time was most evident to witnesses in the vicinity. This noise may have been propeller tip noise. Estimates made of propeller tip speeds showed that during a rapid descent at higher than normal speeds with significant power applied the blade tips could have reached high subsonic, or transonic, speeds thus creating a distinctive rasping noise. Also, the noises heard in the last moments before break-up may have been mechanical noises from the structure.

It cannot be determined why the aircraft entered such a rapid descent during the turn. There can be no doubt however that to achieve the observed flight profile it must have entered a significant dive followed by an aggressive recovery terminating in almost level flight just above the ground. One possibility is that, although having been trained to fly in cloud and holding an IMC rating, the pilot could have suffered some spatial disorientation whilst turning in the unusual flight conditions of falling snow. Such a phenomenon, caused during manoeuvres in areas affected by falling snow, is well known. Secondly, it is conceivable, though unlikely, that an accumulation of ice on the tail could have affected the control moments and response of the aircraft, thereby changing the pilot's 'feel' of the controls leading to a momentary loss of control.

AAIB calculations show that in a descent from the estimated height of 1,000 feet there was sufficient height change to permit acceleration of the aircraft beyond the design diving speed, VD (ignoring drag). At such a speed, manoeuvring to achieve the necessary radius of turn to recover from a dive could generate the total normal load factor required to break the wing spar. The manufacturer submitted calculations which showed that, for an initial speed of 148 KTAS, a 10° descent angle in a 60 degree bank, 2 'g' turn, sustained for 15 seconds, the speed would increase to 177.5 kts with an altitude loss of 723 feet. If the turn was sustained for 20 seconds, the speed increased to 217 kts. These speeds compare closely with the minimum speed of 179.5 kts for wing structural failure, and the design diving speed, VD, 207 kts.

The similarities between the wing failure and the wing destruction test carried out for certification are strong and show that the observed pattern of damage can be explained by a simple recovery manoeuvre, albeit involving high 'g' levels. The calculations show that the height loss in the descent would allow sufficient speed build up for such a recovery to cause structural failure in the manner of the wing destruction test. This, combined with the flutter investigations carried out by the manufacturer, the FAA DER and the AAIB, lead to the conclusion that the in flight break up was due to a recovery manoeuvre as the pilot attempted to pull up to avoid impact with the ground. The observations of the witnesses concerning unusual behaviour of the structure were made after major structural damage had been sustained in the pull up manoeuvre.

In the light of the work described above, it is considered that the intent of its previously formulated safety recommendation to review the aeroelastic behaviour of the aircraft has been met, and that the aircraft has been shown to conform with the relevant requirements.