Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Piper PA-34 (Seneca II) G-BFKO

Report on the accident at Beaulieu Heath, Hampshire, on 17 November 1979

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2 March 1981

The Rt Hon John Biffen MP
Secretary of State for Trade

The Rt Hon John Nott MP
Secretary of State for Defence

Dear Sir

I have the honour to submit the Report by Mr C C Allen, an Inspector of Accidents, on the circumstances of the accident to Piper PA-34 (Seneca II) G–BFKO which occurred at Beaulieu Heath, Hampshire, on 17 November 1979

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch

Aircraft Accident Report No. 7/80
(EW/E20)

Owner and Operator:	Skycabs
Aircraft: Type:	Piper PA-34 (Seneca II)
Model:	Series 200T
Nationality:	United Kingdom
Registration:	G–BFKO
Place of Accident:	Beaulieu Heath, Hampshire 50° 49′ 45″ N 01° 25′ 46″ W
Date and time:	17 November 1979 at 0448 hrs All times in this report are GMT

Synopsis

The accident was reported to the Department of Trade Accidents Investigation Branch by London Air Traffic Control shortly after its occurrence.

The accident occurred at night during an approach to land at Lee-on-Solent after a flight from Manchester. On the first approach the aircraft descended to 500 feet on the Instrument Landing System (ILS) and then overshot. The pilot later reported his position as over the LS non-directional radio beacon (NDB), at the ILS outer marker. He then attempted to make a second ILS approach, during which the aircraft crashed in thick fog onto Beaulieu Heath, about 9 nm west of Lee-on-Solent. The two occupants of the aircraft were uninjured.

The accident was caused by the commander permitting his aircraft to descend below a safe height without having established visual reference. Probable contributory factors were crew fatigue, the passing of an incorrect cloudbase to the commander, an unidentified radio transmission on or near the frequency of the outer marker NDB and the commander's attempt to follow false ILS back course signals.

1. Factual Information

1.1 History of the flight

The aircraft was engaged on a St John Ambulance Air Wing kidney flight (see paragraph 1.17.2). The commander was telephoned by St John Ambulance Operations at about 2330 hrs on 16 November 1979, with the request that a kidney be flown from Leeds to Portsmouth. He obtained some weather and air traffic information from Manchester Airport and, after St John's Operations had confirmed that the destination would be Lee-on-Solent, advised his co-pilot of the flight.

The pilots arrived at Manchester Airport at about 0100 hrs on 17 November where the kidney, which had come by road from Leeds, was handed to them at about 0130 hrs. The commander filed an Instrument Flight Rules (IFR) flight plan to the Royal Naval Air Station at Lee-on-Solent, the facilities of which were to be opened especially for the flight. He later telephoned Manchester Tower and obtained a weather report from Lee-on-Solent, which included a visibility of 10 kilometres and 2/8 cloud at 3,000 feet.

Due to very low temperatures, trouble was experienced in starting the aircraft's engines, which resulted in a flat battery. The engines were finally started with external power. Because of this the take-off did not take place until 0334 hrs, by which time the visibility at Manchester had decreased to 250 metres. After take-off the commander was told by Manchester Air Traffic Control (ATC) that there had been no significant change in Lee-on-Solent's weather. The flight, on airways at flight level 90 to Lee-on-Solent, was unremarkable. During the flight the 75 MHz marker beacon receiver was tested and the marker lights functioned correctly. On contacting Lee-on-Solent Tower at about 0432 hrs the aircraft was cleared to descend to 3,000 feet to the LS NDB, positioned at the ILS outer marker for Runway 23 (see Appendix 1, a copy of the Jeppesen ILS approach chart as used by the commander). The co-pilot tuned the automatic direction finder (ADF) to the frequency of LS (407 KHz) when the aircraft was about eight miles out and the signal and call sign were quite clear. The commander later received clearance to make a direct ILS approach to Runway 23 and was passed a weather report which, according to the controller, included a visibility of 5 kilometres and a cloud base of 8/8 at 2,500 feet. After the accident the commander stated that he had understood the cloudbase to be 1/8 at 3,000 feet, information which he had repeated back without receiving any subsequent correction.

Whilst en route the aircraft had been flown on the autopilot in the 'heading' mode with the pitch channel disengaged. The commander decided to continue using this mode for the approach. He made most of the frequency changes on the radio and navigation equipment himself and also handled the radio communications.

The commander has said that he intercepted the ILS localiser when the aircraft was above the glidepath. After making a fast descent the aircraft entered cloud at about 2,000 feet and then intercepted the glidepath. It was fully established on the ILS on passing LS (ADF indication) at the correct height of 1,638 feet QFE (1009 mbs). The aircraft descended on the ILS to 500 feet at which point, being still in cloud and having no visual reference, the commander decided to level off. He maintained 500 feet

until he judged he was well past the aerodrome, still with no visual contact, and then took overshoot action. During this approach he had heard the outer marker aural signal, but did not obtain a visual marker light indication of its passage, nor did he have either a visual or an aural signal at the middle marker.

The aircraft's lights were seen, in and out of cloud at about 500 feet, by personnel in the Tower, as the aircraft passed across the aerodrome, north of the runway centre line.

Following the aircraft's passage across the aerodrome the commander told the Air Traffic Control Officer (ATCO) that he was holding 500 feet and later that he was returning to LS for a further ILS approach. The aircraft was cleared to LS, to climb to 2,000 feet. The ATCO estimated that there was a 2½ minute time interval between the aircraft's passage across the aerodrome and his clearance. According to the commander he then made a climbing turn to the left and took up a northerly heading to home onto LS on the ADF. The co-pilot said that after the overshoot and during the return to LS he checked the callsign again and received LS 'loud and clear'. This was the last time he checked LS. According to the commander the aircraft passed LS on the required heading for the procedure turn. During the passage towards and over LS the commander used only the ADF indication and did not watch the ILS; he neither saw nor heard an outer marker signal. After making the procedure turn, he changed the autopilot mode selector from 'heading' to 'localiser normal' as the aircraft approached the localiser, intending to make an autopilot-coupled ILS localiser approach. The aircraft immediately started to roll from side to side, with bank angles of up to 20°, so he disengaged the autopilot and assumed full manual control. He intercepted the localiser and glidepath, and on passing LS (identified by a 180° swing of the ADF pointer) called 'marker inbound'; at this stage the aircraft's configuration was: landing gear down, 10° flap, landing lights on. The commander has stated that the aircraft was central on both localiser and glidepath. He did not make a time check on passing LS nor did he see the visual or hear the aural outer marker signal. Soon after passing LS the ILS localiser needle moved fairly quickly to show an almost full-scale deflection to the right. The commander turned the aircraft about 15° to 20° to the right and continued descending with an 'on glidepath' indication, but still with an almost full right deflection localiser indication, until he reached his previously determined decision height of 260 feet QFE; he did not see or hear the middle marker. He said that at 260 feet he levelled the aircraft and that almost at the same moment it hit the ground. The aircraft crashed in thick fog on Beaulieu Heath, about 9 nm west of Lee-on-Solent, at 0448 hrs, and on a track of 268°M. The ground elevation was 131 feet. Both crew members climbed out of the wreckage unhurt.

1.2 Injuries to persons

None.

1.3 Damage to aircraft

The left wing was detached from the fuselage which was only slightly damaged; all the landing gear units were broken.

1.4 Other damage

None.

1.5 Personnel information

1.5.1 *Commander:* Male aged 52.

Licences: United Kingdom (UK) Private Pilot's Licence rated for Groups A and B.
Night rating.
IMC rating issued 1 April 1968, not subsequently renewed.

United States of America (USA) Private Pilot's Certificate rated for airplane single and multi-engine land.

Medical certificate: UK Class 3. Issued on 28 February 1979 and valid at the time of the accident.
USA Class 2. Issued on 6 June 1979 and valid at the time of the accident.

Instrument rating: USA rating issued on 1 November 1974 and valid at the time of the accident.

Most recent certificate of experience: 4 July 1979.

A biennial flight review, a currency requirement for the USA pilot's certificate, was satisfactorily made on a single engine aircraft on 4 July 1979. This review included instrument flying but not an instrument approach.

Flying experience:

Total hours –	1,848 (95 night)
Total hours instrument –	303
Total hours PA–34 –	289 (13 night).

The commander's USA Private Pilot's Certificate, issued on the basis of his UK PPL, was deemed valid under Article 19(3) of The Air Navigation Order 1976 (ANO)*. He had also passed the required tests for the issue of a USA instrument rating on a single engined aircraft in December 1972 and had maintained its currency. Consequently the commander's USA pilot's certificate with instrument rating was in order and was applicable for the conduct of this IFR flight.

**Article 19(3) of the ANO states, inter alia: For the purpose of this Article, a licence granted under the law of a Contracting State other than the United Kingdom purporting to authorise the holder thereof to act as the member of the flight crew of an aircraft, ... shall be deemed to be a licence rendered valid under this Order but shall not entitle the holder to act as the flight crew of any aircraft flying for the purpose of public transport or aerial work or on any flight in respect of which he receives remuneration for his services as a member of the flight crew.*

1.5.2	*Co-pilot:*	Male aged 50.
	Licence:	Private Pilot's Licence rated for Groups A and B.
		Night rating.
		IMC rating renewed on 18 May 1979.
	Flying experience:	Total hours – 1,278
		Total hours PA–34 – 17 (co-pilot)

1.5.3 Both pilots had carried out a full day's office work before being called out at about 2330 hrs the previous evening.

1.6 Aircraft information

Manufacturer:	Piper Aircraft Corporation, USA
Date of manufacture:	1977
Registered owner:	Skycabs
Certification of Airworthiness:	Transport Category (Passenger) valid until 28 March 1982
Total airframe hours	266
Flying time since last check:	1 hour 14 minutes (accident flight)
Engines:	Two Continental TS10–360–E
Weight at take-off:	4,239 lb
Estimated weight at time of accident:	4,059 lb
Maximum weight authorised:	4,570 lb
Estimated C of G at time of accident:	87.76 inches aft of datum
C of G range applicable:	86.8 to 94.6 inches aft of datum
Fuel remaining at time of accident:	554 lb (77 gallons) Avgas 100LL

1.7 Meteorological information

The commander telephoned Manchester Airport's Meteorological Office at about 2335 hrs on 16 November for weather information. He was given a very general briefing to the effect that, with predominantly clear skies and a slackening pressure gradient, there was a risk of fog not only at Manchester but also in the Midlands and the south of England. He was also given a number of actual reports which included the following:

	Gatwick 2250 hrs	Southampton 2300 hrs
Visibility:	3,000 metres	5,000 metres
Cloud:	5/8 stratus 900 feet 8/8 stratus 1,200 feet	3/8 stratocumulus 3,000 feet

Forecasts for Birmingham and Gatwick were also quoted, indicating the probability of foggy conditions.

On his arrival at the airport the commander telephoned Manchester Tower at about 0200 hrs and was given a weather report which Lee-on-Solent ATC had previously passed to Manchester ATC, this was:

Wind: 010° 07 knots, Visibility: 10 kilometres, Cloud: 2/8 stratocumulus 3,000 feet.

Following the aircraft's take-off at 0334 hrs, Manchester ATC telephoned the take-off time to Lee-on-Solent ATC and, according to the Manchester controller, was told the weather was: Wind: calm, Visibility: 10 kilometres, Cloud: 2/8 3,000 feet. The controller then informed the aircraft that there had been no significant change in Lee-on-Solent's weather. However according to the Lee-on-Solent controller he had passed to Manchester the 0300 hrs observation which was: Wind: calm, Visibility: 5 kilometres, Cloud: 8/8 3,000 feet.

When the commander contacted Lee-on-Solent on radiotelephony (RTF) at about 0432 hrs he was given the 0400 hrs observation which, according to the controller, included: Wind: calm, Visibility: 5 kilometres, Cloud: 8/8 2,500 feet, QFE: 1009, QNH 1010. The commander understood and recorded the cloudbase as 1/8 at 3,000 feet. The misunderstanding of the actual cloudbase and amount passed cannot be resolved since no RTF recording was in operation at the time.

The 0500 hrs observation was almost identical to the 0400 hrs observation (the pressure had risen very slightly).

According to the evidence of the crew, the aircraft descended to 500 feet on their first approach without obtaining visual reference. The lights of the aircraft were seen on this approach by personnel in the tower, who stated that it flew across the aerodrome at about 500 feet in and out of cloud.

The officer in charge of the Meteorological Office at Lee-on-Solent later reported:

> 'On the morning of 17 November 1979 the cloud searchlight at RNAS Lee-on-Solent was unserviceable and the height of the cloudbase was assessed by estimation.
>
> The weather at 0500 hrs was overcast, the wind calm and the relative humidity 100%. When it became light two hours later the cloudbase was estimated at 1000 feet, with no wind and a relative humidity of 100%.

I have no doubt that the cloudbase of 2,500 feet estimated at 0500 hrs was a serious error, and that in the light of the cloud conditions two hours later a cloudbase of between 500 and 1,000 feet would have been the likely base at 0500 hrs. Unfortunately, without the searchlight, and in the absence of any reference points for an estimation of the cloudbase at night in overcast conditions depends on the experience and knowledge of the observer'.

Aerodrome actual weather reports (METAR and SPECI), made by meteorological offices at civil aerodromes and passed to ATC for dissemination to pilots, include the letter 'E' with the information on cloudbase, when the cloudbase has been estimated rather than measured. There is no requirement for this procedure to be followed at Lee-on-Solent, because it is a Naval Air Station.

An aftercast prepared by the Meteorological Office at Bracknell, covering the period 0300 hrs to 0600 hrs, included the following:

> Fog had formed at Bournemouth (Hurn) Airport by 0400 hrs and mist had reduced the visibility to 2,000 metres in central Southampton (at the Weather Centre).
>
> It seems probable that during the period between 0400 hrs and 0450 hrs when G–BFKO was in the area there were thick fog patches below the aircraft as it descended. These fog patches would continue over Beaulieu Heath with a horizontal visibility of some 300–600 metres. The fog layer at that time would not have been particularly thick.
>
> Along both sides of Southampton Water and extending inland from the estuary for about 1 kilometre the visibility improved to 3 to 5 kilometres and there is evidence of broken stratocumulus cloud with base 2,000–2,500 feet.

The accident occurred at night.

1.8 Aids to navigation

1.8.1 On the ground

The radio navigational aids at Lee-on-Solent Aerodrome consisted of the following:

(a) ILS for Runway 23 on 110.1 MHz, callsign LS, (the localiser is offset 4°, localiser beam 228°, runway centreline 232°) with outer and middle marker beacons operating on 75 MHz.

(b) An NDB on 407 KHz (AOA2), callsign LS, located at the same position as the ILS outer marker, 5.1 nm from the threshold of Runway 23 and which has a promulgated coverage* of 10 nm.

These aids were operating and serviceable.

**Promulgated coverage is the area surrounding an NDB within which the field strength of the vertically polarized component of the ground wave exceeds seventy microvolts per metre.*

(c) Solent Radar. This was not manned because the contract requirement for the emergency opening of the aerodrome outside normal hours, is to provide one ATCO and one assistant. As the radar is not remoted into the Control Tower the ATCO can act as Approach and Aerodrome Controller only. (The Air Traffic Control at Lee-on-Solent is operated by civilian employees under contract).

Additional information relating to the ILS and NDB installations is as follows:

(a) The ILS

The ILS installation at Lee-on-Solent is a Pye FGRI 18017-BILS, which is designed to be used in the front beam sector only. Technical trials of a similar installation were carried out at Bovingdon in 1956, which included air checks of field strength and differences in depth of modulation (DDMs) around a complete orbit. The results of the checks, in graphical form, are at Appendix 2, Figures 1 and 2. It can be seen from Figure 1 that the field strength behind the localiser transmitter is, as one would expect, markedly reduced compared with that of the front beam. Figure 2 shows that there is an unflyable false back beam on the localiser, which is nominally the reciprocal of the front beam and at Bovingdon was found to be at 173°. In addition there are two unflyable localiser false courses, each at 100° to the front beam. Between the 100° false courses and the back beam lie regions in which the received signal is of opposite sense to that received in the regions between 100° false courses and the front beam. Consequently an aircraft flying inbound to the right of the front beam would receive the correct indication to turn left. However, on passing the localiser transmitter, it would receive an indication to turn right. In the back beam region it is possible to receive glidepath signals, giving a fly up or fly down indication, which bear no relation to the position of the aircraft relative to the glidepath transmitter. The ILS localiser false courses, in addition to the front beam, have been plotted on the chart at Appendix 3.

A post-accident flight inspection of the ILS installation was carried out on 19 November 1979 by the Support Command Flight Checking Unit of the Royal Air Force. All readings were found to be within the limits specified other than that for the bottom edge of the glidepath, which was marginally out of limit.

Advice from the Radio Society of Great Britain on anomalous propagation of radio-waves during the early morning of 17 November 1979 includes the following information:

> 'The refractive index gradient at Crawley (the nearest available upper air station) was quite normal for the time of year overall but the lower 2 millibars. Between 990 and 988 millibars there was a steep gradient associated with ground fog. This would produce enhancements at VHF and UHF on paths where both the transmitting and receiving aerials were within the moist air'.

(b) The NDB

The frequency band of 405 KHz to 415 KHz is allocated for maritime direction finding. This band is not normally used by the UK and its use for purposes other than direction finding is contrary to national regulations; however, ships do have the capability to transmit relatively high power in this band. If such a transmission occurred it would probably be on the frequency of 410 KHz. At the time of the accident a number of vessels were berthed at the Fawley Oil Refinery, near witness B (see Appendix 3).

A frequency for the LS NDB in the 405 KHz to 415 KHz band was assigned to the Royal Navy in 1969 by the National Frequency Committee responsible for such assignments, in the knowledge that this was a shared frequency band but that no other more suitable assignment was available.

The National Air Traffic Service states that, up to the date of the accident, there is no record of the frequency (407 KHz) being unsuitable due to interference from any other radio service and there have been no reports of unusual effects during the 12 years the beacon has been in operation. It has also been confirmed that there could be no possible interaction with power line carrier (PLC) systems as there is no frequency higher than 210 KHz in use in the vicinity.

Between August 1979 and April 1980 the CAA Pailton Radio Measuring Station took 173 readings of the field strength of LS NDB; these measurements show that LS has a history of erratic behaviour. On 20 December 1979 a special ground check was carried out using a mobile facility. The checks showed that the level of the LS signal was some 5-6dB below nominal, except for momentary increases to nominal. At this lower level, an adequate signal would be achieved at about 7 nm instead of 10 nm. The checks started at night, before dawn, and the transition from night to day conditions produced no measurable effect on the LS signal.

1.8.2 In the aircraft

The aircraft was equipped with two VHF communication transceivers, two VHF navigation receivers, a 75 MHz marker beacon receiver, a single distance measuring equipment (DME), an automatic direction finder (ADF), a radar transponder and an area navigation system; the latter utilises VOR and DME signals to establish electronic waypoints from which the aircraft's bearing and distance can be determined.

The No 1 VHF navigation receiver was found selected 'on' and set to 110.1 MHz (the Lee-on-Solent ILS frequency). On subsequent tests it operated within specification, apart from a delay in 'lock-on' of up to 20 seconds after a change of frequency, attributed to a frequency synthesiser defect.

The No 2 VHF navigation receiver was found selected 'off' and set to 110.1 MHz; it operated satisfactorily. The co-pilot was certain that the equipment had been functioning during the approach. However, the commander had re-entered the aircraft after the accident in an unsuccessful attempt to contact Lee-on-Solent and had probably switched off the No 2 VHF navigation receiver at that time.

Both glidepath receivers operated within specification.

The marker beacon receiver was found set to 'low' and functioned satisfactorily.

The DME was checked and found satisfactory, apart from a small error on the indicated groundspeed display.

The ADF was found set to 407 KHz (the LS NDB frequency) and selected to ADF. It operated within specification in all respects apart from a small error in indicated bearing at 799 KHz. A check of the ADF response to an incoming 410 KHz signal with the ADF tuned to 407 KHz showed that the indicator would respond when the incoming signal strength was of the order of 400 microvolts/metre. This suggests that a normal marine transmission in the frequency band 405 to 415 KHz could break through on an ADF receiver tuned to 407 KHz and cause an erroneous bearing indication.

The radar transponder had been unserviceable since the take-off from Manchester.

The area navigation system, (used en route only), was checked satisfactorily and showed maximum errors of some 3 nm along track and 2 nm across track.

The ADF, VOR/ILS and marker aerials were checked satisfactorily; their associated looms were checked for electrical continuity and found satisfactory.

1.9 Communications

Satisfactory VHF communications were established between the aircraft and the various ATC units from the time of take-off at Manchester until shortly before the time of the accident and RTF transcripts of some of the communications were made. The last communication from the aircraft was at the time the commander reported passing 'marker inbound' during the second approach. At Lee-on-Solent the emergency VHF radio equipment was in use because of the unscheduled opening of the aerodrome. Due to an oversight, the speech recorder was left connected to the main VHF communications equipment. Consequently no recording of the communications between the aircraft and Lee-on-Solent Tower was made.

1.10 Aerodrome information

Lee-on-Solent Aerodrome is a Royal Naval Air Station, situated 3 nm west-northwest of the town of Gosport. It has an elevation of 32 feet and there are three asphalt runways, 17/35, 10/28 and 05/23; the aircraft was making an approach to the latter runway in a southwesterly direction. Runway 23 has a length of 1,325 metres; there is no approach lighting. At the time of the accident the runway lights were at medium intensity (maximum setting). The ILS approach chart for Runway 23 at Lee-on-Solent is at Appendix 1.

1.11 Flight recorders

There was no requirement for flight recorders and none were fitted.

1.12 Wreckage and impact information

1.12.1 Site examination

The aircraft had crashed on New Forest heathland, coming to rest 10 metres east of the B3054 road, one and a half miles from Beaulieu. The first ground marks were found 230 metres east of its final position and consisted of wheel-tracks and propeller blade slash-marks; the wheel-tracks ran in a direction of 268°M. Shortly before coming to rest the aircraft had pivoted sharply to the right onto 323°M. The initial nosewheel track started 2 metres before the mainwheel tracks and indicated a very slight pitch down attitude, with the aircraft laterally level. The nosewheel and both main landing gear doors were found at the beginning of the wreckage trail and fragments from the wings and nose area were found towards the end of the trail; the remainder of the aircraft was found intact at its final position.

1.12.2 Airframe

Both the main landing gear legs as well as the nosewheel, which were locked down before ground contact, were broken and the aircraft was resting on the under-fuselage. Apart from the nose section, which was broken away, the fuselage was only slightly damaged. The left wing had almost separated from the aircraft and its integral tank had lost a considerable quantity of fuel.The right wing was almost undamaged and its fuel tank was intact. The tail unit was not damaged. Examination of the flying controls and trims revealed no evidence of any defects before impact.

1.12.3 Propellers

Evidence of high speed rotation of both propellers was present from ground slashes, scored blade tips and nicked leading edges. Examination of the engines was not considered necessary.

1.12.4 Electrical system

Both alternators were bench checked and found satsifactory. Examination of the aircraft battery indicated that it was in a fully charged condition at the time of the accident.

1.12.5 Flight instruments

The main altimeter was found set to 1009 mbs (QFE), and the standby altimeter to 1010 mbs (QNH). They and the airspeed indicator were subjected to calibration checks. The main altimeter was within limits up to 35,000 feet. The standby altimeter was outside limits up to 20,000 feet, tending to underread by 30 to 60 feet below 1,000 feet and continued to underread at all heights above this. The airspeed indicator suffered slight errors of a maximum of 2.5 knots between 80 and 160 knots on increasing airspeed, and +4 to +2.5 knots between 120 and 90 knots on decreasing airspeed. The pitot/static system was visually satisfactory, apart from impact induced damage.

The artificial horizon was tested and found to be within specification; scratches were found on the rear lower base of its casing.

Examination of the Edo-Aire navigation situation display instrument, (No 1 VHF navigation receiver), showed it to have sustained damage to the upper/rear area of its outer case. This was probably caused by contact between the case of the artificial horizon, situated above, and that of the navigation situation display, situated below, during the accident sequence. The damage 'shorted out' some slip rings located below this area causing an electrical failure of the associated diode. Upon renewing the diode the unit operated satisfactorily except that the glidepath pointer was sticking on the raised zero deflection datum. This fault was considered to have been caused by the crash damage, which had stretched the forward lower chassis area, effectively increasing the distance between the glidepath galvanometer pointer arm pivot and the graduated display scale, causing the pointer to foul on the datum. No calibration checks were therefore carried out on the glidepath pointer although all other checks were satisfactory. These included checks on the glidepath flag currents, which were within specification.

The second VOR/ILS instrument, a Collins IND-351, (No 2 VHF navigation receiver), was on the co-pilot's panel. This was checked and found satisfactory in all respects.

1.12.6 Flight control system

The autopilot mode selector panel and the radio coupler unit were checked and found to operate satisfactorily.

Examination of the computer/amplifier unit revealed that the end-plate was loose; it was concluded that this had no bearing on the cause of the accident. Apart from a 2 to 3 second delay in response to heading or roll commands to the left, the unit was satisfactory in all other respects.

Both roll and pitch servos were tested satisfactorily.

Discussions with the autopilot manufacturer's agent in the UK, on the reported 20° oscillation in bank apparent on engagement of the autopilot in 'localiser normal' mode, indicated that the amplifier was limiting roll response to 20° (its maximum limit) in response to a command rather than a defective component. Such oscillations would occur if the aircraft overflew the transmitter, or if the radio navigation set was re-tuned whilst the auotpilot was coupled. It would also occur if the aircraft were flying in the overlap area of localiser transmitted signals of opposite modulation, (ie in the back beam reverse signal region of the ILS localiser).

1.13 Medical and pathological information

The Royal Air Force Institute of Aviation Medicine has given the following advice on the possible extent to which pilot fatigue may have contributed to the accident:

> The accident occurred at 0448 hrs, and thus the question of whether fatigue and circadian effects predispose the individual to human error or a reduced level of performance is raised. A clear distinction must be made however between fatigue and circadian rhythm effects. The pilot of this aircraft can reasonably be assumed to have been fatigued in that he had been awake and working during the previous day and into the night (solving irritating problems associated with starting the aircraft) when he would normally have been asleep. This level of sleep deprivation,

of say five hours, combined with his prior activities could not have improved his performance.

However, probably a more important consideration is the effect of circadian rhythms on performance. These effects are summarised in Appendix 5. The salient points are that human performance varies considerably during the course of twenty-four hours, and that the nadir of this curve of performance occurs at 0400–0600 hrs. This deterioration affects performance on a wide range of cognitive and psychomotor tasks, paralleling the circadian change in body temperature (which is also lowest at this time in the morning).

Some studies have attempted to relate the incidence of accidents to time of day and hence daily body rhythms; some of these are referred to in the appendix. However, interpretation of these results is difficult because there are, of course, many factors other than circadian effects which cause accidents. Nevertheless the studies do generally support the contention that the circadian change in performance does partially determine the accident rate and thus this effect cannot be disregarded with respect to this particular accident.

1.14 Fire

No fire occurred.

1.15 Survival aspects

Following the last call, 'marker inbound', from the aircraft ATC received no reply to further calls, nor any report of the aircraft having landed. The controller therefore took overdue action at 0500 hrs and informed the appropriate authorities accordingly. He was advised at 0529 hrs, by the police, that the aircraft had been found.

Both pilots were wearing upper torso restraint harnesses and neither suffered any injury following the ground impact. After the aircraft came to a stop they exited via the front right door and found they were very close to a main road (B3054). After stopping a passing van, the driver of which informed the local police at Hythe, they were picked up by a police car at 0537 hrs; a second police car took the kidney, which was undamaged, to Portsmouth Hospital.

1.16 Tests and research

A flight test of the Lee-on-Solent ILS in a Seneca aircraft was made on 13 December 1979. On his first approach the pilot captured the glidepath from above and found the glidepath signal erratic. The localiser signal was steady. The aircraft's height, just short of the runway threshold, was 500 feet. The pilot had the impression that the aircraft had been following a false glidepath lobe. On the second approach the glidepath was captured normally and the aircraft passed the outer marker at the correct height. The ILS signals were followed up to a point midway between the outer and middle markers, when the aircraft was turned onto a heading of 260°M, tracking between Fawley Power Station and Oil Refinery. Once past the ILS transmitter the localiser indicated 1½ dots fly right and the glidepath fluctuated about the 'on glidepath' position.

A further test flight at Lee-on-Solent was carried out on 28 January 1980 in a Wessex 5 helicopter of the Royal Navy.

On his first run the pilot followed the localiser, at a height of 1,400 feet QFE, from the LS NDB until turning right to intercept a track of 268°M to the crash site. Height was maintained until a simulated glidepath from the crash site was intercepted. Descent at 300 feet/minute was then initiated and maintained to a hover height of 50 feet over the crash site. The localiser indications were correct until passing abeam the localiser transmitter, where the indication was reversed; after passing overhead Warsash a full scale deflection to the right was maintained until the aircraft descended through100 feet. At this height the localiser 'off' flag appeared. The glidepath indications appeared correct until the aircraft was midway across Southampton Water, where the 'off' flag appeared and the indication changed from a two dot fly up to a gentle but variable fly down signal. The fly down signal was maintained to a 50 feet hover at the crash site.

On the second run the aircraft was positioned over the ILS middle marker on a heading of 360° at 1,400 feet QFE. From this position it made a standard procedure turn, but the turn was adjusted in order to position the aircraft on a track parallel to the localiser but displaced to the northwest by ½ nm. This track was maintained until passing abeam the localiser transmitter where the aircraft was turned right onto a direct track to the crash site. Height was maintained up to a point from which a continuous descent at 300 feet/minute could be made to a hover height of 50 feet at the crash site. The localiser indications were normal until passing abeam the localiser transmitter, where, before passing Hill Head, the localiser indications were reversed and a full fly right signal was maintained until the aircraft descended through 100 feet; the localiser 'off' flag then appeared. The glidepath indications were considered to be appropriate to the aircraft's position until it passed Calshot. At this point the glidepath 'off' flag appeared and a gentle but variable fly down signal was maintained down to the 50 feet hover over the crash site.

Additionally, test flights were made both by the Civil Aviation Flying Unit (CAFU) and by a special contract aircraft to attempt to determine possible sources of interference to LS NDB in the Fawley area. During the period of these test flights no interference on the frequency of LS was found.

1.17 Additional information

1.17.1 Witnesses evidence

On its first approach the lights of the aircraft were seen by the Tower personnel, and the aircraft was heard by a number of other witnesses to pass close to the aerodrome, a little north of the Runway 23 centreline.

The ATCO said that there was then a time interval of about 2½ minutes before the pilot reported he was returning to LS for another approach.

A summary of the evidence from a number of other individual witnesses who could have heard and one witness who could have seen the aircraft following its overshoot, is as follows:

Ear witness A (see Appendix 3) said: 'I was awoken at about 0445 hrs by the sound of a low flying light aircraft flying over my house from the direction of Calshot.'

Ear witness B, who was working at Fawley Oil Refinery, said: 'At approximately 0430 hrs to 0445 hrs I heard the noise of a light aircraft pass overhead, I could not see it because of fog. The aircraft passed again overhead within five minutes. On neither occasion could I determine its direction.'

Eye witness C said: 'At about 0445 hrs to 0450 hrs I was outside my house and heard the loud sound of an aircraft engine. I looked in the direction of the noise, approximately west, and saw a flashing white aircraft light.* It passed very close to my house and disappeared in an easterly direction.'

Witnesses D, E and F heard the sound of an aircraft as it passed very close to them, shortly before the time of the accident.

A thorough investigation revealed no evidence that any other aircraft was in the vicinity of Lee-on-Solent or Southampton near the time of the accident.

1.17.2 St John Ambulance Air Wing

The St John Ambulance Air Wing is a voluntary service which operates a scheme utilising experienced pilots, who own or have access to suitable aircraft, to undertake urgent delivery flights of kidneys to centres where kidney transplant operations are undertaken,

The minimum qualifications required for pilots to participate in the scheme are:

500 hours as pilot in command

Night rating

IMC rating; preferably full instrument rating.

Recruitment to the scheme is biased towards pilots of twin engine aircraft, which should be equipped with full radio, navigation and approach aids. It is a requirement of the Air Wing that for night flights a twin engine aircraft shall be used, crewed by two pilots.

The life of a kidney when removed from the donor is limited to the extent of about ten hours. Speed of delivery to the recipient is, therefore, vital. However it is the pilot's decision, after considering aircraft and pilot capability and the weather, whether he undertakes a mission or not.

Since the commencement of the scheme in 1972 and until September 1979, 382 missions have been accomplished, of which the commander involved in this accident had made 7 prior to the accident flight.

**Note: the accident aircraft was fitted with strobe lights*

1.17.3 *Instrument rating requirements*

The knowledge, experience and examination requirements for the issue of a USA instrument rating as described in Federal Aviation Regulations, part 61, are broadly similar to the requirements for the issue of a UK instrument rating.There are however two significant differences, one being that in the USA a pilot does not have to complete an instrument rating test in a multi-engine aircraft to gain multi-engine privileges on an instrument rating, whereas in the UK the Civil Aviation Authority (CAA) insist that he does. The other difference is in the command time requirement, in the USA 100 hours is required whereas in the UK the requirement is for 150 hours. The holder of a USA instrument rating has to show logbook evidence of at least six hours' instrument time, including at least six instrument approaches in the past six months, to maintain the privileges of his instrument rating. The holder of a UK instrument rating is required to pass an appropriate test every thirteen months on his ability to fly on instruments, to maintain the privileges of his instrument rating.

The CAA sent out a Letter of Consultation in May 1979, followed by a Letter of Intent in March 1980, proposing an amendment to Article 19(3) of the ANO. The proposal would exclude from the provisions of the article the right of the holder of a non-United Kingdom licence which includes an instrument rating, to pilot a UK registered aircraft in controlled airspace under circumstances requiring compliance with the Instrument Flight Rules (IFR).

2. Analysis

2.1 Introduction

The examination of the wreckage and the pilots' evidence with regard to the aircraft's performance and handling characteristics established that there were no defects in the airframe, flying controls, engines or flight instruments. In addition, tests of the radio navigation equipment showed that it was all in correct working order, apart from the transponder, the unserviceability of which did not affect the cause of the accident. Although the aircraft's battery had been discharged during the difficulty in starting the engines at Manchester, it had been re-charged during flight to the extent that sufficient electrical power was available for the proper operation of the radio navigation equipment. The cause of the accident must therefore be attributable elsewhere.

2.2 Reconstruction of the flight path (see Appendix 3)

The assessment of the sequence and of the time of the principal events of the flight given in Appendix 4 indicates that if the aircraft returned to LS following the overshoot, the derived time of the accident, namely 0456.30 hrs, is far too late; the electric clock in the aircraft, which stopped at the time of impact, indicates that the accident occurred at 0448 hrs. Consequently it would appear that the aircraft did not return to LS.

In addition to the recollections of the crew, whose ideas of the time sequences involved were vague, account has to be taken of the witnesses who heard or saw the aircraft. From their evidence it appears that after overflying the aerodrome, slightly north of the runway centre line (at approximately 0438.30 hrs), the aircraft turned right onto a westerly heading. This is considered feasible because the aircraft, overshooting close to but north of the false back beam of the ILS localiser, could expect to receive a fly right signal because of the localiser region in which the aircraft was then positioned. If the commander followed this indication during the overshoot he could well have turned sufficiently to the right to finish on a westerly heading. Ear witness A would have then heard the aircraft (at about 0441hrs) just before or during its left turn back towards what the crew thought to be LS. The witness's position was just past 2½ minutes flying time from the aerodrome, the time interval estimated by the ATCO between the aircraft's passage over the aerodrome and the commander's report that he was returning to LS. The commander subsequently stated that after the turn he followed a northerly heading on his ADF, which was, as he believed, pointing towards LS. If the previous assumptions are correct, this heading would take the aircraft over ear witness B for the first time, (at about 0444 hrs). In this area, according to the crew, the ADF gave an indication of passing overhead LS and the commander started his procedure turn timing. There is little doubt that eye witness C saw the aircraft on its procedure turn (between about 0445 hrs and 0446 hrs) flying from west to east. The aircraft then, heading south, passed through the northwest false course beam of the ILS localiser, prior to which the commander selected the autopilot mode from 'heading' to 'localiser normal'. As the commander's navigation situation display instrument was set up for an ILS front beam approach, which the autopilot, in the localiser normal mode, would be attempting to follow, it is not surprising that, on being presented with

this particular problem, the autopilot caused the aircraft to roll from side to side. After disengaging the autopilot the commander again had an ADF indication of passing overhead LS; this appears to have coincided with the position where ear witness B heard the aircraft for the second time (at about 0447 hrs). The commander then commenced descending, following an 'on glidepath' indication and a 'fly right' indication of the localiser. The aircraft was now in the 'fly right' region of the ILS back beam. The commander appears to have continued turning right onto a final heading of 268°M with the localiser needle still giving a substantial 'fly right' indication; he also continued descending through his decision height of 260 feet QFE*. The aircraft hit the ground 161 feet below this height (292 feet above mean sea level – 131 feet ground elevation), in a very slight pitch down attitude. The calculated time of impact, following this reconstruction, would be about 0449 hrs, ie within a minute of the crash time established by the aircraft's clock.

2.3 Human factors

As can be seen from sub-heading 1.13 and Appendix 5 it is logical to reason that both pilots, after a full day's work and a night without sleep, must have been feeling tired by half past four the following morning when they commenced their approach to Lee-on-Solent, even though they may not have realised it. It is also significant to note that at this time their circadian rhythms were probably at the lowest point on the twenty-four hour cycle and that their performance is likely to have been affected accordingly. Contributing to their fatigue must have been the worry and frustration at Manchester, due to the difficulty in starting the engines, and the considerable self-imposed pressure to deliver the kidney on time. In addition, it appears that the commander was carrying most of the workload, flying the aircraft, selecting frequencies and handling the radio communications; the only task performed by the co-pilot was to tune the ADF and monitor the instruments.

There are no flight time limitations applicable to private flights, such as this one. The onus must be on the pilots themselves not to fly when tired; however, in a case such as this, on an urgent mercy flight, using volunteer pilots, there is no easy remedy, except recourse to burdensome restrictive legislation. It is therefore recommended that although the operations manual of the St John Ambulance Air Wing stresses that safety is of paramount importance, a warning of the possible dangers of pilot fatigue be included.

2.4 Meteorological factors

There is little doubt that the commander was misled by the erroneous reports of the cloudbase at Lee-on-Solent, and that these in turn were largely due to the fact that the cloud searchlight was unserviceable. If the last report had included the fact that the cloudbase was estimated, it might have alerted the commander to the possibility that the cloudbase could be different from that reported, but would hardly have prepared him for an actual cloudbase of 500 feet, after understanding there was 1/8 at 3,000 feet. Believing that there was very little cloud and with the reported visibility of 5 kilometres he expected to have no difficulty in making an approach and landing. Even with 8/8 cloud at 2,500 feet, as was recorded on the 0400 hrs observation and, according to the Lee-on-Solent ATCO, passed to the aircraft, he would probably have

**50 feet above the published Jeppesen basic decision height*

experienced little difficulty. The commander believes that, had he known that the cloudbase was actually 500 feet, he would have declined the direct clearance to LS and requested to position via Midhurst VOR and thence to intercept the ILS at a considerably greater range from the station. It is possible that the accident might have been avoided if this procedure had been followed.

2.5 Radio navigational aspects

It would appear that on the first approach both the ILS localiser and glidepath were captured shortly before the outer marker, the aural signal of which was heard by the commander. However, since the visual signal was not seen, it is probable that the aircraft was not truly on the localiser centre line. Further support for this supposition was provided by the subsequent failure of the crew to receive the middle marker and the witness evidence that the aircraft flew over the north-western boundary, some 350 metres right of the runway centre line.

Ground and flight checks have failed to locate any anomalous propagation which might have been associated with a transmission on or near 407 KHz in the Fawley area and there have been no reports of unusual effects since the LS NDB has been in operation. However, due to the assignment of a frequency for LS in a frequency band allocated to maritime direction finding, it is quite possible for a ship, for instance, berthed at the oil refinery, to transmit on or near the frequency of LS, even though legitimate use of the frequency in this area would be extremely limited. Checks have also shown that the LS NDB could have been tramsmitting below nominal power at the time of the accident. In any case, following the overshoot and left turn onto a northerly heading the aircraft was, at this stage, some 10 nm away from LS and at the limit of its promulgated coverage. It is therefore quite possible that an unidentified radio transmission could have overridden LS in this area, and accordingly affected the aircraft's ADF. There appears to be no other explanation which is compatible with the crew's evidence of ADF indications of two apparent passages of LS, and that of witness B at Fawley Oil Refinery who heard the aircraft pass over him twice within five minutes.

After the overshoot following the first approach the commander should have noted from the approach chart that the heading back to the LS NDB was towards the north-east and consequently he might reasonably have been suspicious when he found the aircraft on a northerly heading when homing on the ADF to what he supposed was LS.

There is no doubt that during the second approach when the commander saw the 180° swing of the ADF pointer subsequent to the procedure turn, he was convinced that the aircraft was on the ILS at the outer marker. He therefore commenced his approach, following the 'fly right' indications of the localiser. It is pertinent to note that the aircraft would have been in the 'fly right' region of the back beam at this time. However, the commander has said that he also received an 'on glidepath' indication with no warning flag.* Various test flights flown in the area between Fawley and the crash site

**On the instrumentation as fitted to G–BFKO, the flag, when showing, completely covers the glidepath needle.*

have shown that a glidepath needle may fluctuate around the 'on glidepath' position or give a 'fly down' signal, with a warning flag. However, there is evidence that at the time of the accident, the steep gradient of the refractive index could have produced an enhancement of VHF radio waves to a degree sufficient to keep the flag clear. The essential point is that, within the United Kingdom, only the front beam of ILS installations should be used, and even then only within a defined sector. Elsewhere both localiser and glidepath signals are unreliable. However, there is no doubt the pilots believed they were receiving the front beam signals at this time.

There is little reason to doubt that the commander followed a 'false' glidepath signal in the final stage of his let-down to his decision height. At the same time he followed the almost full 'fly right' indication of the localiser, turning, he believed, 15° to 20° towards the front beam. However, the impact trail shows that at the time, the aircraft was on an intercept of 40° to the front beam and it had descended some 160 feet below the self-imposed decision height.

2.6 Pilot performance

There is considerable circumstantial evidence that there was a spurious radio signal on or near the frequency of the LS NDB radiating from a position near Fawley which could have misled the pilots when positioning the aircraft for the second approach. The fact that the commander intentionally descended to his decision height, and then continued below it whilst flying an intercept of 40° to the front beam with a continuing and substantial 'fly right' indication, suggests there was a lack of awareness on his part of the limitations of an ILS approach. Alternatively it indicates that both pilots were suffering from fatigue to the extent that their judgement of the reliability of the radio navigation information they were receiving was seriously impaired.

Although the commander did not require an instrument rating for his approach to Lee-on-Solent, because the aerodrome was outside controlled airspace, it is for consideration whether the application of the 13 month renewal test, as required by a UK instrument rating, might have led to a higher standard of execution of the ILS approach. For example, any descent below intermediate approach altitude before the aircraft is established on the localiser leads to an instant fail in the ILS section of the CAA's instrument rating test. The present situation whereby the holder of a foreign instrument rating may quite legally fly a British registered aircraft under circumstances which require an instrument rating, will no longer apply if the proposed amendment to Article 19(3) of the ANO is enacted.

It was most unfortunate that this mercy flight, planned and undertaken by volunteers with the best of motives, should end in such a fashion, luckily without injury. Nevertheless it should also be borne in mind that had the flight path been very slightly different, the aircraft might have crashed either on Fawley Oil Refinery or on a built up area, with very serious consequences. The need for vigilance and the maintenance of the highest standards on the part of the pilots concerned in these operations cannot be over-emphasized.

3. Conclusions

(a) *Findings*

1 The pilots were properly licensed in accordance with the requirements of the Air Navigation Order to carry out the flight.

2 There is no evidence of pre-crash failure or malfunction of the aircraft, its engines or equipment, apart from the unserviceability of the transponder, which had no bearing on the cause of the accident.

3 Both pilots were suffering from a significant degree of fatigue by the time they commenced their approach to Lee-on-Solent.

4 The commander was passed an estimate of the cloudbase which was substantially too high. Had he known that the cloudbase was actually about 500 feet, he might have carried out his first approach in a different manner and possibly landed from it.

5 Following an unsuccessful ILS approach the commander followed ADF indications to a position he thought to be the LS NDB (ILS outer marker), but was most probably an unidentified radio transmission close to Fawley. He commenced his second approach from this position.

6 During his second approach the commander followed false course indications in the back course region of the ILS. At the same time he followed what he believed to be valid glidepath signals, down to the point of impact.

7 Glidepath signals may be received in the area between Fawley and the crash site which give a fluctuating 'fly down' or 'on glidepath' indication, though with the glidepath flag showing.

8 At the time of the accident there was in the area, a steep refractive index gradient close to the surface. This may have been capable of enhancing the field strength of VHF transmissions sufficiently to hold the glidepath flag clear.

9 The commander permitted the aircraft to descend below the decision height which he had established as being appropriate.

(b) *Cause*

The accident was caused by the commander permitting his aircraft to descend below his self-determined decision height without having established any visual reference. Probable contributory factors were:

1 The state of fatigue of the crew at the time of the let-down, and the self-imposed pressure to complete the flight.

2 The passing of an incorrect cloudbase to the commander.

3 An unidentified radio transmission from a source in the area of Fawley Refinery, on or near the frequency of the outer marker NDB, which misled the crew as to their position.

4 The commander following false ILS localiser and glidepath signals, presented without warning flags, in the back course region of the ILS.

4. Safety Recommendations

Is is recommended that:

4.1 The operations manual of the St John Ambulance Air Wing should include a warning on the possible dangers of pilot fatigue.

4.2 At all aerodromes when pilots are given actual weather reports it should be clearly indicated when the cloudbase is estimated rather than measured.

4.3 Further consideration be given to the possibility of allocating frequencies which are not used by shipping to NDBs situated near the coast.

C C ALLEN
Inspector of Accidents

Accidents Investigation Branch
Department of Trade

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