No: 11/84 **Ref: EW/C876**

Aircraft type and registration:	Piper PA-28R-200 G-AZSE (Light single engined fixed wing aircraft)
Year of Manufacture:	1972
Date and time (GMT):	16 June 1984 at about 1200 hrs
Location:	1¼ miles north-east of Castlebay, Isle of Barra, Outer Hebrides
Type of flight:	Private (business)
Persons on board:	Crew — 1 Passengers — 2
Injuries:	Crew — 1 (fatal) Passengers — 2 (1 fatal, 1 serious)
Nature of damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence with Instrument Meteorological Conditions (IMC) Rating
Commander's Age:	53 years
Commander's total flying experience:	477 hours (of which 285 were on type)
Information Source:	AIB Field Investigation.

Synopsis

The aircraft was on a private business flight from Aberdeen Airport to the beach landing strip on the Isle of Barra, Outer Hebrides. The weather throughout the route across mainland Scotland was fine, however the destination area and the available diversion aerodromes in the Western Isles were covered in low cloud and rolling sea fog. After the aircraft passed the Very High Frequency Omni Range (VOR) navigation beacon at Tiree, a descent through cloud was commenced towards the beach landing area on the Isle of Barra, using a back bearing from the Tiree VOR for track guidance. The aircraft descended to a height of 500 feet above sea level where, although the surface of the sea was visible, the Isle of Barra and surrounding islands ahead were obscured by the low cloud and fog. An overshoot and climb away was initiated during which the aircraft struck the ground about 1¼ miles north-east of Castlebay, at a height of about 950 feet above mean sea level. The aircraft was destroyed.

The pilot and one passenger were killed as a result of the accident. The other passenger survived and was subsequently rescued by a Royal Air Force Search and Rescue Wessex helicopter and transferred to hospital. He had sustained multiple serious injuries.

History of the Flight

The pilot and his two passengers met at Aberdeen Airport on the morning of 16 June 1984 to prepare for a flight to the Isle of Barra. The pilot and one of the passengers had pre-arranged business appointments on the island, and it had been arranged that the other passenger, who held a current Private Pilot's Licence, would accompany them in order to fly the aircraft on the return flight back to Aberdeen. A route weather forecast and comprehensive briefing was obtained from the Aberdeen Airport Meteorological Office, and this indicated that the weather over mainland Scotland was generally fine, with no significant low cloud, but that the destination area and particularly the Western Isles were covered in low cloud and rolling sea fog, with cloud bases varying between the surface and 700 feet above mean sea level. After receiving the weather forecast, the pilot telephoned the Isle of Barra's operating authority representative in order to obtain an assessment of the actual weather conditions in the landing area. Three telephone calls were made. In the first two calls the pilot requested details of the weather, and on both occasions he was advised of the low cloud conditions. In the third call the pilot reported that the aircraft would shortly depart from Aberdeen Airport. A flight plan under Visual Flight Rules (VFR) was filed with Aberdeen Airport Air Traffic Control, and this included the routeing "Aberdeen — direct Tiree — direct Barra". The requested cruising level was 6000 feet (Flight Level 60) with a planned cruising speed of 120 kt, and the selected diversion aerodrome was Tiree. Prior to departure the aircraft had been fuelled to full tanks; the endurance entered on the flight plan was 4 hours. This was sufficient fuel for the aircraft to fly from Aberdeen to the Isle of Barra, and return back to Aberdeen. There are no re-fuelling facilities at Barra.

The aircraft took off from Aberdeen Airport at 1018 hrs with the pilot occupying the front left side seat, the passenger who was also a qualified pilot occupying the front right side seat, and the other passenger sitting in the rear. The flight across mainland Scotland proceeded normally, except that some difficulty was experienced in establishing satisfactory two-way radio contact with Lossiemouth Radar. As the aircraft approached Tiree, radar recordings have shown that it was about 5° north of the planned radial, but on a closing heading towards the VOR

overhead position. At this time the pilot requested details of the latest weather conditions at Barra.

He was advised that a scheduled passenger flight, LC 454, had recently departed Barra for Tiree, and could provide up to date weather information. The commander of LC 454 informed G-AZSE that the weather at Barra was bad, with sea fog and cloud covering the hills, but that he had been able to find a gap in the clouds to the north-west of the island through which he had been able to descend and make a visual approach. This information was acknowledged by the pilot of G-AZSE and, once visual separation from the other aircraft had been established, he commenced a descent towards Barra. Documentary evidence retrieved from the aircraft wreckage has revealed that it was the pilot's intention to descend, using the 341° radial from the Tiree VOR for track guidance and the Tiree Distance Measuring Equipment (DME) as an indication of range. The descent was planned at an indicated airspeed of 150 kt to be at a height of 500 feet above sea level at a range of 32 nautical miles from Tiree, and 5 nautical miles from the beach landing area at Barra. During the descent the passenger in the front seat gave the pilot height checks by cross-comparing the two altimeters. The passenger reports that, when the aircraft had descended to 500 feet, he could see the surface of the sea beneath them, but that the islands ahead were obscured by low cloud and banks of fog. He suggested an overshoot and climb away at maximum gradient. Full power was selected and the aircraft started to climb. Shortly after this the aircraft struck rising ground at a height of about 950 feet above sea level. The impact position was 3.2 nautical miles south-south-west of the beach landing area, and 35½ nautical miles from Tiree on the 338° VOR radial.

Meteorological conditions

An aftercast of the weather conditions prevailing at the time of the accident, prepared by the Meteorological Office, Bracknell, confirms that a ridge of high pressure and associated slack, moist south-south-west airflow covered the area. Surface winds were variable, mainly southerly, at five kt, and visibility varied between 20 kilometres and less than 500 metres in fog. The weather consisted of local fog patches over the sea and coasts, and extensive hill fog over land. The forecast landing conditions for Tiree aerodrome were:—

Surface wind 210°/05 kt. Visibility 2000 metres, drizzle. Cloud 4 oktas stratus at 200 feet, 8 oktas stratus 400 feet. Intermittently, visibility 400 metres, fog, cloud 8 oktas stratus 100 feet.

Aircraft wreckage examination

The aircraft had crashed into rising ground at an altitude of about 950 feet above sea level. It had been in normal flight, wings approximately level, and in a climbing attitude of slightly more than 15 degrees nose up. The wing flaps and landing gear were retracted, and damage to the propeller showed that the engine had been producing power. After the initial impact the aircraft had continued to slide up the hillside for a further 61 metres, suffering severe secondary damage due to successive collisions with the ground and protruding rocks. Both wings were detached and the fuselage was severly disrupted around the cabin area. The impact heading was 303° magnetic. There was evidence that there had been a substantial amount of fuel in the aircraft's tanks; more than half of the total capacity.

The aircraft had been structurally complete at the time of impact, and all the aerodynamic controls had been correctly attached. There was no evidence of any pre-existing defect to the controls or aircraft systems. Both pressure altimeters were set for a barometric pressure of 1023 millibars, which was the correct local setting at the time of the accident. The No 2 VOR receiver was tuned to 117.70 Mhz, which is the frequency of the Tiree VOR transmitter. The radial selector was set to 340°. The DME receiver, which was also tuned to the Tiree frequency, showed a reading of 35.5 nautical miles, which was an accurate measurement of the distance of the accident site from the radio beacon. The No 2 radio navigation receiver was removed from the aircraft for more detailed examination. On bench test it was found that the receiver was functioning, but that it was in error in the "From" mode by about 6° to the left of a selected radial. It was not possible to determine whether this error, seen on bench test, would necessarily have been present before the accident, due to the severe loads that the equipment had suffered at impact and also because there are sometimes differences in indication by such equipment between bench operation and installation in an aircraft. However it was established that on 21 May 1984, when the aircraft was being flight tested for a renewal of the Certificate of Airworthiness, the No 2 radio navigation receiver indicated an error of 4° in the same sense as the bench test error.

VOR total system limitations and accuracy

Recommendatons concerning the overall accuracy of the VOR system are detailed in Annex 10 to International Standards and Recommended Practices adopted by the International Civil Aviation Organisation. The Civil Aviation Authority at this time do not have a tolerance for VOR system accuracy which is more restrictive than these recommendations. The limitations applicable to the accident aircraft require an overall system accuracy of ± 6°, used on a 95% possibility basis, with maximum individual errors as follows:—

VOR radial signal error	± 3.0°
VOR airborne equipment error	± 4.2°
Pilotage error	± 2.5°

The Tiree VOR was last flight checked on 19 July 1983 when the mean error on both transmitters was zero and the standard deviation 0.4°. The CAA equipment specification for VOR receivers of the type fitted to the accident aircraft requires a bearing accuracy of ± 4° or better (95% probability). Although bench testing after the accident revealed an airborne equipment error up to 6°, it is considered likely that this was partly the result of impact disturbance or bench test error, and that in flight the actual bearing error was close to the 4° found on the last air test. In this case, although the equipment would have been within specification and serviceable, the pilot would have been seeing an 'on course' indication when the aircraft was in fact about 4° left of the selected radial. The accident site was 3.2° left of the planned radial.

Conclusion

Where VOR aerodrome approach procedures are approved, the published instructions include the minimum heights to be flown at successive stages in the approach, and a final obstacle clearance limit or minimum descent height is recommended. The calculation of these heights takes into account, amongst other things, the limitations and accuracy of the total VOR system. Where pilots are planning non-approved and non-standard aerodrome approaches using the VOR for guidance, it follows that it is essential for flight safety that they are aware of the possible inaccuracies of the system, and that a minimum safe height is considered, bearing in mind the local terrain. For an aircraft approaching Barra, the minimum safe height that would ensure a clearance of 500 feet above the highest ground within 5 nm of the beach landing area is 1760 feet.