AIRCRAFT ACCIDENT REPORT 4/97

Air Accidents Investigation Branch

Department of the Environment, Transport and the Regions

Report on the accident to Aerospatiale AS 355F1 Twin Squirrel, G-CFLT Near Middlewich, Cheshire on 22 October 1996

This investigation was carried out in accordance with
The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996

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Department of the Environment, Transport and the Regions
Air Accidents Investigation Branch
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Hampshire GU14 6TD

23 October 1997

The Right Honourable John Prescott MP
Deputy Prime Minister and Secretary of State
for the Environment, Transport and the Regions

Sir,

I have the honour to submit the report by Mr M M Charles, an Inspector of Air Accidents, on the circumstances of the accident to Aerospatiale AS 355F1 Twin Squirrel, G-CFLT near Middlewich, Cheshire on 22 October 1996.

I have the honour to be
Sir
Your obedient servant

K P R Smart
Chief Inspector of Air Accidents

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	Air Accidents Investigation Branch
ADF	Automatic Direction Finding
agl	above ground level
amsl	above mean sea level
ANO	Air Navication Order
ATC	Air Traffic Control
BCAR	British Civil Airworthiness Requirements
CAA	Civil Aviation Authority
CAP	Caution Advisory Panel or Civil Aviation Publication
CTR	Control Zone
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
DRA	Defence Research Agency
°T	degrees true
FDR	Flight Data Recorder
ft	feet
g	Acceleration due to gravity
GPS	Global Positioning System
hrs	Time (24 hour clock)
Hz	hertz
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
JAR	Joint Airworthiness Requirement
kg	kilogram(s)
kt	knot(s)
lb	Pound(s)
LH	left hand
MHz	Megahertz (frequency)
MSA	minimum safe en-route altitude
MPa	Megapascal(s)
mm	millimetre(s)
NATS	National Air Traffic Services
nm	Nautical mile(s)
OAT	outside air temperature
POB	Persons on Board
psi	Pounds per square inch (pressure)
RH	right hand
RNAV	Radio Navigation (equipment)
RTF	radio telephone
SB	Service Bulletin
TOW	Take-off Weight
UK	United Kingdom
UTC	Universal Time Co-ordinated
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omni Range
ZFW	Zero Fuel Weight

Air Accidents Investigation Branch

Aircraft Accident Report No: 4/97 (EW/C96/10/8)

Registered Owner:	Aeromega Ltd
Operator:	MGA Limited using the Air Operators Certificate held by Polo Aviation Limited (see Background at Appendix A)
Aircraft Type:	AS 355F1 Twin Squirrel (Ecureuil)
Nationality:	British
Registration:	G-CFLT
Place of Accident:	Near Middlewich, Cheshire, England Latitude: 53° 10.4' N Longitude: 002° 27.5' W
Date and Time:	22 October 1996 at 2150 hrs All times in this report are UTC (local time -1 hour)

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) at 2230 hrs on 22 October 1996 and an investigation began the next day. The investigation was conducted by Mr M M Charles (Investigator-in-Charge), Mr J J Barnett (Operations), Mr P F Sheppard (Flight recorders) and Mr R Parkinson (Engineering).

The accident occurred when the helicopter was returning to London from a private landing site in Bolton, Lancashire with one pilot and four passengers on board. The aircraft was being flown at night in visual contact with the ground when the pilot decided to climb to a higher altitude. During the climb he was deprived of external visual references and the aircraft adopted a steep nose-up attitude during which the airspeed reduced below the minimum recommended speed for instrument flight. This unintentional manoeuvre then developed into a fast, spiral descent. The helicopter did not recover from the dive and it crashed into a field on the outskirts of Middlewich, broke up and caught fire. The accident was not survivable and all five occupants were killed.

The investigation identified the following causal factors:

(i) The helicopter significantly deviated from the intended route.

(ii) The commander's workload in marginal weather conditions was excessive.

(iii) The commander probably lacked recent experience of recovering the helicopter from an unusual attitude using the flight instruments.

(iv) The commander was unable to control the helicopter by sole reference to the flight instruments when he lost external visual references.

(v) The standby artificial horizon was not powered and would have provided confusing attitude information if it had been visible in the ambient cockpit lighting conditions, and if the commander had referred to it.

(vi) The commander may have been distracted at a critical time by the opening of a cabin door.

Five safety recommendations were made during the course of the investigation.

1 Factual Information

1.1 History of Flight

1.1.1 Background

On the day of the accident the aircraft was leased to an air transport undertaking for the purpose of conveying four passengers and one pilot between London and Bolton in Lancashire, and then back to London after an evening football match. The accident occurred during the return flight from Bolton. Relevant background information relating to the commander, the companies involved, previous flights on the day of the accident, and pre-flight preparations for the accident flight is at Appendix A.

1.1.2 The accident flight

When the passengers arrived at the private landing site by car, the commander was already seated in the helicopter, where he remained whilst they boarded. The commander then started the engines and appeared to observers to carry out a number of checks and tests which seemed to them to take between five and ten minutes. The observers noticed a number of external lights including a white flashing light near the tail and a steady light at the front of the helicopter. The latter light resembled a car's headlight and cast a pool of light on the ground. The illuminated area was about one yard wide and about 3 yards in front of the helicopter. The observers did not see this light being swivelled or moved in any way.

The helicopter took off vertically from the car park in Bolton at 2127 hrs. One minute later the commander contacted Manchester Approach Radar by Very High Frequency (VHF) radio and sought a radar service (see Appendix B). A transponder code was assigned to the aircraft and the commander informed the controller of his intended route and his intention to climb to 1,500 feet. The controller could not offer radar vectors at that altitude but she did offer to provide advisory headings. She also reminded the commander that he would be responsible for maintaining clearance from weather and terrain. The commander accepted the offer and revised his intended cruise altitude to 2,000 feet which he believed to be just beneath the cloud base. Having negotiated the provision of service, the controller formally advised the commander that his clearance through the Manchester Zone would be special Visual Flight Rules (special VFR) and the commander acknowledged this clearance.

At 2131 hrs when the aircraft was about 16 nautical miles (nm) north-west of Manchester Airport, in two separate transmissions the controller recommended a track of 190° for the Shawbury overhead and informed the commander that he was receiving a radar information service. The commander acknowledged both transmissions. There then followed a conversation about why the commander intended to route via Shawbury and he explained "THAT'S JUST TO AVOID THE HIGH GROUND TO THE SOUTH OF MANCHESTER". At 2134 hrs the commander was instructed: "TO KEEP YOU CLEAR OF LIVERPOOL'S AIRSPACE MAKE YOUR HEADING NOT GREATER THAN ONE EIGHT ZERO UNTIL ADVISED". At 2138 hrs (12 minutes before the accident) the commander was asked to confirm his altitude and he replied "I'M ACTUALLY AT SIXTEEN HUNDRED FEET"; this was the last altitude report received from him. He was then asked if he specifically wished to route via the Shawbury overhead. He replied "NEGATIVE I JUST WANT TO AVOID THE HIGH GROUND TO THE SOUTH OF YOU ERM WHEN CONVENIENT I'LL TURN TOWARDS BIRMINGHAM".

During the next few minutes the commander maintained a heading consistent with the "not greater than 180" instruction which, coincidentally, kept the aircraft within the horizontal boundaries of the low-level VFR route through the Manchester Control Zone but above the maximum altitude. There was no other air traffic on the same frequency and during this 'quiet period' the commander asked for the latest weather report for Birmingham Airport which was subsequently obtained and relayed to him. The relevant aspects of the report were 18 km visibility and a lowest cloud base of 2,000 feet.

The towns of Winsford and Middlewich are near the southern corners of the low-level route. At 2147 the aircraft was over the town of Winsford when the controller advised the commander "GOLF LIMA TANGO SUGGESTED TRACK FOR BIRMINGHAM OVERHEAD IS ONE FIVE ZERO DEGREES" and the commander replied "ROGER COMING LEFT ONTO ONE FIVE ZERO LIMA TANGO". The controller then reminded the commander that the suggested track should be corrected for wind drift (the wind was southerly at between 15 and 25 kt).

An eye witness standing in his garden in Winsford saw and heard a helicopter about 200 to 300 yards away from him; radar data showed that this sighting must have been G-CFLT because it was the only aircraft flying in the area. The witness reported that the helicopter appeared to be flying due south at a normal height above the ground. He thought the only abnormal aspects of the helicopter's flight were the time of day and the brightness of two flashing lights; a white one at the rear and a red one in the middle of the helicopter.

Winsford is 13 nautical miles from the hill north of Stoke-on-Trent known as 'Mow Cop' which has an elevation of 1,165 feet above mean sea level (amsl) on aviation topographical charts. Having passed over Winsford the helicopter turned left and initially made good a ground track of about 135°T (degrees true). (This track was consistent with a magnetic heading of 150°, an airspeed of 105 kt and a southerly wind of 20 kt). Had that track been maintained, Mow Cop would have been the highest obstruction close to the aircraft's route. The witness stated that when the visibility and cloud base permit, from his garden he can see lights on and around Mow Cop but on this night he could not see the lights. Nevertheless, he and many other witnesses in the Middlewich area reported that the weather at the time was fine and the visibility good.

About two minutes before the accident, when the helicopter was making good a track of 135°T, the controller transmitted "GOLF LIMA TANGO JUST CONFIRMING THAT YOU'RE RESPONSIBLE FOR YOUR OWN TERRAIN CLEARANCE DO YOU REQUIRE FURTHER CLIMB?" Initially the commander declined to climb but 14 seconds later he changed his mind and sought clearance to climb to 3,000 feet. The controller cleared the helicopter to climb to not above 3,000 feet altitude and the commander acknowledged this clearance. At the same time the aircraft ground track altered from about 135°T to about 100°T and the airspeed began to reduce consistent with a climb. However, the airspeed continued reducing to around 30 kt. It remained below 50 kt for about 25 seconds. During this period of slow flight the radar returns showed an erratic flightpath and the commander transmitted "LIMA TANGO REQUESTING A HEADING STRAIGHT BACK TO THE FIELD FOR MANCHESTER PLEASE". The controller asked the commander if he had a problem to which he initially replied "AFFIRM I'M INADVERTENT INDIA MIKE" (Instrument Meteorological Conditions - IMC). She asked him to repeat the message and he replied "I'M INDIA MIKE AND REQUESTING A FURTHER CLIMB ABOVE THREE THOUSAND FEET". Immediately the controller cleared the commander to climb above 3,000 feet and asked him whether he wanted vectors for the Instrument Landing System (ILS) or another type of approach at Manchester. His reply, which was the commander's final transmission, was "YEAH I'M LOOKING FOR VECTORS FOR AN ILS I THINK I'M IN A DESCENT AT THE MOMENT HOLD ON".

In the vicinity of Middlewich, eye witnesses saw the helicopter's lights change their aspect and adopt a nose-up attitude. The helicopter's motion was indicated to them by the movement and orientation of its lights, in particular by a light at the front of the machine. One witness described this light as resembling a spotlight pointing skywards and another described it as a bright blue light.

An eye witness travelling northwards by car along the A530 road heard nothing but saw an aircraft's lights inclined almost vertically upwards as he passed beside Wimboldsley School. He then noticed the white light begin falling towards the ground and as the car approached Lea House Farm, (about 1,000 metres beyond the School), he saw a bright orange flash from the same direction as the falling white light when it disappeared from view.

Another eye witness was standing on the doorstep of his home in south Middlewich when he saw and heard a helicopter approaching. He reported that the helicopter tried to climb by raising its nose until it was almost vertically upwards and then it appeared to turn around in mid-flight at a height he estimated to be between 1,000 and 1,500 feet. He likened the manoeuvre to a stall turn which he had seen stunt aeroplanes perform. Then the helicopter descended towards the ground at high speed giving him the impression that it was a police helicopter chasing something. Next he saw a flash of white and orange light, similar to fire which originated from the rear of the helicopter's fuselage as it dived towards the ground. He did not hear any loud noise associated with the flash of light; he thought it originated from one of the aircraft's exhausts.

A third eye witness was in the bedroom of her home in south Middlewich. Looking out of the window she saw a white search-type spotlight which was pointing skywards at an angle of about 20°. She identified the aircraft as a helicopter by its noise and she gained the impression that the white light was rotating in a clockwise direction and accelerating as if the helicopter was spinning out of control. Whilst watching the light she heard a sound which she associated with a rotor blade problem and a few seconds later she heard what she thought was the engine cut out. The helicopter's lights then descended rapidly and she saw a bright flash of light consistent with a crash.

A fourth witness in the garden of her home in south-west Middlewich heard a very loud helicopter which she could not see. She thought that something was vibrating on the helicopter and ran to a different vantage point from where she could see two lights in the sky, a white circular light and a blue light directly underneath it, pointing directly towards her. Both lights then began to fall and they disappeared behind houses followed by a large orange flash.

A fifth witness who lived near the crash site heard and saw the helicopter in its final moments of flight. He was indoors when he heard it and the engine sounded as if it was misfiring badly. He went outside and saw the helicopter, which was displaying white and red flashing strobe lights, silhouetted against the sky. It was travelling away from him and he estimated its height at 100 feet or less. The helicopter was descending rapidly and he saw it strike the ground followed by a large flash fire and copious black smoke.

Many other witnesses reported hearing the helicopter in flight but did not see it. The majority reported abnormal noises which were consistent with harsh manoeuvring near the housing estate on the south-west outskirts of Middlewich. Some stated that the engine noise seemed normal but others reported a variety of abnormal sounds. Some reported a period of relative silence before they too saw a bright orange flash consistent with the helicopter's ground impact. Nobody reported seeing the helicopter or its lights penetrate cloud.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	4	-
Serious	-	-	-
Minor / None	-	-	-

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

Part of an agricultural field was contaminated by aviation turbine fuel and trees at the edge of a copse were damaged by fire.

1.5 Personnel information

Commander:	Male aged 38 years
Licence:	Airline Transport Pilot's Licence (Helicopters and Gyroplanes)
Type ratings:	AS 355F & AS 355N Twin Squirrel AS 350B Squirrel Bell 206 Jet Ranger SA 341G Gazelle Robinson R22
Instrument rating:	None
Base check:	11 April 1996 (AS 355 at night)
Line check:	05 March 1996 (AS 355 by day)
AS 355 Type Rating Examiner Check:	18 June 1996
Medical:	Class One renewed on 22 February 1996 with no restrictions

The commander's flying and duty hours had to be estimated (see Appendix A)

Flying experience:	Total all types	4,506 hours
	Total on type	84 hours
	Last 90 days	90 hours
	Last 28 days	30 hours
Flying Duty Period:	12 hours 20 minutes	
Rest Period Before Duty:	14 hours 55 minutes	

1.6 Aircraft information

1.6.1 General description

The AS 355 is a twin-engined helicopter certified for single-pilot operation. The pilot occupies the front right seat and the cabin can seat four passengers with one occupying the front-left seat which has removable flight controls. The main rotor, which has three-blades attached to a semi-rigid rotor head, rotates in a clockwise direction when viewed from above and there is a two-bladed tail rotor. The flight controls are conventional with dual hydraulic servos for the main rotor and a single servo for the tail rotor; hydraulic power is generated by two pumps driven from the main rotor gearbox. Electrical power is supplied by two starter-generators driven by the engines and a battery. The electrical distribution system has considerable provision for load-shedding and redundancy, and a direct battery busbar for powering vital systems.

1.6.2 AS 355 variants

There are a number of AS 355 variants, the detail of which need not concern this report apart from the fundamental differences between the VFR and IFR variants. (For definitions of VFR and IFR see Appendix E).

The IFR machine has an IFR flight instrument panel in place of the standard panel with a 3-axis automatic flight control system (autopilot) and flight director coupler. The electrically powered autopilot has basic pitch, roll and yaw modes which provide rate damping (autostabilisation) in each axis. The autopilot's main design function is to permit the pilot to fly the machine 'hands off' by coupling the autopilot servo motors to flight director demands for altitude, airspeed, vertical speed and instrument approach modes.

The VFR machine may or may not have comprehensive flight instruments, navigation aids and an autopilot but it will always be restricted to VFR operations if it lacks an autopilot approved for IFR operations. With no autopilot fitted, the cyclic control has no spring feel trim and hence no mechanism for returning the control to a neutral position. There is, however, an adjustable friction which can be used to retain the cyclic control position if the pilot releases the hand grip.

1.6.3 G-CFLT specification

G-CFLT had no autopilot and was restricted to VFR operations. It was certified for public transport in Performance Groups A, A (Restricted) and B. The aircraft had been modified to accept air ambulance and police air support role equipment which replaced the co-pilot's flight instruments and introduced a sliding door to the passenger cabin. At the time of the accident the co-pilot's flight controls and most of the role equipment had been removed.

The helicopter was fitted with a comprehensive intercom. The system included the facility for rear crew members (or passengers) with headsets to hear RTF exchanges in addition to the usual intercom features. The pilot also had the capability of excluding the rear crew members from the RTF exchanges provided that he made the appropriate selections.

1.6.4 G-CFLT history

The helicopter was delivered, in November 1981, as an 'E' model, without cockpit instrumentation or avionics by the manufacturer to their agents in the USA for customisation prior to delivery to an operator in Canada where it was registered as C-GKHO. This customisation would have included cockpit instrumentation, avionics installation, modification to comply with Canadian certification requirements and any additional operator's specified modifications. In September 1986, along with two other helicopters from the same Canadian operator, it was imported into the UK, as an 'F' model, by the manufacture's approved UK agent and registered as G-BNBI. In February 1987 it was exported from the UK to New Zealand where it was modified to an 'F1' model and registered as ZK-MHS. In February 1988 it was re-imported into the UK and re-registered G-BNBI. In August 1989 it was registered as G-CFLT.

1.6.5 Main cabin doors

The door installation on this helicopter consisted of two forward cockpit doors, a small rear right-hand door and a large fore/aft sliding door on the rear left-hand side. None of these doors had any mechanism fitted that would give the pilot an indication that they were closed and locked.

The two forward doors, the left-hand being smaller than the right-hand, were both hinged at their forward edges and were jettisonable. Neither door had a 'slam shut' closing mechanism they had to be held in the closed position whilst a locking handle was rotated through 90° from the OPEN to the CLOSED position. The action of rotating the locking handle was to extend locking pins from the edges of the doors to engage with keep plates located in the cabin structure. It would have been impossible to close the doors with the locking handles in the CLOSED position.

The small door at the rear right-hand side of the cabin was hinged at its rear vertical edge. This door was locked in the closed position by the manual engagement of two sliding 'shoot' bolts. It was not possible to open this door when the forward right-hand door was closed.

The fore/aft sliding door at the rear left-hand side was mounted on three guide rails which ensured that it was correctly fitted in the cabin structure profile when it was in the closed position. The top and bottom rails, curved inwards at their forward ends, guided the leading edge of the door into the rear centre locking pin of the forward door. The door had two locking handles, one located inside the door halfway down the forward edge and the other located on the outside, halfway down the trailing edge. The locking handle located on the inside was orientated horizontally in the OPEN position and vertically in the CLOSED position whereas the external handle was orientated to operate in reverse. The action of placing these handles to the CLOSED position extended two locking pins at the rear of the door which engaged into keep plates located in the rear cabin structure. It was not possible to close the sliding door with the locking handle in the CLOSED position. To close the door, after having slid it fully forward, a separate action was required to pull from the inside or push from the outside the trailing edge of the door to locate it within the cabin structure before the locking handle could be placed in the CLOSED position. Towards the trailing edge of the inside of the door, mounted on the lower window sill was a small fingertip grip to facilitate the pulling inwards of the door's trailing edge when closing it from the inside. This fingertip grip was not illuminated although there was a legend to indicate its purpose. In the middle of the inside of the door, just below the window was a door secondary lock mechanism which, when engaged, mechanically prevented the main door locking handle from being moved from the CLOSED position. This secondary lock mechanism was primarily designed to secure the door when the helicopter was parked and unattended. It was possible to open the sliding door with the forward door in the closed and locked position.

The Flight Limitations for this helicopter state that the sliding door should not be moved from the open or closed position at speeds above 60 kt and that with the door in the locked fully open position speeds are not to exceed 110 kt.

1.6.6 Direct battery busbar and standby artificial horizon

The helicopter had, within its electrical distribution system, a direct battery busbar. This busbar supplied safety related items such as cockpit lights, transponder, height encoding, engine fire extinguishers and generator resets with electrical power direct from the helicopter's battery in the event of a total electrical generation and/or distribution failure. A switch selection in the cockpit had to be made to connect the direct battery busbar to the battery which, when selected ON, extinguished a warning light on the Caution Advisory Panel (CAP). In 1989 a standby artificial horizon was fitted to the helicopter. The electrical power supply for the instrument and its dedicated lighting system was also taken from the direct battery busbar and was routed via an ON/OFF switch mounted in the forward right-hand 'eyebrow' cockpit switch panel.

Note: The standby artificial horizon may be fitted in a number of different positions within the cockpit layout of other AS 355 helicopters. Of the two other aircraft which the commander flew, neither had a standby artificial horizon. One was fitted with a single horizon only and the other was fitted, in addition to the normal commander's instrument, with a co-pilot's horizon on the far left of the instrument panel.

1.6.7 Weight and centre of gravity

No weight and balance computation for the flights was recovered from the burned wreckage. The helicopter's centre of gravity was estimated to be within limits for all the flights undertaken on the day of the accident.

The engineer who completed the helicopter's pre-flight inspection at Stapleford stated that the fuel tanks were filled to full at the commander's request before the aircraft departed Stapleford. Later that day 358 litres of fuel were loaded at Welshpool. Detailed calculations indicated that this quantity was almost identical to the calculated fuel burn between Stapleford and Welshpool. Consequently, the following weights were estimated using the basic weight and balance schedule dated 10 January 1996 supplemented by standard weights for male passengers and calculated fuel contents based on full tanks at Stapleford and Welshpool.

Aircraft empty weight	1,518 kg
Estimated zero fuel weight	1,538 kg
Maximum authorised weight	2,400 kg
Estimated take-off weight at Battersea	2,472 kg
Estimated take-off weight from Oswestry (5 POB)	2,487 kg
Estimated weight on takeoff from Bolton	2,401 kg
Estimated weight at time of impact	2,330 kg

1.7 Meteorological information

A large quantity of meteorological data were gathered during the investigation. Relevant data are contained in Appendix C.

1.7.1 Meteorological summary

Using all the available data the AAIB assessed the lowest cloud structure at the accident site as broken with a base of 1,200 feet above ground level (agl) and tops 1,500 feet agl. Above this layer was another broken or overcast layer with a base between 2,000 and 2,500 feet and tops at 3,500 feet. Beneath cloud the visibility was about 10 km. There was no weather apart from isolated and sporadic light drizzle. The surface wind was south-south-easterly at 8 kt; the surface air temperature was 15°C and the dewpoint 13°C. The QNH altimeter setting was 1019 HPa and the freezing level was at 11,000 feet.

1.7.2 Natural light conditions

The moon rose at 1512 hrs and the sun set at 1658 hrs. At the time of the accident the moon was on a bearing of about 195°T and it was 83% illuminated; the next full moon occurred four days later.

1.8 Aids to navigation

1.8.1 Radio aids

The helicopter was equipped with several radio navigation aids including VHF Omni Range (VOR), Distance Measuring Equipment (DME) and Automatic Direction Finding (ADF) receivers which can be tuned to receive ground beacons. For area navigation there was an Radio Navigation (RNAV - a system for creating pseudo waypoints in the form of bearings and distances from co-located VOR/DME beacons). A transponder was installed (without altitude encoding) and there was a radio altimeter to indicate height above ground.

1.8.2 Global Positioning System (GPS)

GPS is a satellite navigation system which does not suffer from the reception range problems associated with ground based navigation beacons. The helicopter was carrying a portable Garmin GPS 100 receiver fitted and owned by the lessors. The equipment has its own internal and adjustable lighting which provides an illuminated display independent of the aircraft's own lighting; it also has its own battery. The database can store 250 user defined waypoints but the device was destroyed in the accident and it was not possible to recover any navigational data from the electronic memory.

The GPS 100 can be programmed to navigate along a specific route which has to be constructed from waypoints in the database. For off-airways routes, these waypoints have to be entered by the user but this requires pre-planning and familiarity with the specific equipment. The GPS 100 also has a simple 'GOTO' facility. To use it, the operator selects the desired destination waypoint and presses the 'GOTO' button. The equipment then provides navigation data from the operator's present position direct to the waypoint.

1.8.3 Navigation charts

The remains of the commander's personal navigation bag were recovered from the wreckage. Amongst its contents were several quarter million scale topographical air navigation charts which had been folded. All these charts had suffered peripheral fire damage but the central areas were undamaged. Two charts covered the Manchester and Birmingham regions (Sheets 10 and 13) which overlapped. These charts were old (Sheet 10 was marked 'Edition 3' and at the time of writing the current version is Edition 16). Both charts had hand drawn route legs annotated with timing marks equivalent to a ground speed of 84 kt.

There was also one half-million scale topographical air navigation chart, dated September 1993, in the bag which covered northern England and the Scottish Border region.

1.9 Communications

The commander was receiving a service from Manchester Approach Radar on frequency 119.400 Megahertz (MHz). A recording of the conversation between the controller and the commander for the period 2128 hrs to 2150 hrs was obtained and transcribed by the Transcription Unit of National Air Traffic Services Ltd. Relevant extracts from the transcription are to be found in Appendix B.

The final radio transmission from the aircraft was about 3.5 seconds in duration. Half way through this, what can best be described as a "buzzing" noise became apparent and increased in strength through the remainder of transmission. The onset of the noise occurs just after the pilot starts to say he is in a descent. On examination by the AAIB flight recorder specialists it was apparent that this noise was a series of pulses of sound. An attempt was made to examine the frequency content of the signal with a view to determining the source of the noise.

The sound pulses were found not to be entirely regular, and it is possible that they were the result of some electrical interference on the aircraft's radio transmission. However, close examination of the signal indicated that were possibly two main frequencies present. They were 20 to 22 Hertz (Hz) and 35 to 39 Hz. These frequencies are close to the frequencies which would be expected from the main rotor blade passing and tail rotor at the normal transmission rotational speeds, ie 19.7 Hz and 34.8 Hz respectively at a main rotor speed of 394 rpm. It is therefore also possible that the sound was acoustically generated partially from those two components, and an increased amplitude in the associated frequencies was being received at the pilots microphone.

Due in part to the short duration of the signal and the fact that the buzzing sound was buried in the main speech content for most of its duration, it is impossible to be absolutely certain of the frequencies. Previous transmissions from the helicopter were examined but there was no evidence of the buzzing noise. During a subsequent test flight in another AS 355 helicopter which reproduced a flightpath similar to the accident flight, a recorder was connected into the pilot's microphone system, but examination of the recording failed to detect any similar buzzing sound.

A number of air traffic engineers, transcription officers and air traffic controllers from the Civil Aviation Authority/National Air Traffic Services (CAA/NATS) were asked for their opinion of the buzzing noise. They were unable to identify positively the source of the noise but were in little doubt that it was generated by a source not within the Air Traffic Control (ATC) recorder or radio circuitry. One individual offered the unprompted view that it might have been generated by a door or window opening in flight.

1.10 Aerodrome and approved facilities

Not applicable.

1.11 Flight recorders

There was no requirement to carry a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR) on board the helicopter and neither was fitted.

Recorded radar data from ATC area control radars at St Annes near Blackpool and Clee Hill near Ludlow, and from the airfield control radar at Manchester Airport were obtained. These data were analysed by the AAIB with the assistance of Manchester ATC and Defence Research Agency (DRA) Malvern. Area radar data were used to analyse the helicopter's flightpath between Bolton and Winsford.

The higher-resolution airfield radar data were used to analyse the flightpath between Winsford and the crash site.

Neither Clee Hill nor St Annes radar recorded continuous coverage of the entire flight, almost certainly because of the low altitude of the helicopter relative to its distance from the radar heads. Clee Hill radar briefly detected the helicopter as it departed Bolton and then re-acquired it, almost continuously, after it overflew Northwich. St Annes radar, from which the helicopter was generally increasing its distance, lost contact as it passed overhead Warrington and regained contact as it passed south of Winsford.

The ground track flown by the helicopter together with relevant communications and calculated airspeeds are shown at Appendix D. The entire flight is shown on page D-1 The smaller scale diagram on page D-2 shows the helicopter's actual and projected flightpaths together with the surrounding terrain.

An expanded view of the final 160 seconds of flight is shown on the diagram on page D-3. This diagram shows each radar return received by Manchester airport's radar at four second intervals. The range resolution is 1/64 nm and the azimuth resolution is 0.09° although at low altitudes a typical azimuth error might be twice as great as the resolution. Small errors in the radar returns gave rise to apparently random and significant changes in ground speed. These errors were minimised by using a centre-weighted averaging technique on a running data set of nine returns. Estimates of wind velocity were then applied to the ground speeds to produce calculated airspeeds. The effect of variations in the estimated wind speed are likely to be more significant when the helicopter was tracking north-south than when it was tracking east-west because the wind was southerly.

Superimposed on the large scale diagram are the helicopter's calculated airspeed and the conversation between its commander and the air traffic controller.

1.12 Aircraft examination

1.12.1 Accident site

The helicopter crashed in a cattle grazing field which was located approximately 630 metres to the south of the main Norcroft Farm buildings. The area, which was sparsely populated, consisted of a mixture of wood and farm land through which ran the River Wheelock and its tributaries and a number of electricity power lines. The general height of the land in the area was about 160 feet amsl with the initial impact site being at 140 feet amsl.

The accident site was in the south-eastern corner of the field with the wreckage trail running nearly parallel to the eastern boundary. The southern boundary of the field was made by two rows of trees that rose to a height of about 60 feet. The initial ground impact by the helicopter was 59.45 metres to the north of these trees. There was no evidence that the helicopter had struck either these trees or the electricity power lines that crossed the field that lay to the south of the accident field. Approximately 81 metres to the north of the initial impact point there was a wood and to the east was a substantial hedgerow. Both to the north and east the ground sloped down into medium sized gullies that fed surface water from the surrounding land into the River Wheelock.

1.12.2 Impact sequence and parameters

The initial impact by the helicopter with the ground was made by the tips of the main rotor blades and the forward section of the right-hand mainskid. Immediately following these ground contacts the tailskid and tips of both tail rotor blades contacted the ground. The length of each main and tail rotor blade ground strike marks, together with the associated earth throw, was consistent with both rotors rotating at about their normal operating speeds. Evidence from the initial impact marks indicated that at the point of impact the helicopter was banked to the right by about 30°, had the nose pitched down by about 5°, yawed to the right by about 10°, on a heading of 045°M (degrees magnetic), on a track of 035°, with a forward speed in the region of 125 kt and a downward vertical speed in excess of 3,000 feet per minute. As a result of the main rotor blade impacts with the ground the body of the helicopter was slewed to the left by about 15° and changed the track to 030°. Due to the high vertical and forward speed of the helicopter at the initial impact the structure was severely disrupted. The shattered body of the helicopter bounced following the initial main impact and upon it's second impact the fuel from the ruptured fuel tank ignited, which produced a fireball that travelled with the main body of the wreckage until it came to rest within a wood, where the fire continued until extinguished by the fire service some 90 minutes later.

Three days after the accident there was good evidence, in the form of large areas of fuel stained grass that there was a large quantity of fuel aboard the helicopter at the time of the accident.

1.12.3 General aircraft damage

The helicopter was very severely disrupted by both the initial ground impact and the second impact following the bounce. From the initial impact to the helicopter's final resting place, sections of the body panels, structure and cabin items were scattered either side of the impact path. From the point of the second impact the majority of these items suffered medium to severe burning. The tail rotor gearbox complete with the tail rotor blades, the upper and lower fins and the right-hand main landing skid detached from the main body of the helicopter at the point of the initial impact. The tail boom remained with the helicopter until the wreckage struck a tree at the edge of the wood where it detached. The main body of the helicopter, complete with the main rotor gearbox, rotor head and blades and both engines came to rest about 10 metres inside the wood and was almost totally consumed by the post-impact fire. There was no evidence of a pre-impact explosion or fire.

1.12.4 Structure

The main body of the helicopter consisted of, primarily, an aluminium alloy and titanium box construction that supported the main transmission (main rotor gearbox, rotor head and blades), the engines, the landing skid assembly and the cabin floor. The fuel tank was largely consumed by the post-accident fire. The titanium and steel items and a few sections of the aluminium alloy structure remained identifiable. None of the main body structure that was identified showed any evidence of a pre-impact failure or damage.

The main cabin structure, which was mainly constructed of reinforced plastic and aluminium alloy materials was severely disrupted with large sections having been consumed by the post-impact fire. Generally the degree of destruction was far more severe on the right-hand side than on the left which was consistent with the attitude of the helicopter at the initial ground impact. There were enough identifiable items to indicate that at impact all the panels were attached to the airframe but it was not possible to determine if they were all correctly closed and locked. The two baggage bay doors were fitted with a system that would give a warning in the cockpit if the doors were not correctly locked. The filaments of the bulbs from the DOOR caption in the Caution Advisory Panel (CAP) were microscopically examined and evidence was seen that indicated that the bulbs were not illuminated at impact. There was no evidence on any of the pieces of the main cabin panels or doors having been struck by the main or tail rotor blades. Sections of all four cabin doors were identified together with parts of their locking mechanisms. Three of the cabin doors showed good evidence of having been correctly closed and locked at impact. The sliding door, located at the rear left-hand side of the cabin was found to have its main locking handle in the CLOSED position with the locking pins extended and the secondary lock in the unlocked position. The two lock pins at the rear of the door, although extended to their engaged position did not show any evidence of having been located in their keep plates on the main cabin structure at impact. The keep plates were not identified and therefore could not be examined for evidence of the locking pins having been engaged at impact. A section of the lower sliding door guide rail was identified with the door guide roller located within the rail. Detailed metallurgical examination revealed positive evidence that the sliding door was partially open at impact. By comparing this section of rail to one fitted to a similar helicopter it was determined that the door was slid rearwards by approximately 14 inches.

Damage to the tail boom, upper and lower vertical fins and both horizontal stabilisers was consistent with the impact attitude of the aircraft. There was no evidence of main or tail rotor blades having struck this structure before ground impact.

1.12.5 Main rotor drive system, rotor head and blades

The main rotor gearbox was recovered intact but with severe fire damage. It, together with the remains of the main rotor head were striped and examined by the helicopter's representatives at the AAIB and no faults or pre-impact failures were found. There were a number of warning captions in the CAP associated with the main rotor gearbox. Microscopic examination of all the bulb filaments associated with these captions showed good evidence that none of these bulbs was illuminated at impact.

The rotor head, which was largely constructed from steel and reinforced plastic material, had been severely damaged in the post-accident fire. A detailed strip examination did not reveal any pre-impact failures. All three main rotor blade starflex arms were found to have failed in a mode that was consistent with the rotor blades having impacted whilst under considerable power.

The main structure of all three main rotor blades, from the roots to the tips remained attached to the rotor head and were severely damaged by the post-impact fire. There was no evidence on the burnt remains of the blades of any pre-impact damage although no assessment of the trailing edges could be made due to their destruction by the post-impact fire.

1.12.6 Tail rotor drive system and rotor blades

The majority of the tail rotor drive system and the rotor hub and blades were recovered in a relatively unburnt condition. Examination of the drive system showed that there had not been a pre-impact failure and that the failures that had occurred were consistent with the system coming to a rapid halt whilst power was being applied from the main rotor gearbox. Both tail rotor blades had failed in rearward bending at the blade roots which was consistent with damage seen following a massive high energy blade strike.

1.12.7 Flight controls

The majority of the flight control system was manufactured from aluminium alloy and located in the main body of the helicopter. As a result of the post-impact fire a substantial part of the system was destroyed and consequently a flight control system integrity check could not be carried out. The small number of items that were not destroyed by the fire showed no evidence of a pre-impact disconnect, failure or restriction.

1.12.8 Hydraulic system

The hydraulic system, which was located in the main body of the helicopter was, in the main, destroyed by the post-impact fire. Both engine driven hydraulic pumps were severely heat effected but strip examination showed that they were serviceable units at the time of the impact. The remains of both hydraulic fluid reservoirs were identified, one was extremely badly fire damaged whereas the second, which was less severely damaged, was found to contain a small quantity of hydraulic fluid. All the pipe connections were identified and found to be intact and correctly connected. All the flight control hydraulic servo actuators were identified and the three associated with the main rotor had suffered severe fire damage. External visual examination of all the servo actuators did not show any evidence of pre-impact failures or actuator runaways. There were a number of warning captions in the CAP associated with the hydraulic system. Microscopic examination of all the bulb filaments associated with these captions showed good evidence that none of these bulbs was illuminated at impact.

1.12.9 Fuel system

The fuel system, which was located in the centre area of the main body of the helicopter was, in the main, destroyed by the post-impact fire. Both fuel tank electrically driven centrifugal boost pumps were severely damaged. Visual external and internal examination of both units did not reveal any pre-impact failures and there was evidence which indicated that they were both rotating at impact. Both engine high pressure pump/filter assemblies were examined and both filters were found to contain insignificant debris and the pumps showed positive evidence that mechanical failures had not occurred. Neither of the two fuel shut-off valves were identified but both of the cockpit fuel shut-off control levers were found in the ON positions.

Both fuel quantity and fuel pressure gauges were recovered relatively undamaged. The indications on these gauges were consistent with those that would be observed when there was no electrical power available. The bulbs from the Fuel Transfer, LH Engine Pump and the RH Engine Pump captions mounted in the

Control Push-button Panels were not recovered. All the fuel system warning caption bulbs in the CAP were recovered and examination of the filaments showed that they were not illuminated at impact.

1.12.10 Electrical power

Electrical power was provided by two engine driven DC generators and a single battery. Control and distribution of the electrical power was achieved by switches, relays, busbars and circuit breakers. Due to the post-impact fire the majority of the control and distribution system was destroyed beyond recognition. Both engine driven DC generators had received severe fire damage to an extent that they could not be tested. Visual examination did not show any evidence of pre-impact mechanical or electro-mechanical failure. Both generator drive shafts from the engine driven accessory gearboxes had failed in rapid torsional overload caused by the driving system coming to a rapid halt. The battery was thrown clear of the helicopter during an early stage of the impact sequence and was relatively undamaged. Expert examination and testing of the battery found no evidence that it had ever been subjected to a massive electrical short circuit or that a thermal runaway had occurred. It was considered that at the time of the accident the battery was in an airworthy condition with adequate capacity for safe flight. There were a number of warning captions in the CAP associated with the electrical system which included a caption to warn when the Direct Battery Bus Bar was either not selected ON or had failed. Microscopic examination of all the bulb filaments associated with these captions showed good evidence that none of these bulbs was illuminated at impact.

1.12.11 Engines

Both engines were recovered relatively intact although badly damaged by the post-impact fire. They were taken to a manufacturers approved overhaul facility and with the assistance of a manufacturers representative were subjected to a strip examination. Both engines were found to be in a good condition consistent with their time in service and there was positive evidence that they were both in a serviceable condition at the time of the impact. Visual and metallurgical examination of the rotating components revealed that at the time of impact both engines were rotating at similar high speeds and that they had not flamed out.

The cockpit engine fuel flow control levers were found at their fully forward flight position. The engine mounted free turbine governor fuel metering units showed that high power, consistent with almost maximum collective pitch lever input, was being demanded from both engines at the time of the impact. Examination of the engine instruments that were recovered revealed no impact indications. Only a small number of the engine related captions were recovered intact but bulb filament analysis showed that none of them was illuminated at impact. All the engine system warning caption bulbs in the CAP were recovered and examination of the filaments showed that they were not illuminated at impact.

1.12.12 Cockpit instrumentation and avionics

The majority of the helicopter's instruments, warning captions and avionic equipment were either totally destroyed or relatively undamaged.

Three cockpit instruments were examined in detail, the main and standby artificial horizons and the altimeter. The remains of both artificial horizons were taken to their respective manufacturers for examination and test where possible. The main artificial horizon was very badly broken-up and some of the components were not identified. The main core of the unit was found to function correctly when tested. Witness marks within the unit indicated that it was functioning correctly and indicating the correct attitude of the helicopter at impact. The standby artificial horizon was relatively undamaged. When examined there was no evidence of any pre-impact failures within the unit and the main core functioned correctly when tested. Witness marks within the unit showed good evidence that it was not functioning at impact and that the main rotating assembly (gyro) was stationary. This indicates that electrical power was not supplied to the unit for some minutes prior to the impact. The two bulbs that provided the dedicated illumination for the standby artificial horizon were recovered intact and microscopic examination of the filaments showed that the bulbs were not illuminated at impact. The altimeter was severely damaged during the impact sequence but examination revealed that the sub-scale was set at a figure consistent with that last one passed to the pilot by ATC.

Many illuminated switches and captions were recovered and some were identified. The majority were broken into pieces which made the association between the illumination bulbs and the caption or switch impossible. Those few captions and switches that remained relatively intact gave indications, under microscopic examination, which were consistent with the selections appropriate to a night VFR flight and confirmed that the console illumination was selected ON. There were no indications of system failure warnings at impact from those captions or switches that could be examined. The CAP and the Master Warning Caution were recovered relatively undamaged and all the illumination bulbs were intact. None of the filaments of these bulbs showed evidence of having been illuminated at impact.

1.12.13 Interior and exterior lighting

The interior lighting consisted of the pilot's and passenger's overhead lighting, the pilot's instrument panel and compass lighting and the overhead panel, console and outside air temperature (OAT) gauge lighting.

The overhead lighting consisted of two pairs of rotatable lamp holder diffuser units (dome lights), one pair in the rear passenger area and one pair in the forward cockpit area. The forward overhead lights were equipped with individual dimmer and ON/OFF controls and were supplied directly from the battery busbar and provided emergency instrument panel and console lighting. In addition the helicopter had a 'storm' light fitted to the cabin roof near the two front seats. This light was of the non-dimmable and non-removable swivel type.

None of the four cabin rotatable lamp holder diffuser units was recovered as identifiable units. The 'storm' light unit was recovered intact and examination of the bulb filament showed that it was in a serviceable condition but not illuminated at impact.

The pilot's instrument panel lighting was provided by the light produced from a single 70 watt halogen bulb and transmitted by fibre optic guides to a number of plexiglas light-diffusers mounted on the instrument panel. The unit containing the 70 watt halogen bulb was mounted, with the lighting output at the top, on a panel in an area of the cockpit forward of the tail rotor pedals. All the single fibre optic guides were joined together to form one large male connector which was locked into the female part mounted in the unit by means of three sprung locking tangs. To disconnect the male part of the fibre optic connector an outer sleeve had to be slid back to disengage the sprung locking tangs before it could be removed from the unit.

The instrument light unit and the male fibre optic connector were recovered as separate items. Both items had been severely damaged by the post-impact fire. The 70 watt halogen bulb filament was microscopically examined and good evidence was seen to indicate that the bulb was illuminated at impact. The female half of the fibre optic coupling, which was mounted in the light unit, was examined and there was no evidence of the sprung locking tangs of the male half of the connector having been engaged in the locking grove of the female half when the impact occurred. The damage to the male and female halves of the connector were very different in that the male half was severely impact and fire damaged whereas the female half was relatively undamaged. This evidence suggested that they were either not coupled together at impact or that they were coupled but not locked together allowing them to separate freely during the very initial part of the impact sequence.

The overhead panel, console, compass and OAT gauge lighting was provided by dedicated bulbs located in or near the individual items that were to be illuminated. The control of the pilot's instrument panel and compass lighting and the overhead panel, console and OAT lighting circuits was achieved by independent ON/OFF switches and independent brightness controls. In normal operation these two lighting circuits were powered by two separate electrical power distribution busbars but if either busbar failed then, by pilot selection, the other could provide electrical power to both circuits.

The two bulbs that illuminated the OAT gauge were recovered and microscopic examination of their filaments showed that both bulbs were illuminated at impact. The two independent brightness control were identified and both were found to be set at about the three quarters brightness position. The two ON/OFF switches and the compass illumination bulbs were not identified.

The exterior aircraft lighting consisted of three position lights, one mounted at the rear and one mounted on the left and right-hand sides. There were two powerful halogen landing lights fitted to the underside of the helicopter. One light was retractable but fixed in azimuth whereas the other was a swivelling retractable unit. There were two strobe lights, one was a standard red anti-collision unit mounted on top of the helicopter's rear vertical fin and the other was a white unit mounted under the belly of the helicopter between the two baggage bays. There were two passenger boarding lights, one mounted either side above the main cabin doors.

Only one bulb from all of these exterior lights was recovered intact and this was from one of the position lights. Microscopic examination of the filament of this bulb showed good evidence that it was illuminated at impact. The swivelling retracting mechanism from one of the landing lights was identified and examination indicated that the unit was retracted at impact.

1.13 Medical and pathological information

Autopsies were performed on the deceased by aviation pathologists. These revealed that all on board died, essentially at impact, from multiple injuries.

Toxicological tests on the commander were negative and he had no pre-existing medical conditions which were likely to have contributed to the accident. Toxicological tests on the passengers revealed that some had consumed alcoholic beverages but, in the opinion of the pathologist, not in sufficient quantities to have provoked irrational or unrestrained behaviour.

1.14 Fire

The aircraft broke up on impact and caught fire. There was a large flash fire caused by atomised fuel and a number of residual fires which were extinguished by the local authority fire service. The main body of the wreckage was largely destroyed by fire.

1.15 Survival aspects

The accident was not survivable.

1.16 Tests and research

1.16.1 Helicopter handling tests

An IFR equipped AS 355 helicopter was used to evaluate the handling qualities of the type. By disabling the autopilot and autostabilisation functions, it was possible to compare the handling qualities with and without: autostabilisation, autopilot, cyclic stick spring feel and flight director.

In the basic VFR mode without autostabilisation the aircraft was easy to fly in straight and level flight at 105 kt in smooth air. However, the cyclic control was sensitive in both axes and the stick could not be trimmed to return to a fixed datum when disturbed. A nose-up pitch rate could be initiated and sustained by moving the cyclic stick aft by a few millimetres without any force feedback cue to the pilot.

Without autostabilisation pitch disturbances were easily corrected but spiral stability was weak and roll control inputs were required every 5 to 10 seconds to maintain a level attitude. With autostabilisation and cyclic stick trim engaged, the frequency of cyclic control inputs required to maintain a steady attitude was significantly reduced. Moreover, the cyclic stick trim provided a useful force feedback cue to the pilot when a control input was applied. Full autopilot allowed the pilot to control the machine 'hands off'.

The zoom climb potential of the aircraft was explored at a representative weight using maximum continuous engine power. Airspeed was reduced from 105 kt to 33 kt over a period of about 30 seconds from an entry altitude of 1,000 feet. The aircraft gained 900 to 1,000 feet altitude during the tests.

Several attempts to replicate the unusual noise heard during the last two seconds of the commander's final RTF transmission were made in daylight at low altitude. Manoeuvres including torque turns, tight turns, steep dives and steady heading sideslips were performed. The effects of stimulating the automatic engine relight system and progressively opening the cabin sliding windows at a range of speeds were also tested and recorded. The noise was not reproduced.

1.16.2 Night navigation and cockpit assessment

Pilot workload was evaluated whilst flying an AS 355 along a low-level route at night in full moonlight conditions. One hour was spent simulating the VFR mode whilst navigating with a half-million topographical chart and stopwatch at between 1,200 and 2,000 feet altitude. This phase also included an assessment of the ground lighting conditions in the accident area. A further 30 minutes was spent evaluating handling and navigation in the IFR mode at 3,500 feet altitude. The following observations were noted:

a. The flight instruments were well lit, although a variety of lighting installations exist and no comparison was possible with the accident aircraft.

b. The cabin dome lighting was too weak for easy chart reading. (The primary function of these lights is to provide back-up illumination of the flight instruments; they were not intended for use as chart reading lights).

c. When dimmed the dome lights had a yellow tint and the yellow coloured towns on a 1:500,000 topographical chart could not be easily identified.

d. Minor terrain features on the chart, depicted in yellow, could not be seen in flight due to the yellow tinted light.

e. The cabin dome light eyeball could be vectored far enough forward to shine on the pilot's left knee.

f. Even in clear air it was quite obvious to the pilot when the landing lights were switched on and pointing forwards.

g. Both left and right landing light beams were narrow (about 10° cones) and powerful; only the right swivelled in azimuth. Extension of each landing light took several seconds (8 to 10).

i. Minor terrain features could not be seen from the air from 1,500 to 2,000 feet agl.

j. There was no true horizon after astronomical twilight despite excellent visibility, no cloud and a full moon.

k. Optical perception of the horizontal plane was provided by an illuminated ground plane.

l. Unlit line features such as rivers and roads were hard to see and could not be followed. Motorways were the best line features.

m. The area between Middlewich, Winsford and Crewe was unexpectedly dark because there was little artificial lighting outside the towns.

1.16.3 Main cabin sliding door

A number of other helicopters of the same model as G-CFLT with a similar sliding door fitted to the rear left-hand side of the cabin were examined and the sliding door operated both from the outside and inside. It was found that there were three separate actions required to close the door and that they had to be performed in a set sequence to correctly close and lock the door. It was also found that the initial action required to close the door was very similar to that required to close the sliding door of a mini-bus/people-mover type vehicle but there the similarity ended. On a mini-bus/people-mover type vehicle the action of sliding the door closed as well as locating the leading edge of the door into the door frame it also located the trailing edge of the door whereas on the helicopter it did not; the trailing edge had to be located by a separate action of either pulling on a fingertip handle located on the inside of the door near its trailing edge or pushing the trailing edge in from the outside. On the mini-bus/people-mover type vehicles the sliding doors are of the slam shut type so that the one action would both close and lock the door whereas on the helicopter a separate action of rotating the locking handle was required once both the leading and trailing edges of the door were correctly located within the door frame. It was found on the helicopter that it was a great deal easier to close the sliding door with the front door open than when it was closed.

It was noted that on the inside of the helicopter door there was only one dedicated handle fitted to facilitate the closing of the door and that was the one fitted towards the door's trailing edge. This was a fingertip handle that was provided to pull-in the door's trailing edge when closing the door or to push-out the trailing edge when opening it from the inside, it could not be used to slide the door open or closed. A number of operators of the helicopter type commented that the fingertip handle was inadequate in that, in flight, it was very difficult to apply the pull force required to locate the door's trailing edge correctly within the door frame. There was no handle on the inside to facilitate the sliding of the door. A number of operators were asked how they slid the door closed from the inside and they said that they tended to push on the forward vertical door frame forward of the door's window. On the inside of the door, in the area at the leading edge below the window there was the door's locking handle which was labelled with an arrow pointing forward and the legend CLOSE and an arrow pointing rearwards and upwards and the legend OPEN. To those rear seat passengers not familiar with the helicopter this handle could be mistaken for one that could be used to slide the door forward to the closed position. If it was used to slide the door forward to the closed position then the locking pins at the trailing edge of the door would be extended to their door locked position. This would make it impossible to pull-in the door's trailing edge into the door frame.

On a number of occasions when the sliding door had been closed and locked from the inside, on the ground and in daylight, the door was found not to be correctly locked although visually the door and the locking handle indicated that the door was secure. It was found that it was possible, with the trailing edge of the door not pulled-in completely, to move the locking handle to almost the fully closed position when it would meet resistance, as if the handle had reached the end of its travel, giving the impression that it had been correctly located in the CLOSED position. What had actually occurred was that the locking pins had only partially engaged the keep plates mounted in the fuselage structure. It was found that in this condition a firm push on the inside of the trailing edge of the door could cause it to move to its open position. Once the trailing edge was open the door was free to slide rearwards. It was noted that when the locking handle was not in its fully closed position the secondary lock could not be engaged.

Attempts were made to move the door locking handle accidentally rearwards from the CLOSED to the OPEN position but, because of the location of the handle, this was found to be extremely difficult.

1.17 Organisational and management information

1.17.1 Background information

Background information on the pilot and the helicopter companies involved are contained in Appendix A.

1.17.2 UK certification

When the helicopter was first imported into the United Kingdom (UK) from Canada in 1986 it is not known to what airworthiness requirements it was certificated. When it was imported for the second time into the UK from New Zealand it was granted a Certificate of Airworthiness in the Transport Category in January 1989 after meeting the requirements laid down in Airworthiness Notice No.18 dated August 1977 and Airworthiness Approval Note No. 18466 dated March 1984. In August 1989 the CAA produced Issue 1 of 'Aerospatiale

AS 355F, F1 and F2 Additional Requirements for Certification in the Transport Category', reference 9/31/RY3001 and in September 1994 produced Issue 2 of this instruction. Paragraph 4 (e) (vii) of Issue 2 of this instruction states '*The provision of independent switches for the power supplies to the attitude indicators is not acceptable, British Civil Airworthiness Requirements (BCAR) J1-3,3.*". There were no entries in the aircraft logbooks or the maintenance worksheets, that were available, to indicate that either Issue 1 or 2 of this instruction had been carried out on this helicopter. There is no requirement to carry out the work necessary to comply with these instructions retrospectively once the initial Certificate of Airworthiness, following importation into the UK, has been issued.

1.17.3 Maintenance and modification

No aircraft or engine logbooks were available for the helicopter prior to January 1989 and no maintenance worksheets were available prior to January 1992. It is noted that paragraph 5 of Article 16 of the Air Navigation Order (ANO) requires that every logbook be preserved for a period of two years after the items to which they refer have been destroyed or permanently withdrawn from use.

Examination of the maintenance worksheets that were available indicated that the helicopter was well maintained. In September 1996 a fault was found with the cockpit instrument and console lighting that was traced to the console lighting dimmer control unit. A temporary repair was carried out to the unit whilst awaiting the delivery of a replacement item. This temporary repair routed the console lighting supply and control through the instrument lighting circuit. The engineer that carried out this work did not disturb the instrument lighting fibre optic connector mounted in the light unit containing the 70 watt halogen bulb. There were no entries in the maintenance worksheets for work having taken place on the instrument lighting fibre optic system or the light unit.

Over the life of the helicopter a large number of modifications had been carried out but only a small amount of the paperwork associated with these modifications was available. This made the task of determining what equipment was fitted and the detail of the installations virtually impossible. It is noted that Joint Airworthiness Requirements JAR-145, titled Approved Maintenance Organisations, only requires the retention of maintenance records, to which the work relates, for two years from the date the aircraft was released from the JAR-145 approved maintenance organisation.

The modification record at the back of the aircraft logbook, which was commenced in 1989, showed that the sliding door was fitted to the left-hand side of the helicopter in 1987. This modification did not require a door warning light to be fitted. However, Service Bulletin (SB) 52.08 was embodied at the same time which incorporated an indication in the cockpit when the sliding door was not correctly locked. A number of pilots and engineers who were familiar with the helicopter have stated that this modification was no longer fitted at the time of the accident. There were no entries in the available maintenance paperwork to show when the modification was removed.

1.18 Additional information

1.18.1 Applicable regulations

Regulations pertinent to the conduct of the flight are contained in Civil Aviation Publication CAP393 entitled 'AIR NAVIGATION: THE ORDER AND THE REGULATIONS'. Extracts from this document are reproduced at Appendix E.

1.18.2 JAR-OPS 3

New European regulations entitled 'JAR OPS 3 - Commercial Air Transportation (Helicopters)' - have been formulated by the Joint Aviation Authorities (JAA). The planned implementation date for these regulations is 1 October 1998. In the context of this report, the two most relevant sections concern INSTRUMENTS AND EQUIPMENT (SUBPART K) and FLIGHT CREW (SUBPART N). Extracts from these sections are reproduced at Appendix F.

1.18.3 Polo Aviation Ltd Operations Manual

Although the commander was not operating a Polo Aviation Ltd flight, that Company's weather minima were familiar to him in his capacity as Chief Pilot. Consequently it was assumed that he had been respecting the same mimina for the MGA Limited flight. The relevant section from the Polo Aviation Operations Manual governing company weather minima was as follows:

VFR-Minima: Class D, E, F and G Airspace

NOTE: All Flights below 10,000 Feet

Up to FL 100	5 Km visibility, 1,500 M horizontal 1,000 feet vertical distance from cloud.	(In Class D airspace with speed <140 kt this does not apply.)

At and below 3,000 Feet AMSL Class F and G airspace only.	Clear of cloud and in sight of surface.

The company minima for dispatch with reference to cloud base height above the surface, are:

	DAY	NIGHT
Overland	600 feet cloud base 1,000 m visibility	1,200 feet cloud base 6 km visibility Horizon clearly discernible
Over water	600 feet cloud base 6 km visibility	1,200 feet cloud base 6 km visibility Horizon clearly discernible

(a) The above minima are applicable to Group 'A', Group 'A' Restd. (and Group B. operations overland only).

(b) At all times, aircraft are to be flown at a speed which will give at least 1 minute's forward visibility.

(c) In the event of encountering weather below the above minima, either:

(i) Divert to an airfield with above minimum weather conditions, avoiding below minimum conditions en route or
(ii) Land as soon as possible or
(iii) Turn through 180 degrees.

1.19 Useful or effective investigation techniques

Not applicable

2 Analysis

2.1 Overview

The most striking clues to the cause of this accident arise from the commander's declarations that he had penetrated IMC conditions coupled with the evidence of three eye witnesses who saw the helicopter in a steep nose-up pitch attitude. These clues indicate loss of control in flight conditions which the neither the pilot nor the helicopter were qualified to enter. However, the local weather was described as fine by the witnesses who saw the helicopter's lights throughout its final manoeuvres and no-one reported seeing it penetrate cloud. Moreover, the accident might have been avoided if the helicopter had been recovered correctly from this abnormal manoeuvre.

This analysis leads to the conclusion that IMC penetration was a perception rather than a fact and explains the probable reasons for the mis-perception and unsuccessful recovery from the nose-high manoeuvre. The report ends with a resume of the findings, conclusions, causal factors and safety recommendations.

2.2 Flight constraints

2.2.1 Rules of the Air

Rule 22 of the Rules of the Air (see Appendix E) required this night flight to comply with the IFR outside controlled airspace and with Special VFR within it, but the pilot had no instrument rating and the helicopter was not approved for IFR operations. Consequently, the flight had to be conducted in accordance with Rule 29(d) which is, in effect, a dispensation to operate an IFR flight in much the same way as a day VFR flight by remaining in visual contact with the terrain.

In this manner the commander also complied with sub paragraph 2(b)(i) of the helicopter pilot's licence privileges contained in Schedule 8 of the Air Navigation Order. These require that the pilot shall not, unless his licence includes an instrument rating (helicopters), fly a helicopter on any scheduled journey or on any flight for the purpose of public transport other than in visual meteorological conditions.

2.2.2 Terrain separation under IFR

Although at night a pilot may be able to orientate himself spatially using terrain references, he may still be unable to see unlit high ground or obstacles. Even if he can see them, it is more difficult to estimate separation distances by night than by day, if only because objects lack texture and detail. For this reason, when practicable, prudent pilots observe the general statement of Rule 29 of the Rules of the Air which requires a cruising altitude at least 1,000 feet above the highest obstacle within 5 nm of the aircraft. This altitude is usually known as the minimum safe en route altitude or 'MSA'. In practice an MSA is calculated for each leg or section of the route.

South of Bolton, the MSA along the intended route to Shawbury was 1,800 feet. Along the route which the aircraft was taking (which was not the planned route) it was 2,200 feet. This assumes that the commander knew where he was and where he was heading when he deviated from the plan. If he had become uncertain of his position, the appropriate MSA was the published minimum within 25 nm of Manchester Airport which was 3,500 feet.

2.2.3 Relationship between cloud base and MSA

Rule 29(d) requires a helicopter to fly below 3,000 feet amsl and below any overcast cloud layer. If a helicopter is flying at or above 'MSA' there is no danger of inadvertently flying into an obstruction and the pilot is able to concentrate on flying without the added worry of proximate obstructions. However, if as in this case, the flight has to remain below an overcast cloud layer which is itself below 'MSA', then the pilot must avoid obstacles by detouring around them. The commander was advised to detour via Shawbury and thereby avoid the 'hills south of Manchester'. Reasonably good weather, suitable topographical charts, pre-flight planning and accurate navigation are pre-requisites for safe flight in these conditions.

2.2.4 Navigation aids

Most of the navigation aids installed in G-CFLT relied upon ground beacons. The nearest VOR/DME beacon was at Manchester Airport and it could have supplied the commander with a range and bearing. However, the commander was not intending to fly along a constant bearing (a radial) from this beacon and so the information would have been of limited use unless he had carefully calculated the range and bearing of each turning point from the nearest beacon before flight, and entered this data into the RNAV computer. Even if he had done so, the RNAV was vulnerable to reception range problems at low altitude.

The commander could have made use of the portable GPS carried on the instrument coaming. There are many types of GPS receiver, all working on the same principle, yet having different user interfaces with idiosyncrasies which require familiarity. Most can be initialised without detailed knowledge of the particular equipment and they will present the user with an accurate present position. However, the present position output of the GPS 100 is in latitude and longitude which is virtually unusable by a pilot flying a helicopter without an autopilot.

The commander may have used the same type of GPS before but it was not a type he used regularly and he had not used the specific receiver before (ie the database of user defined waypoints). Consequently, he may have been unable to enter user waypoints and thereby exploit fully its capabilities. He may have been able to use the 'GOTO' facility but that would have depended upon the presence of the desired waypoint in the database plus his knowledge that it was there and its assigned name.

Lacking a good working knowledge of the GPS, the commander would have had to resort to chart and stopwatch navigation techniques, perhaps supplemented by GPS guidance to any waypoints already in the database. According to people who had flown with the commander this was his preferred operating technique.

2.2.5 Low altitude navigation

The normal method of chart and stopwatch navigating at low altitude requires pre-flight planning. The route is marked on a suitable topographical chart and the tracks and distances for each leg are measured and recorded. Prudent pilots then make allowance for forecast wind effect when calculating headings and times for each leg.

In flight the pilot flies the calculated compass heading at the appropriate airspeed and then observes any deviation from the planned track and timing. To do this successfully the pilot must frequently cross refer between his chart and the visible features ahead. The only reliable features are areas of terrain with marked changes in reflectivity such as lakes and coastlines, or features rich in electric lighting such as arterial roads, towns and masts.

Whilst flying without an autopilot, the pilot has to read the chart using fairly dim light and numerous glances, each of a few seconds at most. It is difficult for him to keep track of his current position unless he uses a finger or thumb as a moving marker, but he cannot do so whilst holding up the chart to inspect its detail. With these constraints it is very difficult for the pilot to fix his position if he deviates from the planned track, but deteriorating weather ahead may force him to deviate. The worse the weather becomes, the harder is the pilot's task, particularly if he has other concurrent duties such as attending to his passengers and liaising with air traffic control.

2.3 Pre-flight planning and activity

2.3.1 Weather forecast

Before taking off from Stapleford Tawney the commander obtained actual and forecast weather reports for numerous airports throughout England but by the time the football match had ended, these forecasts were hours old and he needed to update them. At the football ground he had two choices: either to telephone for the pre-recorded aviation information available from the CAA, or to contact a forecaster. He chose the latter option and obtained a route forecast.

The forecaster was well acquainted with helicopter operations and was able to advise a suitable route and provide a forecast for that route. The meteorological aftercast established that the forecast was accurate and the advice sound because the route followed the general pattern of low ground between Manchester and Birmingham.

2.3.2 Weather limits

The minimum weather parameters for dispatch of a night flight in visual conditions should ensure that the flight can be conducted safely with adequate margins for unexpected weather deterioration and obstacle clearance. The limits in the Polo Aviation Ltd Operations Manual, with which the commander was most familiar but not necessarily observing, were 1,200 feet cloud base height above the surface, 6 km visibility and a clearly discernible horizon.

The RTF transcript reveals that initially the commander intended to follow the routing advice given to him by the forecaster. For takeoff he could estimate the weather conditions in the Bolton area and it is self-evident that they were adequate. For the remainder of the route, the forecast visibility exceeded the 6 km minimum and so, apart from the requirement for a discernible horizon, the only problem was likely to be low cloud. Between Manchester and Birmingham, where the cloud was likely to be lowest, the highest ground he would have had to cross was about 500 feet amsl.

Area weather forecasts quote cloud bases above sea level so to determine whether the cloud base is suitable for despatch along a route, it is necessary to compare the height of the terrain en route with the forecast cloud base. In this case, to comply with the limits, the commander required (at the planning stage) a cloud base not lower than 1,700 feet amsl along the planned route.

He was advised that the main cloud base was approximately 2,000 feet amsl and south of Birmingham there would be no significant cloud. The scattered cloud around Manchester (scattered means between a quarter and a half of the sky is covered with cloud) would not preclude flight in accordance with Rule 29 (d) because the flight could be conducted in clear air above that layer with large gaps through which the ground would remain visible. The only forecast cloud that was problematic was the overcast (full cover) or broken (5/8 to 7/8 coverage) cloud at 1,000 feet on hills to the south, and the commander intended to avoid this area.

There was no specific weather parameter that was demonstrably below the minima for which the commander had responsibility, other than in localised areas and for which he had a reasonable avoidance strategy. Therefore, the weather conditions were acceptable for attempting the flight.

2.3.3 Visual horizon

It would have been difficult to determine before takeoff whether there was a visual horizon all the way from Bolton to London. The presence and suitability of a visual horizon are subjective in nature and sensitive to many variables, and there seems no practical method of forecasting a discernible horizon. Although the moon was nearly full, moonlight alone does not provide a horizon, even in excellent visibility. In practice it is the light from urban areas which provides a good indication of the ground plane and hence indications of pitch attitude and bank angle. A similar effect may be produced by light reflected by a cloud layer. More dispersed lighting in rural areas can also provide horizon cues but in some isolated areas where there are few if any lights, the horizon cues may be sparse or even misleading. Consequently the presence of a horizon would be indeterminate for a long flight under variable cloud coverage over a mix of urban and rural terrain.

On the accident flight a useful horizon would have existed over the urban areas and might have existed where there were breaks in the cloud to allow moonlight to shine through and illuminate individual clouds. But where the cloud coverage was extensive and thick over rural areas, the moonlight would be obliterated and there would have been little or no discernible horizon. Consequently, if the lack of a visible horizon was to become a problem during the flight, it was most likely to occur over a rural area somewhere between Manchester and Birmingham where the cloud coverage was extensive and multi-layered.

2.3.4 Flight planning

Most of the cockpit paperwork including the helicopter's technical log was destroyed by fire. The charred remnants of a pilot's kneeboard was found but no flight log or loose (ie in-use) chart was recovered.

Any reasonable route from Bolton to Heathrow would have spread across 3 quarter million scale topographical charts or 2 half-million scale charts. The obsolete quarter million charts in the commander's flight bag bore a likely route but they could not have been in use and the leg times were inappropriate to the cruising speed of a turbine powered helicopter. There were several of these obsolete charts in the bag and given the limited space available, it is unlikely that the commander would have carried a duplicate set of up-to-date charts. There was, however, one half-million scale chart in his bag covering Scotland, dated September 1993, but the equivalents for northern and southern England were missing. These two charts would have covered the entire flight. Consequently, it is likely that the commander kept the quarter million charts for reference but used half-million scale charts in flight, and that the latter were destroyed in the post-impact fire.

The commander needed time and external light to study a chart three times before takeoff. He may have been attempting to memorise the route or determining the correct motorway at which to turn south, or he may have been studying the chart for areas of high ground en route. Whatever concerned him, it took more than a quick glance to satisfy him. The most logical explanation for not using the security guard's lighted office is that the commander realised that after takeoff he would have to rely on the dimmed cabin dome lights and he did not wish to destroy his night vision adaptation.

There is, therefore, no evidence to indicate that detailed planning and chart annotation was either done or not done before the aircraft arrived in Bolton. However, there were no reported sightings of the commander amending his route and re-calculating his headings and times for the Shawbury leg, either at the football ground or at the helicopter. Therefore, it is unlikely that the section of the route from Bolton to Birmingham via Shawbury was a pre-planned route or a contingency option for which the headings and leg times had been carefully calculated.

2.4 Conduct of the flight

2.4.1 Navigation

Shortly after takeoff the commander asked for radar vectors direct to the Shawbury overhead from his position near Bolton. The controller rightly declined to provide radar vectors because the aircraft's altitude was below the minimum safe altitude for the area. She reminded the commander that he was responsible for his own separation from terrain and weather before she offered to provide suggested radar headings, an offer which the commander accepted.

When the helicopter was 16 miles north-west of Manchester Airport (incorrectly stated as north-east) the controller advised the commander of the recommended track for Shawbury of 190° to which the commander replied "ROGER TURNING LEFT ONTO ONE NINE ZERO" meaning a heading of 190°. There would have been little drift on that heading so turning onto 190° was not unreasonable but the commander's immediate response indicated that he was not flying a pre-planned heading corrected for drift. Another example of this disregard for drift occurred when the helicopter was overhead the southern end of the Manchester VFR corridor when the controller said "GOLF LIMA TANGO SUGGESTED TRACK FOR BIRMINGHAM IS ONE FIVE ZERO DEGREES". On this track there would have been appreciable drift but again the commander turned without allowing for wind effect. The controller, however, was alert and she reminded him of the need to allow for drift but the track plot indicates that he still did not do so.

These verbal exchanges would not have occurred if the commander was following a pre-planned route using basic heading and stopwatch techniques with sensible allowances for wind effect. Equally, had he been using the GPS or RNAV to home to a waypoint, he would not have needed advisory headings. Consequently, the commander's actions and words indicate that he was relying on the controller for directional guidance.

2.4.2 Flight progress

Apart from the inappropriate reliance on advisory headings for navigation, the flight from Bolton to Winsford seems to have progressed uneventfully, at least until it reached Winsford. The transcript and radar data for 2138 hrs show that the commander was cruising at 1,600 feet altitude over Warrington. This was probably just below the cloud base which would have been about 1,500 feet above the ground. A little further south the aircraft disappeared from the coverage of the area radar at St Anne's and then reappeared on radar near the crash site which may be an indication that the helicopter had descended to a lower level near Winsford.

All the while the commander sounded relaxed on the radio and even if the cloud base was lower, the witness in Winsford who was used to seeing helicopters was surprised only by the time of day and the brightness of the helicopter's lights. Therefore it seems likely that the helicopter's height was not particularly low when it passed over Winsford and that the commander was not embarrassed by the lowering cloud base. Indeed, all the estimates of weather point to a cloud base of 1,200 feet agl in the Winsford area which would have been acceptable for continued flight provided the aircraft remained over flat terrain.

2.4.3 Cruising speed

The radar data showed the aircraft cruising at about 95 kt ground speed which, allowing for wind effect, was consistent with a cruise airspeed of 105 to 110 kt. This is some 10 to 15 kt slower than the fast cruising speed achieved by using maximum continuous power but this airspeed is consistent with the 105 kt planning airspeed contained in the Polo Aviation Ltd Operations Manual. The commander was the only Polo Aviation Ltd pilot to fly the Twin Squirrel and he would have chosen this speed to suit his own operating preference. Therefore, it was considered that the slower cruising speed was normal and not an indication of any aircraft malfunction or operating problem such as reduced forward visibility.

2.4.4 High ground near Manchester Airport

There are hills to the east of Manchester Airport which are nearly 2,100 feet high. They gradually reduce in height until they disappear some 30 miles south of the airport at the River Trent valley near Stafford. To the commander of a fixed-wing aircraft approaching the airport under IFR, the hills to the east are dominant because they are close to the final approach track for Runway 24. The hills to the south are lower and well away from the extended runway centrelines for either runway. They are, therefore, insignificant to fixed-wing IFR operations.

This is not the case for the pilot of an aircraft forced to fly beneath a 1,200 foot cloud base. The 900 foot hills around Stoke-on-Trent (some 20 nm south of Manchester Airport) are highly significant because they could be uncomfortably close beneath the aircraft. Nevertheless, any air traffic operating in this area at such a height would normally be operating VFR and responsible for its own navigation and terrain avoidance.

2.4.5 Deviation from the intended route

Much of the dialogue whilst the aircraft was flying through the Manchester Control Zone (CTR) has no relevance to the accident but one aspect of the conversation was highly relevant. The controller was unsure why the commander wished to route via Shawbury and twice she asked him to explain why. The first time she asked the commander explained "THATS JUST TO AVOID THE HIGH GROUND TO THE SOUTH OF MANCHESTER". The second time she asked he replied "I JUST WANT TO AVOID THE HIGH GROUND SOUTH OF YOU WHEN CONVENIENT I'LL TURN TOWARDS BIRMINGHAM".

What the commander probably meant in his second reply was that he wanted to head south until he was beyond the hills around Stoke-on-Trent and then to turn left onto a track for Birmingham. Unfortunately he did not say so and the controller gave him a track for Birmingham as soon as the helicopter vacated the Manchester zone. This was 'convenient' to the air traffic situation and Manchester ATC did not consider the hills around Stoke-on-Trent to be 'high ground'. Nevertheless, the commander was ultimately responsible for navigation and he could have turned right towards Shawbury, followed the M6 motorway or simply maintained a southerly heading across the Cheshire plain towards Telford. That he did not do so is another indication that he was overly and unwisely relying on the controller for navigation. The consequence was that the aircraft significantly deviated from the intended route.

2.4.6 Controller's actions

The radar controller gave the commander a recommended track for Birmingham Airport as soon as the helicopter vacated the CTR. Seconds later she also reminded him that he was responsible for his own terrain separation and, in effect, offered to lift the previously imposed altitude restriction by asking him if he wanted to climb. In the circumstances her actions were entirely proper and reasonable. The inappropriate track would not have developed into a safety issue if the commander had realised that he had failed to communicate his exact requirements to the controller. Being outside the CTR he was free to take up any heading with a southerly component but he accepted the controller's advisory heading without question or compensation for drift. In so doing he turned towards the high ground surrounding Stoke-on-Trent, the area he had been advised to avoid by the meteorological forecaster.

2.5 Flight beyond Winsford

2.5.1 Commander's awareness

If he was unsure of his position the commander could have asked the controller but that might have alerted those passengers wearing headsets to his predicament which would have been embarrassing for him. If he was unsure but still intent on flying towards Shawbury then a logical request would have been to ask the controller for clearance to fly in that direction. She had no reason to withhold such a clearance and she would probably have cleared him with an advisory heading which would have spared his embarrassment.

On the other hand, unless the weather had appeared to be worse towards Shawbury, it is not clear why he did not follow his intended route and thereby avoid high ground. The aircraft had plenty of fuel and Heathrow Airport remains open all night so there would have been no pressing reasons for the commander to route direct to Birmingham. His custom of flying at 10 to 15 kt slower than the fast cruise speed also suggests that he was not concerned with minimising the transit time. He appears to have made good a track of about 135° which is consistent with adopting the recommended track as a heading and steering 150°, having effectively ignored the advice to allow for wind drift. Therefore, it seems likely that the commander was, at least initially, unaware that he was heading towards high ground.

2.5.2 The decision to climb

It was not possible to determine precisely why the commander changed his mind so quickly after the controller asked if he wished to climb. He may have interpreted the controller's remarks about terrain separation as a hint that he ought to climb but at the time he was unlikely to have seen the hills ahead. However, after a few seconds thought, he may have realised that on a heading of 150° the helicopter was bound to close with the high ground which he had been advised to avoid, and which was his original intention.

The commander was off the intended track and below MSA. He may also have been uncertain of his position and forced to descend by a lowering, broken cloud base. With cloud just above him the commander must have known that climbing was not the safest option for dealing with his uncomfortable predicament. However, he had other options. If the weather conditions were deteriorating, he could have turned about or diverted to Manchester Airport. Alternatively, if the weather was not deteriorating, he could have retrieved the situation by turning right for Shawbury or following the M6 motorway, but these two options were impractical unless he knew where he was, and he was probably too pre-occupied with other tasks to keep abreast of his exact position. Climbing to 3,000 feet could have solved all his navigation problems. The extra altitude was sufficient to clear the hills south of Manchester and it would have enabled him to receive transmissions from the ground navigation beacons which he may have needed to fix his position or home towards a suitable beacon.

One of the helicopter's retractable landing lights was on and pointing forwards when the helicopter was observed by witnesses in the vicinity of the accident site. There was no indication within the radio telephone (RTF) dialogue that the commander intended to land and it is unlikely that he had forgotten to turn it off after takeoff because the beam can be seen from the cabin when it is pointing forwards. However, there are two likely reasons for the light being on. Firstly, the commander could have kept it switched on as an aid to conspicuity but there was no real need to do so. The helicopter had a flashing strobe light specifically to provide conspicuity, there were no other aircraft working the radio frequency and the commander was receiving a radar information service from Manchester ATC which would have alerted him to the presence of conflicting air traffic. The light would have interfered with his forward view to some extent and so to have kept it switched on to enhance conspicuity seems illogical under those circumstances. The second likely reason would be to use the powerful beam to search for cloud. This may be a clue to the commander's intentions to find a clear gap in the cloud layer through which to climb. Consequently, the rapid change of mind about whether or not to climb could have been because he unexpectedly came upon a suitable gap. All the weather reports indicated there were gaps in the lower layer and nobody saw the helicopter penetrate cloud so it seems likely that the commander exploited a gap with the intention of continuing, either by pure instrument flight or by flying 'VFR on top', until the cloud dissipated south of Birmingham.

2.5.3 Entry into the climb

The reduction in airspeed seen shortly after the helicopter turned left occurred at the same time coverage from St Annes radar was restored, having been lost some minutes before, and just after the radar controller cleared the commander to climb. The combination of these facts indicates that the reduction in airspeed was consistent with climbing. Also, the commander's request was made before the climb started which suggests that he had not initiated an emergency pull-up manoeuvre after penetrating cloud.

Another significant aspect of the climb is the track change onto east which happened during the few seconds between making the request and receiving the clearance. The track alteration of about 35° to the left equates to a heading change of some 30° which appears to be quite unnecessary for the avoidance of obstacles or towns. One reason for the turn could be that the commander applied additional power but did not compensate with right yaw pedal and the heading changed accordingly, but in view of his experience and qualifications on helicopters, this seems unlikely. A more plausible reason would be to exploit a gap in the lower cloud layer by climbing though it to reach clear air. If so, the left turn reinforces the probability that the commander had seen a gap. However, there is a third possibility and that is that the commander's instrument flying skills had degraded to the extent that he did not notice or correct the unwanted left turn.

In the climb the helicopter's airspeed began to reduce and went on reducing to speeds significantly below any sensible climb speed; it fell from 105 kt to 33 kt or slightly less in 30 seconds. As the trials showed, this would have resulted in an altitude gain of between 900 and 1,000 feet.

The nearest eye witness likened the climb manoeuvre to a stall turn and stated that the pitch attitude was almost vertical for a short while before the machine turned to the right and entered a steep dive. A true stall turn would have resulted in a ground speed below 30 kt and the radar trace shows that the helicopter always had forward speed. However, this is not incompatible with the witness's perception because his perspective could have been affected by the aspect from which he saw the helicopter's manoeuvres. For much of the period of low airspeed, the helicopter was travelling towards the witness. Consequently, its flightpath may have appeared to be more vertical than was actually the case. Of the other eye witnesses to this part of the flight, one in a car also reported that the helicopter was almost vertical. He was diametrically opposite the nearest witness and so could have seen a similar illusion. Therefore, although the helicopter appeared to two witnesses to be travelling vertically upwards, it did not necessarily do so, although the climb was undoubtedly steep. The main consequence of the steep climb was that the commander was deprived of visual ground references.

Given the aircraft's sensitivity to cyclic pitch inputs and the lack of force feedback cues, it is entirely possible that the commander moved the cyclic stick aft to initiate the climb but failed to stabilise and monitor the required climb attitude. The helicopter could then have continued slowly pitching upwards with the airspeed reducing without any feedback cues to the commander, other than that given by the attitude instruments. For some reason the commander may not have noticed the pitch attitude developing until the airspeed was well below the minimum for instrument flight and the machine was becoming increasingly unstable due to lack of airflow over the vertical fin and horizontal stabilisers. At that stage, safe recovery depended on his instrument flying skills.

A similar process occurred during an incident which was investigated by the AAIB and reported in Aircraft Incident Report 5/95. In that incident the helicopter pitched up and lost forward airspeed which led to control difficulties, an erratic flightpath and a recovery dive comparable to this accident.

2.5.4 Radio transmissions

The first indication that the commander was in difficulty was his request for "a heading straight back to the field"; in this context "the field" meant Manchester Airport. Deductions can be made from superimposing this transmission on the helicopter's flightpath over the ground (see Appendix D).

Firstly, for several seconds before he asked for a heading to the Airport, the helicopter's flightpath was erratic and its airspeed was unusually low. Secondly, when the commander next transmitted, airspeed was increasing rapidly and by then, the helicopter's nose was almost certainly pointing downwards. When asked if he had a problem, the commander twice replied that his problem was that he was "INDIA MIKE". Had he been aware of a mechanical or electrical failure, under the circumstances the commander would have declared it, if only to spare himself any professional embarrassment. Consequently, when he declared the fact that he had inadvertently penetrated IMC conditions, it is most unlikely that he was aware of any significant malfunction within the helicopter.

2.5.5 Disorientation

The commander's final words to ATC "YEAH I'M LOOKING FOR VECTORS FOR AN ILS I THINK I'M IN A DESCENT AT THE MOMENT HOLD ON" could be interpreted in two ways. Either he thought he was descending, or he thought he wanted an ILS approach. A close relative and a friend were in no doubt that he meant the former and so the analysis proceeds on the basis that he thought he was in a descent.

The erratic flightpath illustrated by the radar data and the harsh manoeuvring heard by witnesses are both indicative of pilot disorientation but the commander's use of the words "I THINK" are the key. Had he been sure of the flightpath he would not have used these words and the tone of his voice revealed that he was acutely aware that he was in difficulty.

Another clue to disorientation was the commander's desire to climb above 3,000 feet. The request was made after the helicopter had reached its apogee. Moreover, the maximum altitude the helicopter could have reached was in the order of 2,350 feet amsl (ie having gained 1,000 feet from an entry height of 1,200 feet above the ground which was 150 feet amsl). To have asked for a further climb when the helicopter was well below the cleared altitude, and according to eye witnesses clear of cloud and in a descent, was illogical unless the commander was disorientated.

The sum of the evidence indicates that the commander became disorientated after he lost external visual attitude references.

2.6 Human factors

2.6.1 Instrument flying recency

The commander's instrument flying skills had not been formally examined since April 1992 when he renewed his military instrument rating and examiner status. In his civilian career there was no requirement to rehearse recoveries from unusual positions and his night base checks had been conducted where ground lights are abundant. Furthermore, he had not undergone a night line check and he had not been required to demonstrate his ability to cope with sudden and unforeseen cloud penetration.

Instrument flying skills are foremost amongst those pilot skills which suffer through lack of use. Having not flown in IMC regularly and recently, the commander's instrument flying skills would undoubtedly have degraded relative to his former capabilities.

2.6.2 Standby attitude indicator

Had the commander looked at the standby attitude indicator, he would have been faced with conflicting information because it was unpowered. The instrument had its own lights which were off but if he could still see it by the light of the cabin dome lights, the indications would have been erroneous. The instrument had a small warning 'flag' which shows when the instrument is unpowered but the flag is not always noticed during a quick glance.

Unusually for AS 355s on the UK Register, G-CFLT had a separate ON/OFF push-button switch for the instrument. It was not possible to determine whether the switch was on, only that the instrument's gyroscope had been unpowered for some minutes before impact. Nevertheless, the standby instrument was powered from the same busbar as the transponder and that was working, so unless the individual fuse had ruptured, power was most probably available at the instrument switch. By far the most likely explanation for the instrument being unpowered was that it had not been switched ON at the beginning of the flight.

2.6.3 Commander's disorientation

Evidently the commander was attempting to regain control of the helicopter but not succeeding and, in the absence of any equipment malfunction, the most likely reason was that he was unable to resolve his disorientation.

If the helicopter pitched upwards slowly and steadily for 30 seconds, the pitch rate would probably have been sufficiently low that the commander would not have been aware of the attitude change without reference to the attitude indicator. If so, when he first noticed that the situation was deteriorating, he probably believed that he was still in a shallow climb attitude. He would then have been faced with a mismatch between his expectations and the indication on the main attitude indicator. In not sensing a change in pitch attitude and, believing himself to be in a shallow climb, the commander would have to decide whether his sensations were wrong or whether the attitude indicator had failed.

One way a pilot can convince himself that it his sensations and not the instruments which are at fault is to compare the primary attitude indication with the secondary. If both instruments are giving much the same attitude information, the pilot may safely assume that he is suffering from an illusion. But if, on the other hand, he mentally senses one attitude, sees a second on the primary attitude indicator, and a third on the standby instrument, he could well be hopelessly confused as to which is correct. He may resort to using each in turn to see which produces sensible correlation from the other instruments but the correlation lags behind the attitude change and the instruments have to be given time to steady. If he does react to each in turn, the flightpath is likely to be erratic and feature abrupt changes as the pilot resorts to ever more rapid and bolder control inputs to address a deteriorating situation.

The manoeuvres flown by G-CFLT and the rapid changes in the noises produced by the main rotor blades were consistent with the situation described above.

2.7 Possible subsequent malfunction

The possibility of an aircraft malfunction during the dive was considered because a buzzing noise was audible in the background of the commander's final RTF transmission. It was increasing in amplitude but was not so loud as to be immediately apparent to the casual listener. Several witnesses reported that the engines were misbehaving and the possibility that the noise was linked to engine behaviour was examined. There was also an orange flash reported by one witness which came "shooting out" from the rear of the helicopter's fuselage during the dive.

2.7.1 Unidentified noise

The buzzing noise could not be reproduced during flight trials which included manoeuvres similar to those reported by the eye witnesses. The auto-relight systems were tested in flight but found to be inaudible both within the cabin and when transmitting on the radio. Other faults were postulated but there was no physical evidence of any significant malfunction within the helicopter's critical systems.

The most probable source of the buzzing was either electrical interference affecting the radios or acoustic noise which became apparent when the sliding passenger door came open. Electrical interference could have affected the helicopter's transmitter but the likelihood was considered small, given the absence of similar noises throughout the earlier part of the flight. However, evidence was found within the wreckage which showed that the sliding passenger door on the left side was partially open at impact.

The commander had remained seated at the controls when the passengers boarded the helicopter so a passenger must have closed the door. Although the commander probably watched him do it to ensure that the door was closed, there was no indicating light for this door to show that the locks were properly engaged. The door could have appeared to be closed but then sprung open later in the flight.

The possibility was considered that the door had opened at the time when the helicopter had begun to follow an easterly track. The natural reaction of the pilot would have been to reduce airspeed and the radar confirms a marked reduction in speed at this point. However, as has been already been discussed at paragraph 2.5.3, the reduction in speed was consistent with a climb which the pilot had previously requested. Furthermore, there is no evidence of a similar noise on the four calls before the final RTF transmission on which the noise became evident. Therefore, it seems more probable that the door sprang open during this final transmission.

There were limitations placed on the door in flight. When establishing these limits, the manufacturers must demonstrate safe operation at slightly higher speeds than the published limits. The quoted maximum speed for opening or closing the door was 60 kt but with the door fully opened or removed, the limit was 110 kt.

When the noise was first audible, the helicopter's airspeed was between 89 and 97 kt so the partly open door is unlikely to have caused a significant control difficulty at that moment. The helicopter's speed during the remainder of the dive could not be calculated with the same degree of confidence as for the earlier portions of the flight but the data trend indicated a top speed no greater than 130 kt, which corresponded closely to the ground impact speed calculated from the impact marks. Consequently, when the door opened, it was probably as a result of losing control and not a causal factor of the loss of control. Nevertheless, when the door opened the distraction would undoubtedly have compounded the commander's difficulties.

2.7.2 Engine failure

The reports by several witnesses that the helicopter's engines had failed during the manoeuvres were not supported by all the witnesses, some of whom were convinced that the engines were working normally until impact. In practice, it is difficult to hear the sound of a turbine powered helicopter's engines in flight because the sounds made by the main and tail rotors are dominant. These sounds will vary a great deal if the machine is manoeuvred in a spirited or harsh manner and it seems likely that variations in the main rotor blade noises are what some witnesses reported. Nevertheless, their impressions of engine failure were not lightly discounted during the investigation and the failure of both engines was considered.

If both engines had failed at the top of the climb, the helicopter would still have had ample kinetic energy for a controlled forced landing which the occupants could and should have survived. Moreover, both engines were running at impact although they could have flamed out for some unidentified reason and have been relit during the subsequent dive by the automatic relighting system.

2.7.3 Flash of light

The flash of white and orange light from the centre of the helicopter is more difficult to explain. Being silent it was not an explosion and it might have been a visual effect caused by the strobe lights or it might have been produced by one of the engines.

Temporary fuel starvation due to an extreme body attitude which was corrected by the auto-relight system was considered. However, engine stability in extreme attitudes is not a problem during training and testing and, as the helicopter was carrying ample fuel, the probability of the fuel supply pipe becoming uncovered during the manoeuvre was considered to be most unlikely. The abrupt changes in main rotor blade noise heard by many witnesses could be caused by the commander's movements of the flight controls as he attempted to regain control. This in turn places large demands upon the engine governors and consideration was given to this causing overfuelling of the engine(s) resulting in a brief flash of excess fuel burning in the exhaust. Operating experience has also shown that engine stability has not presented a problem during large power demands. The evidence indicates that both engines were running at impact and it is concluded that the flash, whatever it's cause, was likely to have been a benign event and one of which the pilot was probably not aware.

2.7.4 Instrument lighting failure

The microscopic analysis of the various lighting and warning caption bulbs which were identified made it clear that there had not been an electrical failure or a failure of any of the significant aircraft systems. In particular the 70 watt halogen bulb, which was the source of illumination for the pilot's instrument panel lights, was shown to have been illuminated at impact. The male fitting, for connecting the bundle of fibre optic cables to the unit in which the halogen bulb was mounted, was found separated from the female fitting among the wreckage. If the fitting had been positively locked in engagement, separation at impact could not have occurred without leaving distinctive evidence. The absence of such evidence leads to the conclusion that the male fitting was not positively locked in position. However, it is inconceivable that the pilot would have embarked upon a night flight without instrument panel lighting. This suggests that the male fitting was sufficiently engaged (but not positively locked) to transmit the light to the instrument panel along the fibre optic cable and provide normal lighting. The fitting is inserted at the top of the bulb unit and, under normal operations, gravity helps to keep it in this position. There was nothing in the maintenance records to indicate that this unit had been disturbed and it seems likely that the unit had been flying in this condition for some time.

Consideration was given to the possibility that the male fitting had become completely disconnected during the harsh manoeuvring of the accident sequence. There is unlikely to have been any significant failure of the helicopter systems up to the point when the commander transmitted that he was "...INADVERTENT INDIA MIKE" otherwise he would have declared it to save himself professional embarrassment (see paragraph 2.5.4). From that point until his final transmission some 20 seconds later he would still have had the opportunity to declare an emergency, but his requests for a "...A FURTHER CLIMB..." and "...AN ILS..." suggest that there were no failures of which he was aware. This leaves the final 30 seconds of the accident sequence. The radar evidence suggests that the helicopter was experiencing positive g manoeuvres during this interval which would have tended to retain the connector in position. Although disconnection of the light fitting during this final period could not be positively eliminated it seems more likely to have been a feature of the impact.

2.7.5 Unlawful interference

The possibility of unlawful interference with the helicopter was considered but there was no evidence of an explosive device or tampering in the wreckage. Before the fatal flight the helicopter had been parked within a reasonably secure area at Bolton and a security guard had watched over it for part of the time. The helicopter was behaving normally between Bolton and Winsford and the first indication of abnormal behaviour occurred after the commander had announced his intention to climb. The probability of timing an act of unlawful interference to coincide with an unplanned and unexpected manoeuvre is too remote to be a realistic consideration. Unlawful interference may be eliminated as a factor.

2.8 Recovery of control

The commander could have seen the lights of Middlewich in the last 10 to 20 seconds of flight, thereby allowing him to appreciate the helicopter's true attitude. If it was not too extreme he should have been able to avoid the ground had he realised its proximity. Factors which may explain why the aircraft struck the ground in a relatively high speed dive are considered below.

2.8.1 Incapacitation

The final radio message from the commander occurred 30 seconds before impact and the possibility that he subsequently collapsed under extreme stress was considered. He was talking lucidly during the last message and the autopsy found no evidence of any medical condition which was likely to have incapacitated him. Similarly, there was no evidence of toxicological impairment. Witnesses heard the helicopter manoeuvring harshly in the last few seconds of flight and the radar data shows evidence of tight turns just before impact. The ground marks at the crash site established that the machine had been in an erect dive with pitch and roll attitudes within the normal range for controlled flight. There was also good evidence that the collective pitch lever was close to the fully up position. Consequently, it seems highly probable that the helicopter was being flown by someone throughout the last 30 seconds of the flight.

The flight controls for the front left seat occupied by the client had been removed and he was the only passenger able to reach the cyclic control in front of the commander. The client was not a pilot and never had been. Had he attempted to fly the helicopter, he would most probably have moved this sensitive control sufficiently to cause the machine to pitch or roll far more wildly than appears to be the case according to the eye witnesses who had a good view of the aircraft's final dive. Consequently pilot incapacitation as a contributory factor was considered to be most unlikely.

2.8.2 Pilot workload

In times of high workload a pilot's brain can become saturated with competing tasks. Frequent practice, experience and individual ability allow some pilots to cope with more tasks than others but every pilot has a limit to the number of tasks which he can address simultaneously. When that limit is exceeded, the pilot must resort to prioritising tasks which are addressed consecutively rather than concurrently.

During his attempted recovery from the nose-high unusual attitude the commander would have had to prioritise his tasks. To some extent his brain would have done that automatically by failing to register events and indications which were not identified as demanding immediate attention. He indicated that he was approaching task saturation when he asked the radar controller to "HOLD ON". That very message indicated that he wanted to stop talking and deal with a perceived problem. Exactly what he was concentrating on for the remainder of the 30 seconds cannot be determined but there was no logical reason for the sharp left turn eight seconds before impact unless the commander was disorientated. He may have given up looking for external attitude references, especially since there probably were none until the last few seconds of flight, and fixated on the flight instruments trying to resolve confusing indications. Consequently, the commander may not have been looking for visual references at the time they became available; he was probably still disorientated when the helicopter struck the ground.

2.9 Commercial pressures

Unfortunately, commercial pressures, particularly those which affect the one-man charter company and the newly formed company competing for business, can adversely affect a pilot's judgement. For instance, in this accident, to have turned back at the first sign of difficulties ahead may have been the commander's instinct, but his fledgling business needed the client's custom. The client had chartered the helicopter in order to travel to a football match and return to London that same evening. This was the first of seven similar trips arranged for him by the commander, and for the latter to have failed to complete the first task could have jeopardised the business agreement. Consequently, there could have been intense commercial pressure upon the commander to 'press on' towards London, whatever the weather. The risks in so doing would have been much less had the commander been instrument rated and in good practice at instrument flying.

2.10 Interim safety action

When it became clear to the investigators that weather conditions and recency were causal factors in this accident, the AAIB held discussions with the CAA to establish measures which would improve safety in the interim. Following these discussions three safety recommendations were made to the Authority in December 1996; these are repeated in Section 4.

On 20 December 1996, in a letter addressed to all helicopter AOC holders, the Authority issued new instructions to helicopter operators. The letter instructed operators to include training and testing in recovery from unusual attitudes for non-instrument rated pilots operating public transport flights by night. It also included revised guidance on the weather minima for despatching a night flight. The letter of 20 December 1996 was subsequently amplified and refined in a second letter dated 12 February 1997. Copies of both letters are at Appendix G.

2.11 Current regulations

The privileges of the professional pilots' licences for fixed and rotary wing aircraft are contained in Schedule 8 of the Air Navigation Order. When used in their abbreviated form (ie CPL, ATPL) these licences bear the suffixes 'A' for aeroplanes and 'H' for helicopters contained in brackets eg [CPL(A), ATPL(H).]

2.11.1 CPL and ATPL

The major difference between the CPL and ATPL for either discipline is the limitation upon age whilst in command of a machine which has a maximum total weight authorised exceeding 20 tonnes. Apart from the (unstated) fact that the pilot who applies for an ATPL(A) will not obtain it unless he holds a current instrument rating, whereas no such caveat is applied to the ATPL(H) applicant, the privileges of the ATPL holder are identical to those of the CPL holder within each discipline.

2.11.2 Comparison of fixed and rotary wing licence privileges

Across the two disciplines, although many privileges are common, there are important differences. In the context of this report, the most significant differences are the restrictions placed on pilots who do **not** hold an instrument rating. For illustrative purposes, it is assumed that both a helicopter and an aeroplane, each weighing 2,400 kg, were considered for an air taxi flight between Manchester and Heathrow.

The privileges in Schedule 8 reveal that the accident flight was not a practical proposition for the CPL(A) holder (without an instrument rating) because he or she is limited to flights beginning and ending at the same aerodrome and not extending more than 25 nautical miles from that aerodrome, **irrespective of the weather conditions and time of day**. No such distance restriction is placed on the holder of a CPL(H) who may operate a public transport flight over any distance provided that it remains in VMC. In practice, commercial pressures ensure that the CPL(A) holder has an instrument rating to overcome the 25 nm restriction and make air taxi work viable.

2.11.3 Supplementary instructions

The two letters issued by the CAA in response to the AAIB's initial recommendations (see Appendix G), particularly the second letter, illustrate the complexity of the regulations and instructions issued to helicopter operators. No such equivalent instructions exist for fixed wing operators because their pilots have to hold instrument ratings.

The supplementary instructions to onshore helicopter operators exist solely to exempt pilots from the requirement to hold instrument ratings when flying IFR at night. The instructions have reached a level of complexity which is difficult to interpret and possibly too difficult to comply with in practice, particularly for commanders operating from temporary landing sites. They have come about piecemeal as the capability, stability and equipment fit of helicopters has developed. That, however, is no reason to perpetuate the status quo. The situation would best be simplified by applying similar standards to rotary wing operations as are applied to fixed-wing operations.

2.12 JAR-OPS 3

JAR OPS 3 - Commercial Air Transportation (Helicopters) - will, if implemented, introduce new requirements for public transport helicopters and crews. Extracts from the two most relevant sections (in the context of this report) are reproduced at Appendix F.

Under these regulations:

a. Pilots carrying out commercial transportation in helicopters under IFR will be required to hold an instrument rating [see JAR-OPS 3.940(b)(1)].

b. Helicopters certified for single pilot IFR operation will require an autopilot with at least altitude and heading hold [see JAR-OPS 3.655(a)].

The need for additional pilot training and currency is also recognised in these regulations.

2.13 Proposed amendments to JAR-OPS 3

There are 27 member countries within the JAA which is a rule-making body and not a law-making body. JAA member countries have to enact their own legislation to implement JAR OPS 3 but there are difficulties surrounding this process. The regulations were due to be implemented in the UK on 1 April 1998 but this date has been postponed by six months to 1 October 1998, in part because of proposed amendments to the regulations.

The JAR-OPS 3 regulations appear to permit night VFR flights (see paragraph 3.652) but in Rule 22 (2) of the Rules of the Air, the UK prohibits night VFR flight outside controlled airspace. JAR-OPS 3 will not supersede Rule 22 and so UK helicopter operators will have to meet the IFR requirements of JAR OPS 3 for night public transport flights unless the UK relaxes Rule 22 (2) and permits VFR flights at night outside controlled airspace.

Discussions about amendments to the Joint Regulations, to which the AAIB was not a party, were in progress during July 1997. Because publication of this report was unlikely to take place in time to influence both the JAR OPS 3 amendment and helicopter operations during the forthcoming winter, two further recommendations were made to the CAA and these are repeated in Section 4.

2.14 Public interest

Apart from the commander's lack of instrument flying recency, there were a number of other factors which made this flight more hazardous than a flight in an IFR machine, either rotary or fixed-wing. Firstly, the workload for a lone pilot flying a helicopter at night without autostabilisation or an autopilot is excessive. Secondly, the necessity for the commander to avoid obstacles by detouring around them required a standard of flight planning and in-flight navigation accuracy which was not achieved, and which was probably unachievable under the circumstances. Thirdly, the current regulations do not require the existence of a visible true horizon and there is no method for predicting its existence. Consequently, until GPS or a similar system usable at all altitudes acquires IFR approval and a requirement for user skills, there are bound to be occasions when the unrated pilot must fly by sole reference to the instruments whilst at the same time, attempting to navigate using visual techniques over an unfamiliar route. The two requirements are incompatible.

When comparing the difficulties, risks and weather limitations of an air taxi flight by helicopter or aeroplane, there is little difference during daylight hours in good weather. This is not generally the case at night or in poor weather if the helicopter operation is restricted to VMC by limitations placed on the machine and its pilot. The public are unlikely to be aware of the limitations and relative risks and the helicopter operator is under no obligation to explain them to prospective clients. Therefore, the public interest should be protected by appropriate regulation which ensures comparable standards of safety between night helicopter and night aeroplane public transport flights.

3 Conclusions

(a) Findings

(i) The commander was licensed and qualified to conduct the flight but he had no instrument rating and the privileges of his licence required him to remain in visual meteorological conditions.

(ii) MGA Limited, the operating company, did not possess an Air Operator's Certificate.

(iii) The helicopter had no autopilot or autostabilsation and was not approved for IMC operations.

(iv) The helicopter had valid documentation and had been maintained in accordance with the appropriate maintenance schedule.

(v) The flight had to operate below an overcast cloud layer which was below the minimum safe en route altitude.

(vi) The flight had to avoid obstacles by detouring around them.

(vii) The commander was probably unfamiliar with the type of GPS available in the aircraft. He would also have been unfamiliar with the contents of the user waypoint database.

(viii) The meteorological forecast obtained by the commander was accurate and the advised route was sound.

(ix) The weather conditions were acceptable for attempting the flight.

(x) The lack of a visible horizon was most likely to become a problem between Manchester and Birmingham where the cloud cover was overcast and the ground lighting sparse.

(xi) The commander's actions and words indicated that he was relying on the controller for directional guidance.

(xii) The commander accepted the controller's advisory headings without question or compensation for drift and thereby allowed the helicopter to deviate from the intended route.

(xiii) The commander turned the helicopter towards high ground surrounding Stoke-on-Trent which was the area he had been advised to avoid by the meteorological forecaster.

(xiv) It was not possible to determine precisely why the commander decided to climb.

(xv) The commander requested clearance to climb before the climb started.

(xvi) During the manoeuvre which immediately preceded the accident the helicopter was in view of some witnesses throughout and did not enter cloud.

(xvii) The track alteration during the climb was unnecessary for the avoidance of obstacles or towns.

(xviii) The helicopter adopted a steep nose-up pitch attitude during the climb.

(xix) In the climb the helicopter's airspeed fell from 105 kt to 33 kt or slightly less in 30 seconds; this would have resulted in an altitude gain of between 900 and 1,000 feet.

(xx) The excessive nose-up pitch attitude deprived the commander of visual ground references.

(xxi) The commander became disorientated after he lost external visual attitude references.

(xxii) Safe recovery from the unusual attitude depended on the commander's instrument flying skills.

(xxiii) It is most unlikely that the commander was aware of any significant malfunction when he lost visual references.

(xxiv) During his civil flying career, the commander had not undergone a night line check and he had not been required to demonstrate his ability to cope with sudden and unforeseen cloud penetration.

(xxv) The standby attitude indicator was unpowered at impact and had probably not been powered throughout the flight.

(xxvi) The manoeuvres flown by G-CFLT and the rapid changes in the noises produced by the main rotor blades were consistent with pilot disorientation.

(xxvii) The opening of the passenger cabin sliding door was probably a consequence of the loss of control and not a causal factor in that loss of control.

(xxviii) Both engines were running at impact.

(xxix) Unlawful interference and pilot incapacitation were not contributory factors.

(xxx) The commander may not have been looking for visual references at the time they became available during the latter stages of the recovery.

(xxxi) The commander was probably still disorientated when the helicopter struck the ground.

(xxxii) Current regulations governing VMC flight at night do not require the existence of a visible true horizon and there is no method for predicting its existence.

(xxxiii) The necessity for the commander to avoid obstacles by detouring around them required a standard of flight planning and in-flight navigation accuracy which was not achieved, and which was probably unachievable under the circumstances.

(b) Causal factors

(i) The helicopter significantly deviated from the intended route.

(ii) The commander's workload in marginal weather conditions was excessive.

(iii) The commander probably lacked recent experience of recovering the helicopter from an unusual attitude using the flight instruments.

(iv) The commander was unable to control the helicopter by sole reference to the flight instruments when he lost external visual references.

(v) The standby artificial horizon was not powered and would have provided confusing attitude information if it had been visible in the ambient cockpit lighting conditions, and if the commander had referred to it.

(vi) The commander may have been distracted at a critical time by the opening of a cabin door.

4 Recommendations

4.1 If either the helicopter or its crew are unqualified for IFR flight, more restrictive weather conditions should apply to the despatch of visual contact flights in darkness. (Recommendation 96-90 made on 23 December 1996).

4.2 Company operations manuals should specify that the cloud base minima must be related to the highest obstacle within 10 nm of track along the entire planned route. (Recommendation 96-91 made on 23 December 1996).

4.3 The Authority should ensure that for helicopter pilots who are required to operate at night, line checks should include a night section as specified in CAP 360, Part ONE, Chapter 5, paragraph 7.2.1 dated 9 November 1992.
(Recommendation 96-92 made on 23 December 1996).

Note: The Authority's initial response to the above three recommendations is contained in Appendix G.

4.4 The requirements of the following JAR-OPS 3 regulations, as formulated in the original 22.5.95 edition, should be adopted by the UK as soon as practicable:

a. Paragraph 3.652

b. Paragraph 3.655

c. Sub paragraph (b) (1) of Paragraph 3.940

d. Sub-paragraph (a) (2) of Appendix 1 to Paragraph 3.940

e Paragraph 3.950

(Recommendation 97-54)

4.5 The UK should continue to prohibit any helicopter from carrying out night commercial air transportation under VFR within UK airspace.
(Recommendation 97-55)

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