AIRCRAFT ACCIDENT REPORT 7/2007

Air Accidents Investigation Branch

Department for Transport

Report on the serious incident to Airbus A310-304, F-OJHI on approach to Birmingham International Airport 23 February 2006

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

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This report contains facts which have been determined up to the time of publication. This information is published to inform the aviation industry and the public of the general circumstances of accidents and serious incidents.

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3/2006	Boeing 737-86N, G-XLAG at Manchester Airport on 16 July 2003.	December 2006
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3/2007	Piper PA-23-250 Aztec, N444DA 1 nm north of South Caicos Islands, Caribbean on 26 December 2005.	May 2007
4/2007	Airbus A340-642, G-VATL en-route from Hong Kong to London Heathrow on 8 February 2005.	September 2007
5/2007	Airbus A321-231, G-MEDG during an approach to Khartoum Airport, Sudan on 11 March 2005.	December 2007
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Department for Transport
Air Accidents Investigation Branch
Farnborough House
Berkshire Copse Road
Aldershot
Hampshire GU11 2HH

November 2007

The Right Honourable Ruth Kelly
Secretary of State for Transport

Dear Secretary of State

I have the honour to submit the report by Mr R J Tydeman, an Inspector of Air Accidents, on the circumstances of a serious incident to an Airbus A310-304, registration F-OJHI, during an approach to Birmingham International Airport on 23 February 2006.

Yours sincerely

David King
Chief Inspector of Air Accidents

Contents

Appendices

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	Air Accidents Investigation Branch
AFS	Automatic Flight System
agl	above ground level
AIP	Aeronautical Information Pubilcation
amsl	above mean sea level
AP	Autopilot
AP 1	No 1 Autopilot
AP 2	No 2 Autopilot
ATC	Air Traffic Control
A/THR	Automatic Throttle
ATIS	Automatic Terminal Information System
CAA	Civil Aviation Authority
CDA	Constant Descent Angle
CDU	Control Display Unit
CFIT	Controlled Flight Into Terrain
CMD	Command mode
CRM	Crew Resource Management
CRS	Course
CVR	Cockpit Voice Recorder
CWS	Control Wheel Steering
DME	distance measuring equipment
EFIS	Electronic Flight Information
EGPWS	Enhanced GPWS
FAA	Federal Aviation Administration (USA)
FAF	Final Approach Fix
FCOM	Flight Operating Manual
FCU	Flight Control Panel
FD	Flight Director
FDR	Flight Data Recorder
FL	flight level
FLC	Flight Level Change
FLTA	Forward-Looking Terrain-Avoidance
FMA	Flight Mode Annunciator
FMC	Flight Management Computer
FMS	Flight Management System
FO	First Officer
Fpm	feet per min
ft	feet
ft/min	feet per minute
GA	Go-Around
GPS	Global Positioning System
GPWC	Global Proximity Warning Computer
GPWS	Ground Proximity Warning System
HDG	Heading
hrs	hours
HON	Honiley
hPa	hectopascal (equivalent unit to mb)
IAC	International Approach Charts
IATA	International Air Transport Association
ICAO	International Civil Organisation Authority
ILS	Instrument landing system
IMC	Instrument Meteorological Conditions
IRS	Inertial Reference System
JAA	Joint Aviation Authorities
KCAS	knots calibrated airspeed
km	kilometre(s)
kt	knot(s)
m	metres
MDA	Minimum Descent Altitude
METAR	a timed aerodrome meteorological report
Mhz	Megahertz
min(s)	minutes
N_1	engine fan or LP compressor speed
ND	Navigation Display
NAV	Navigation Mode
nm	nautical mile(s)
NOTAM	Notice to Airman
PANS Ops	Procedures for Air Navigation Services - Aircraft Operations
PDA	Premature Descent Alert
PF	Pilot flying
PFD	Primary Flight Display
PNF	Pilot not flying

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT (Cont)

QDM	magnetic heading
QNH	pressure setting to indicate elevation above mean sea level
RMI	Radio Magnetic Indicator
RT	Radio Transmission
SCWO	Supervisory Control Wheel Operation
SOP	Standard Operating Procedure
SRS	Speed Reference System
TAF	Terminal Aerodrome Forecast
TAWS	Terrain Awareness and Warning System
TCF	Terrain Clearance Floors
TRP	Thrust Rating Panel
TRTO	Type Rating Training Organisation
UFDR	Universal Flight Data Recorder
UK	United Kingdom
USA	United States of America
V_{APP}	Approach Speed
V_{LS}	Lowect Selectable Speed
V_{SS}	Stick Shaker Speed
V_{S}	Stall Speed
VOR	VHF omni-range
ºC, ºM	Celsius, magnetic

Air Accidents Investigation Branch

Serious Incident Report No: 7/2007 (EW/C2006/02/03)

Registered Owner:	CIE Kerman Aviation (a subsidiary of Mahan Air)
Operator:	Mahan Air
Aircraft Type:	Airbus A310-304
Nationality:	French
Registration:	F-OJHI
Place of Incident:	During the approach to Birmingham International Airport Latitude: 52° 21' N Longitude: 000° 47' W
Date and Time:	23 February 2006 at 1212 hrs All times in this report are UTC unless otherwise stated.

Synopsis

Air Traffic Control at Birmingham International Airport notified this serious incident to the Air Accidents Investigation Branch (AAIB) at 1240 hrs on 23 February 2006. The following Inspectors participated in the investigation:

Mr R J Tydeman	Investigator in Charge
Mr P Hannant	Operations
Mr S J Hawkins	Engineering
Mr M W Ford	Flight Recorders

The aircraft was on a scheduled flight from Tehran, Iran, to Birmingham International Airport in the United Kingdom (UK). Following an uneventful flight, the aircraft was radar vectored for a Localiser/DME approach to Runway 33. The aircraft commenced a descent from 2,000 ft to the published minimum descent altitude of 740 ft whilst still 11 nm from the runway threshold. At a point 6 nm from the runway the aircraft had descended to an altitude of 660 ft, which was 164 ft agl. The radar controller noted this descent profile and, through the tower controller, issued an immediate climb instruction. However, the crew had already commenced a missed approach, which they initiated when they received a GPWS alert. The aircraft was radar vectored for a second approach during which the flight crew again initiated an early descent. On this occasion, the radar controller instructed the crew to maintain their altitude and the crew successfully completed the approach. The aircraft landed safely from the second approach.

The investigation identified the following contributory factors:

1. The primary cause of the incident was the use by the crew of the incorrect DME for the approach at Birmingham International Airport.

2. There was also a substantial breakdown in CRM, which was partly due to the presence of a third flight crew member on the flight deck. He was not present during the approach briefing nor when the navigation information displayed was selected. He attempted to support the crew in their efforts to fly the approach but inadvertently re-enforced the commander's misinterpretation of the DME indications. This occurred despite the first officer initially recognising the discrepancy between the distance to the threshold and the distance displayed on the VOR/DME, and attempting to communicate this to the other members of the flight crew.

Three Safety Recommendations have been made.

1 Factual Information

1.1 History of the flight

1.1.1 Departure and en route

The aircraft departed Tehran Imam Khomeini International Airport, Iran, at 0620 hrs on a scheduled passenger flight to Birmingham Airport, in the UK. Two flight crews, each comprising a captain as an aircraft commander and a first officer (FO) were onboard. One flight crew operated the aircraft from Tehran to Birmingham and the second crew were to operate the aircraft on the return sector to Tehran. Prior to departure the operating crew were aware, from the published NOTAMs, that the ILS glideslope for Runway 33 at Birmingham was not available.

The commander was the handling pilot for the flight, and the departure and en-route segments proceeded normally. The route was flown with the No 2 autopilot (AP 2) engaged in the 'Command' mode (CMD) and with the navigation mode selected. This allows the Flight Management System (FMS) to provide track guidance to the AP system.

Prior to the descent into Birmingham, the commander briefed the FO for a Localiser/DME[1] approach to Runway 33. The briefing was conducted between the commander and the FO; the captain of the crew for the return sector was not present. The briefing included the approach procedure to be followed, the minimum descent altitude (MDA) to be used and the navigation aids to be selected. The use of an FMS waypoint to define the runway threshold, in order to provide the required DME distance, was also covered. The ability of the FMS to 'autotune' the Honiley (HON) VOR/DME and display that DME distance on the Radio Magnetic Indicator (RMI) was not specifically covered, but the crew were aware of that capability.

The aircraft was cleared for the Grove 1A standard terminal arrival, via Honiley, Ebony and Grove, for the Localiser/DME approach to Runway 33. The approach procedure is shown at Figure 1. At some stage, which the crew recalled as being probably during the downwind leg, the captain of the crew for the return sector entered the flight deck and secured himself in the 'jump seat' located behind and between the operating crew. He is referred to as the supernumerary captain throughout the report.

[1] Distance Measuring Equipment (DME): a navigation aid that provides aircraft distance from a land-based transponder of fixed location. DME distance provides the physical distance from the aircraft to the transponder.

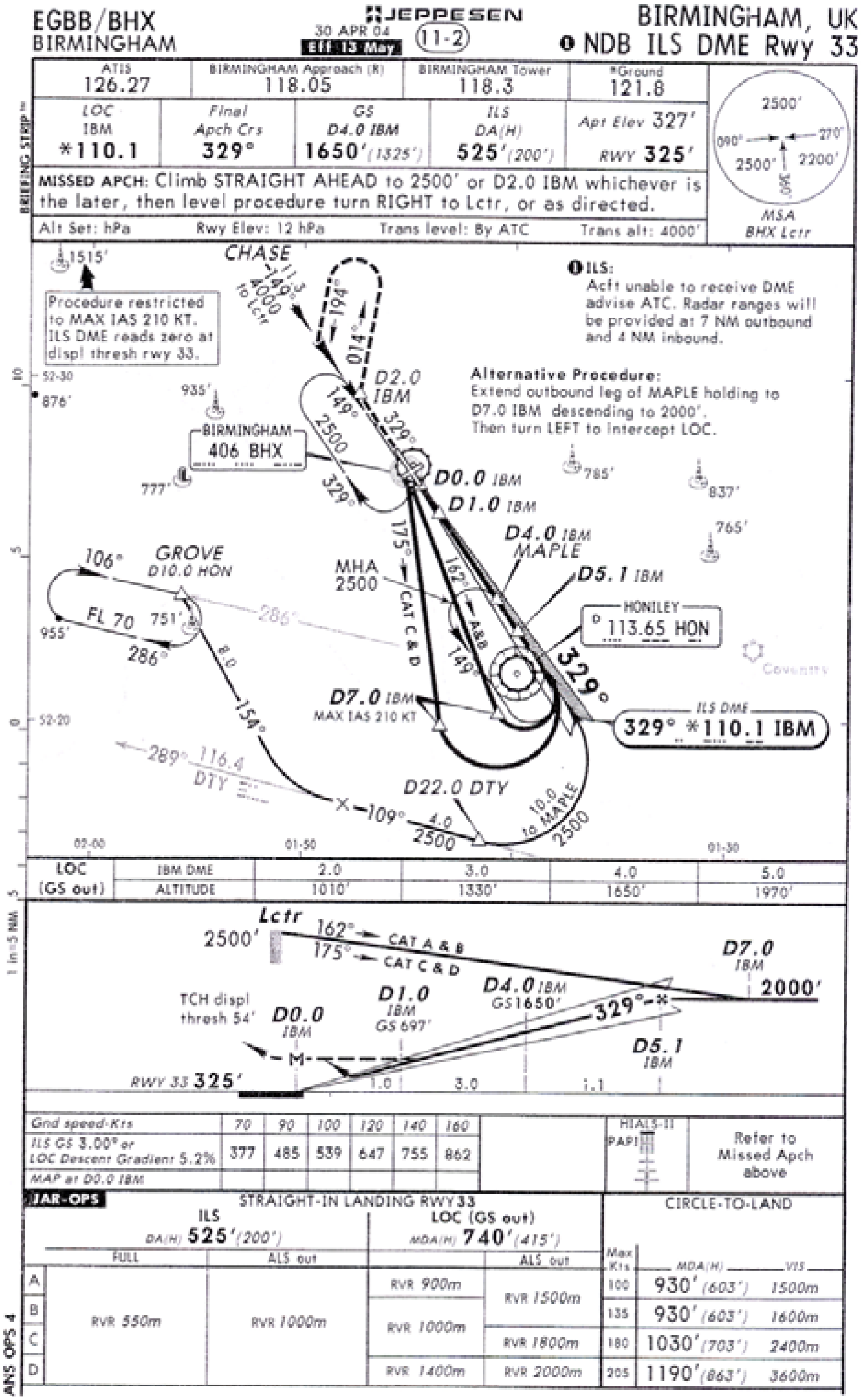

Figure 1

Instrument approach chart used by the crew for the Localiser/DME approach

1.1.2 Descent and first approach

The ground tracks of the aircraft during both approaches were derived from the ground based radar. They are included at Appendix A and B with timings overlaid to assist interpretation.

The approach checks were completed whilst the aircraft was descending through 4,500 ft (all altitudes are amsl, based on the aerodrome QNH, unless otherwise stated). ATC provided radar vectors for the approach and positioned the aircraft to intercept the localiser from the left; the aircraft was at 2,000 ft and 160 kt. When the aircraft was about 11 nm from the runway threshold and about 5 nm from the HON VOR, the crew discussed the origin of the relevant DME data and the point at which they should commence their descent. Meanwhile the AP was manoeuvring the aircraft to intercept the localiser, and the recorded bank angle reached a maximum of 36º to the left. The aircraft eventually rolled to a wings level attitude, whilst still left of the localiser, and immediately commenced a descent; the published MDA was 740 ft.

The aircraft was now 8.5 nm from the runway threshold and 2.5 nm from the HON VOR and, whilst the AP had captured the localiser beam, it failed to track it accurately. The final approach speed (V_{APP}) calculated by the crew was 140 kt and the aircraft was correctly configured for the approach. During the initial stage of the descent, the rate of descent stabilised at about 1,500 ft/min, at an airspeed of 164 kt. When descending through 1,020 ft, (516 ft agl) the supernumerary captain reported that he could see the ground. Shortly after passing 400 ft agl an aural warning sounded which indicated a change in the status of the AP. At about 300 ft agl, with a descent rate of 1,440 ft/min, a GPWS mode 1 "Sink Rate" warning occurred (see section 1.6.4). The AP was disconnected at 258 ft agl just as a second, and final, GPWS "SINK RATE" warning occurred. The descent rate started to reduce as the aircraft was pitched up and the engine thrust levers moved forward, with the N_1 increasing from about 35% to about 70%. At this point ATC instructed the aircraft to climb to 3,000 ft immediately. The commander said "*WHERE WERE WE I DIDN'T CATCH IT*", to which the supernumerary captain replied "*I DIDN'T SEE THE RUNWAY... VOR DROPPED BUT WE DIDN'T SEE THE RUNWAY*". At this point, the aircraft was about 0.5 nm north-east of the HON VOR beacon. The aircraft started to level off at an altitude of about 660 ft as the height reduced to a minimum of 164 ft agl.

1.1.3 Go-around

The aircraft commenced a climb, the landing gear was retracted and the engine thrust levers moved forwards, with the N_1 increasing from about 70% to about 92%. At 760 ft, at a speed of 148 kt, the flaps started to retract and at 930 ft, at a speed of 155 kt, the thrust levers began to retard slowly. At some point AP 2 was re-engaged. The FO advised ATC that the aircraft had commenced a missed approach and the controller instructed the aircraft to climb to 3,000 ft. At 1,600 ft AP 2 was disconnected and shortly afterwards the slats/flaps were set to 15/0 (see section 1.6.1.1 for slat/flap description).

The aircraft reached an altitude of 1,750 ft, at a speed of 160 kt, before entering a descent as the engine thrust reduced to about 35% N_1. The aircraft descended to 1,300 ft, (860 ft agl), before re-commencing a climb. ATC instructed the crew to turn left onto 245º when level at 3,000 ft.

During the climb to 3,000 ft the crew discussed the validity of the DME indications and the failure of the aircraft to track the localiser; these discussions continued once the aircraft was stabilised on the downwind leg. ATC instructed the aircraft to descend to 2,000 ft, cleared them for a further Localiser/DME approach and requested confirmation that the crew had the Localiser/DME procedure; the crew confirmed the correct procedure was being used.

1.1.4 Final approach

ATC provided radar vectors to intercept the localiser from the left and the crew were informed "*YOU HAVE TWELVE TRACK MILES TO RUN*". Following a further discussion amongst the crew about the DME indications the aircraft commenced its descent from 2,000 ft whilst 5 nm from the HON VOR and 11 nm from the runway threshold. As the aircraft was descending through 1,600 ft ATC asked for confirmation that the aircraft was maintaining 2,000 ft. The FO advised they were descending and ATC instructed them to climb and maintain 2,000 ft.

Whilst intercepting the localiser the aircraft bank angle increased to a maximum of 38º to the left before the aircraft rolled to a wings level attitude. Once again the AP captured the localiser but failed to track it accurately; shortly afterwards the AP was disconnected. The aircraft commenced its final descent from 2,200 ft and descended through 1,650 ft when 5 nm from the runway threshold. ATC cleared the aircraft to land on Runway 33 and passed the surface wind, which was from 320º at 8 kt. At 850 ft (470 ft agl), and about 2 nm from the runway, the FO and the supernumerary captain said "*RUNWAY IN SIGHT*". The supernumerary captain then said *"WE ARE FIVE DME PAST.....WE*

ARE PASSED IT….IT IS SHOWING WE ARE PAST"; the aircraft was now 5 nm from the Honiley VOR. The aircraft landed safely at 1228:32 hrs. An inspection of the aircraft flight deck following the incident noted that the course set on the ILS and Navigation controls was 329º.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor/None	10	88	-

1.3 Damage to the aircraft

There was no damage to the aircraft.

1.4 Other damage

There was no other damage.

1.5 Personnel information

1.5.1 Commander

Male:	Aged 55 years	
Licence:	Airline Transport Pilot's Licence	
Aircraft ratings:	Airbus A300, A310	
Instrument rating:	Valid to 20 December 2006	
Licence Proficiency Check:	Valid to 20 December 2006	
Operational Proficiency Check:	Valid to 20 December 2006	
Line Check:	Valid to 28 January 2007	
Medical Certificate:	Valid to 15 January 2007	
Flying experience:	Total flying:	12,000 hours
	On type:	2,500 hours
	Last 90 days	92 hours
	Last 28 days	56 hours
	Last 24 hours	6 hours
Previous rest period:	More than 12 hours	

The commander had commenced pilot training in the USA in 1976, and later flew the Fokker F27 as an instructor. He had flown 1,800 hours on the Airbus A300 as a commander before converting to the Airbus A310 in October 2003.

1.5.2 First Officer

Male:	Aged 55 years
Licence:	Airline Transport Pilot's Licence
Aircraft ratings:	Airbus A300, A310
Instrument rating:	Valid to 13 December 2006
Licence Proficiency Check:	Valid to 13 December 2006
Operational Proficiency Check:	Valid to 13 December 2006
Line Check:	Valid to 12 December 2006
Medical Certificate:	Valid to 24 October 2006
Flying experience:	Total flying: 10,000 hours
	On type: 2,300 hours
	Last 90 days 80 hours
	Last 28 days 30 hours
	Last 24 hours 6 hours
Previous rest period:	More than 12 hours

The FO was an experienced Lockheed C-130 pilot and had been an instructor on that type. He had operated the Boeing 747 for approximately 2,000 hours before briefly flying the Airbus A300. He then moved onto the Airbus A310 and since this incident has qualified as a commander on that type.

1.5.3 Supernumerary Captain

Male:	Aged 53 years
Licence:	Airline Transport Pilot's Licence
Aircraft ratings:	Airbus A310
Instrument rating:	Valid to 22 August 2006
Licence Proficiency Check:	Valid to 22 August 2006
Operational Proficiency Check:	Valid to 22 August 2006
Line Check:	Valid to 28 January 2007
Medical Certificate:	Valid to 31 December 2006
Flying experience:	Total flying: 9,500 hours
	On type: 1,800 hours
	Last 90 days 130 hours
	Last 28 days 40 hours
	Last 24 hours Nil
Previous rest period:	More than 12 hours

The supernumerary captain had flown 3,000 hours on the Fokker F27 and 4,500 hours on the Boeing 707; he had been an instructor on both types. He had flown the Airbus A310 for two years.

1.5.4 Additional information

All three pilots had operated the Airbus A310 into Birmingham airport on a regular basis and had conducted Localiser/DME approaches as both the handling and non-handling pilot. They all held a French Validation of their Iranian licence to permit them to operate a French registered aircraft.

1.5.5 Air Traffic Controller

Male:	Aged 50 years
Date qualified as an ATCO:	2 July 1981
Commenced duties at Birmingham:	20 August 1979
Qualified as a Watch Manager:	14 April 1993
Medical expiry date:	31 October 2006

1.6 Aircraft information

1.6.1 General Information

Manufacturer:	Airbus
Type:	A310-304
Aircraft Serial Number:	537
Year of manufacture:	1990
Number and type of engines:	2 General Electric CF6-80C2 turbofan engines
Total airframe hours:	44,389 hours and 15,674 flight cycles
Certificate of Registration:	Issued 6 December 2004: valid
Certificate of Airworthiness	Issued 12 December 2005: valid

1.6.1.1 Aircraft description

The Airbus A310 is a wide body, monoplane transport aircraft powered by two turbofan engines (see Figure 2). The aircraft is certified to be operated by two flight crew members. The flight deck is equipped with two flight crew seats and an additional 'jump seat' (for use by an observer), this is a folding seat attached to the rear panel behind the centre pedestal. The passenger seating configuration varies according to the operator but the aircraft is certified to carry 275 passengers.

The aircraft has conventional, hydraulically powered flying controls (ie it is not 'fly-by-wire') operated by a control wheel, control column and rudder pedals. The aircraft's flaps and slats are operated by a single 5-position Slat/Flap control lever. The five selectable combinations of Slat/Flap are:

0/0, 15/0, 15/15, 20/20 and 30/40: Slat/Flap 30/40 is normally used for landing. F-OJHI was equipped with an Automatic Flight System (AFS), a Sperry FMS and a Honeywell Mk III GPWS.

Figure 2

Photograph of F-OJHI

1.6.1.2 Aircraft maintenance history

The last maintenance check before the incident flight was an 'A' check conducted between 5 February and 11 February 2006, when the aircraft had completed 44,330 flying hours and 15,661 flight cycles. At the time of the incident there were no recorded Acceptable Deferred Defects that might have contributed to the event.

However, the flight crew reported that AP 1 had disconnected on a number of occasions as the wing slats deployed. No technical reason for this situation had been identified and the fault had not been entered in the aircraft's Technical Log book. As a consequence, crews tended to use AP 2 for AFS operations since this did not suffer the same problem. AP 2 was the system in use on the flight into Birmingham on 23 February 2006.

1.6.2 Aircraft navigation, avionics and automatic flight systems

The aircraft is fitted with a combined Electronic Flight Information System (EFIS) and electromechanical instrumentation. A dual FMS, Automatic Throttle (A/THR) and AFS can be coupled to fly the aircraft in the selected horizontal and vertical flight paths at the required speeds and rates of climb and descent.

1.6.2.1 Flight instrumentation

The aircraft is fitted with a six-screen EFIS, comprising a Primary Flight Display (PFD) and a Navigation Display (ND) for each pilot. Two multifunction screens are located in the centre of the instrument panels, side by side, which are used to display system condition and checklist information. Electromechanical altimeters and VOR/DME radio magnetic indicators (RMIs) are also fitted, one for each pilot. The instrument layout is shown at Appendix C.

The PFD incorporates a Flight Mode Annunciator (FMA) which is displayed at the top of the screen. There are five columns which display the AFS and mode selected with the colour of the text indicating its status, either armed or engaged. Airspeed, Flight Director (FD) guidance, ILS and DME information are also displayed, as well as target altitude. The three position NAV,VOR or ILS switch is used to display the required navigation aid being used.

Airspeed information is presented on a vertical strip on the left side of the PFD. The scale is annotated every 10 kt with horizontal lines, adjacent to which the speeds are numbered every 20 kt. The lower limit speeds for Lowest Selectable Speed (V_{LS}) and the Stick Shaker Speed (V_{SS}) are indicated at the base of the scale. The speed regime below the V_{SS} is identified by a red and black vertical bar, with an amber vertical bar above it which identifies speeds below the V_{LS}.

Stick shaker activation is based solely on angle of attack; approximately 8.5º in a clean configuration and 15º in other configurations. After takeoff, V_{LS} is calculated as 1.3 x the stall speed (V_S) for the aircraft configuration. When the flaps retract, the V_{LS} increases and the amber, vertical bar moves upwards towards the aircraft current speed.

1.6.2.2 Sperry Flight Management System

The aircraft is fitted with two Sperry FMSs, each consisting of a Flight Management Computer (FMC) and a Control Display Unit (CDU). The purpose of the FMS is to provide optimum profiles for the flight management tasks. The FMS has a database, which contains, inter alia: company routes, navigation aids, airport approach procedures and runway records; these data are related to the routes operated by the specific company. The flight crew therefore have the capability to link a route with an arrival procedure and a specific instrument approach, providing this information exists in the database. The database can be updated periodically, typically this is on a 28 day cycle which corresponds to the normal revision cycle for navigation charts. In addition to this stored database, the flight crew can create and manually insert into the FMC 20 navigation aids and 20 waypoints. The FMS may be coupled to the AP and A/THR systems in order to perform vertical and horizontal guidance and control of the aircraft.

The aircraft position is updated using a combination of Inertial Reference System (IRS) and VOR/DME information. Two three-position switches are provided, one for each pilot, which may be selected to NAV, VOR or ILS. The switch enables the selected NAV, VOR or ILS information to be displayed on the pilot's respective flight and navigation instruments. The information selected is displayed on the RMIs, PFDs, NDs, and CDUs. If the VOR/NAV/ILS switch is in the NAV or ILS position the associated VOR/DME can be:

a) Autotuned by the associated FMS. The DME frequency is automatically selected by the associated FMS without any action by the crew. Dashes are displayed on the related VOR control panel. The VOR control panel cannot be used to make VOR/DME frequency selections.

b) Remotely tuned by the crew by selecting the VOR/DME frequency on the FMS progress page.

The VOR/DME raw date (bearing / distance) are displayed on the associated DME/RMI (Captain's or FO's)

When a localiser/DME is being flown, the ILS/DME information related to that approach is displayed on the lower left corner of the PFD provided the following conditions are met:

a) The ILS/DME frequency is set on the ILS control panel:
b) The ILS/DME is within 30 nm of the aircraft:
c) The VOR/NAV/ILS switch is in the ILS position: and
d) The mach number is below 0.45 (Mach number not displayed on PFD).[2]

[2] If there are more than one possible ILS/DME on the selected frequency, the FMS will check the ILS approach in the F-PLN and display the corresponding DME distance. If no ILS approach is entered in the F-PLN, then the FMS cannot choose which DME to display, and no DME distance will be displayed.

1.6.2.3 Automatic Flight System

The AFS may be used for guidance when manually flying the aircraft or for automatic control of certain flight paths. Automatic control requires at least one of the two APs to be engaged in the CMD mode. The AFS integrates the AP and FD functions and the A/THR function. At any time the pilot can select the desired level of automation, revert to the AP/FD basic modes or to manual flying.

Pilot input to the AFS is performed through the Flight Control Unit (FCU), the FMS CDU, the Thrust Rating Panel (TRP) and the throttle 'go-levers'. The control column, control wheel and rudder pedals may be operated normally when the AP is engaged and the Control Wheel Steering (CWS)[3] mode is available. The CWS mode is selected using a push button on the FCU.

The AFS consists of two FDs (FD 1 and FD 2), two APs (AP 1 and AP 2) and two A/THR systems (A/THR 1 and A/THR 2). The AFS integrates peripheral data from a number of sources; of relevance to this incident are the FMC, the FCU, the FMS CDU, the VOR, and the ILS. The AP is able to control both lateral and vertical profiles, aircraft speed and engine thrust, corresponding to the various modes selected by the crew processed together with the peripheral data.

The LAND mode selection on the FCU provides lateral and vertical guidance during an ILS approach to capture and track the localiser and glide slope beams. The LOC (localiser) mode captures and tracks the localiser beam only and can be used for localiser only approaches or if the ILS glide slope is out of service or unreliable. The convergence of the aircraft towards the localiser beam can either be directed through the FMS or manually selected using the HDG mode. The LOC or LAND modes have three successive phases relating to the localiser: the armed phase is indicated by LOC in blue letters on the Flight Mode Annunciator (FMA); the capture phase is indicated by LOC* in green letters; and the tracking phase is identified by LOC in green letters. In the LOC* condition Supervisory Control Wheel Operation (SCWO) is available; this enables the pilot to assist the AP in capturing the LOC by using the control wheel. The AP commanded bank angle is limited to 30° during localizer capture, but this may be exceeded during SCWO.

The 'go levers' are located below the throttles; operation of these levers engages the AP/FD in 'Go-Around' (GA) mode. This combines the Speed Reference System (SRS) for vertical guidance and HDG for lateral guidance. If the AP is disconnected at GA the FD guidance is retained but the aircraft must be manually flown.

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[3] Control Wheel Steering (CWS) enables the pilot to manually fly the aircraft whilst the AP is engaged. It may be used during take-off, departure, cruise, approach and landing.

1.6.3 Ground Proximity Warning System

The aircraft is fitted with a Honeywell Mk III Ground Proximity Warning Computer (GPWC), which forms part of the aircraft's GPWS. The system provides visual and aural warnings to alert the flight crew when the GPWC detects a flight path that could result in a Controlled Flight into Terrain (CFIT). The system operates between 30 feet and 2,450 feet agl. The system does not have accurate position information and therefore it will not provide a warning for a controlled landing in a location without a runway.

The system provides warnings in five different modes:

- Mode 1: excessive sink rate
- Mode 2: excessive terrain closure rate
- Mode 3: descent after takeoff
- Mode 4: inadvertent proximity to terrain
- Mode 5: descent below ILS glideslope

Mode 1 was the only mode that was relevant in this event. It will provide a "SINK RATE" warning in any aircraft configuration if the aircraft has an unusually high descent rate close to the ground. If the descent rate continues to increase after the initial warning then a "WHOOP WHOOP PULL UP" warning will be provided. Figure 3 shows the envelope boundary for the Mode 1 warnings. At a descent rate of 1,450 ft/min the "SINK RATE" warning will trigger at 300 ft agl (based on inertial vertical speed and radio altitude). At descent rates less than 964 ft/min there will be no Mode 1 warning at any height.

1.6.4 Terrain Awareness and Warning System

General

The Terrain Awareness and Warning System (TAWS) is an enhancement of the GPWS, providing the flight crew with a forward looking capability and giving much earlier aural and visual warning of conflicting terrain. There are two classes of TAWS available, Class A and Class B. Class A is a more capable system and is the class required to be fitted to the A310 aircraft. TAWS Class A is defined in the FAA TSO C151a. As a minimum, it will provide three principal alerting functions. These are:

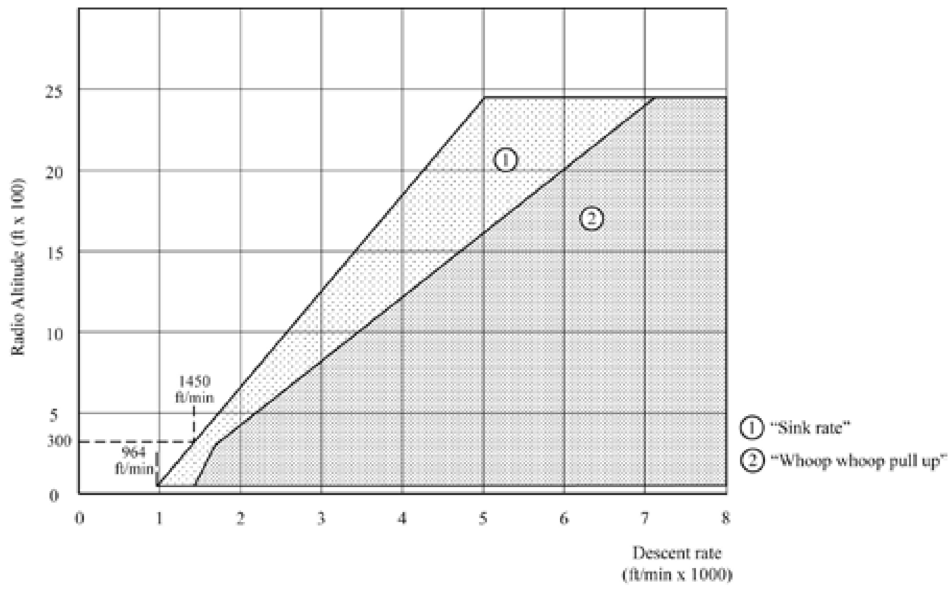


Figure 3

Envelope boundary for Mode 1 GPWS warning

- Forward-Looking Terrain-Avoidance (FLTA) to provide look-ahead terrain and obstacle protection along and below the aeroplanes lateral and vertical flight path. This function includes warnings of:

    a) Reduced required terrain clearance

    b) Imminent terrain impact

- Premature Descent Alert (PDA) to detect when the aircraft is hazardously below the normal (approximately 3º) approach path for the nearest runway and to provide a timely alert.

- Basic Ground Proximity Warning System (GPWS) functions, as defined in FAA TSO-C151a and Radio Technical Commission for Aeronautics Document DO-161A, which includes the GPWS modes 1 to 5 described in paragraph 1.6.3 (Ground Proximity Warning System).

The Class A TAWS requires a display, which can be a weather radar display, an Electronic Flight Instrument System (EFIS) display or other compatible screen. The terrain display and threat alerting are made possible by the TAWS' acceptance of a variety of parameters, including position, altitude and airspeed, which are used in conjunction with a terrain and airport databases that reside within the TAWS computer. Aircraft position information is normally provided by either the FMC or Global Positioning System (GPS).

Premature Descent Alert

The PDA capability of TAWS is a function of the Terrain Clearance Floors (TCF) programmed within the system. This creates a decreasing terrain clearance envelope around the airport as the aircraft approaches the runway. Alerting is based on current aircraft position and altitude relative to the runway. Protection is therefore provided for a premature descent, such as the approach carried out by F-OJHI at Birmingham.

Legal Requirements

The International Civil Aviation Organisation (ICAO) Annexe 6, Operation of Aircraft, sets out the following TAWS requirement:

> *All turbine-engined aeroplanes of a maximum certificated take-off mass in excess of 15,000 kg or authorized to carry more than 30 passengers shall be equipped with a ground proximity warning system which has a forward looking terrain avoidance function.*

The Joint Aviation Authorities (JAA) adopted this requirement, which was set out in JAR-OPS 1, Commercial Air Transportation (Aeroplanes) as follows:

> *JAR-OPS 1.665© An operator shall not operate a turbine powered aeroplane having a maximum certificated take-off mass in excess of 15,000 kg or having a maximum approved passenger seating configuration of more than 30 on or after;*
>
> > *(1) 1 October 2001 for aeroplanes first issued with a Certificate of Airworthiness on or after this date; or*
> >
> > *1 January 2005 for aeroplanes first issued with a Certificate of Airworthiness before 1 October 2001;*
>
> *unless it is equipped with a ground proximity warning system that includes a predictive terrain hazard warning function (Terrain Awareness and Warning System – TAWS).*

The UK CAA embodied the JAA requirement in Civil Aviation Publication 393, *Air Navigation: The Order and the Regulations*. Aircraft were required to be TAWS equipped in accordance with JAA timescales set out above. This is included in Section 1, Schedule 4, Equipment of Aircraft. Paragraph 9 states:

Description of Aircraft	***Circumstances of Flight***	***Scale of Equipment Required***
(9) Aeroplanes powered by one or more turbine jets or one or more turbine propeller engines which have a maximum total weight authorised exceeding 15000 kg or with a maximum approved passenger seating configuration of more than 30	*When flying for the purpose of public transport*	*X(1)*

Scale X (1) is defined as:

> *Scale X(1) Subject to paragraph (3), a Terrain Awareness and Warning System known as Class A, being equipment capable of giving warning to the pilot of the potentially hazardous proximity of ground or water, including excessive closure rate to terrain, flight into terrain when not in landing configuration, excessive downward deviation from an instrument landing system glideslope, a predictive terrain hazard warning function and a visual display.*

Paragraph (3) states:

> *(3) If the equipment becomes unserviceable, the aircraft may fly or continue to fly until it first lands at a place at which it is reasonably practicable for the equipment to be repaired or replaced.*

From the requirements set out above F-OJHI was required to be fitted with TAWS at the time of this incident but was not so equipped.

1.7 Meteorological information

The Met Office provided an aftercast covering the relevant period for the incident. The Synoptic situation at 1200 hrs on 23 February 2006 showed high pressure near the Faroe Islands feeding a moist north to north-easterly flow over the Birmingham area. Frontal systems were also affecting this area creating outbreaks of rain, drizzle or snow.

The warm front crossing the area at the time of the incident was creating low cloud and poor visibility associated with the precipitation. Although much of the precipitation was falling as rain or drizzle at the surface, it is possible that above 200-500 ft, it could have been sleet or snow. This could have led to more reduced visibilities between the surface and the cloud base.

The surface visibility was 4,000 - 5,000 metres with a mean sea level pressure of 1025 hPa. Cloud was scattered to broken stratus with a base of 700-900 ft and broken to overcast stratus with a base of 1,200 ft. The surface wind was generally from 310º at 10 kt, with the wind at a height of 2,000 ft from 360º at 20-25 kt.

1.7.1 Birmingham Terminal Aerodrome Forecasts (TAFs)

The relevant TAFs for Birmingham were as follows:

EGBB 230303Z 230413 36006KT 9999 SCT035 BECMG 0609 4000 –RASN BKN012 TEMPO 0710 1200 –SN BKN004 BECMG 0912 2000 –RADZ BKN004 TEMPO 1213 6000 NSW SCT008=

EGBB 230400Z 231206 33010KT 2000 –RADZ BKN004 BECMG 1518 6000 –RA BKN012 BECMG 1922 05010KT 9999 NSW SCT014 TEMPO 2202 8000 –RA BKN012 PROB40 TEMPO 0206 4000 –SN BKN012=

EGBB 230605Z 230716 35006KT 9999 SCT030 BECMG 0709 4000 –RASN BKN012 TEMPO 0710 1200 –SN BKN004 BECMG 0912 2000 –RADZ BKN004 TEMPO 1216 6000 NSW SCT012=

EGBB 230912Z 231019 33006KT 3000 –SN BKN003 BECMG 1013 4000 –RADZ BKN008 PROB40 TEMPO 1319 7000 NSW BKN020 BECMG 1719 05010KT

1.7.2 Aviation routine weather reports

The relevant METARs for Birmingham were as follows:

1120 hrs

Surface wind	From 310º at 9 kt
Visibility	4,100 metres
Weather	Light rain and snow, mist
Cloud	Scattered at 400 ft
	Broken at 600 ft
Temperature / Dew point	+ 2ºC / + 1ºC
QNH	1026 hPa

1150 hrs

Surface wind	From 310º at 8 kt
Visibility	4,500 metres
Weather	Light rain and snow, mist
Cloud	Few at 400 ft
	Scattered at 600 ft
	Broken at 900 ft
Temperature / Dew point	+ 2ºC / + 1ºC
QNH	1025 hPa

1220 hrs

Surface wind	From 310º at 10 kt
Visibility	5,000 metres
Weather	Light rain
Cloud	Few at 400 ft
	Scattered at 600 ft
	Broken at 900 ft
Temperature / Dew point	+ 2ºC / + 1ºC
QNH	1025 hPa

1.7.3 Automatic Terminal Information System (ATIS)

The weather conditions recorded on the ATIS covering the relevant period were:

> "BIRMINGHAM INFORMATION QUEBEC TIME ONE ONE FOUR THREE. RUNWAY IN USE THREE THREE, SURFACE WIND THREE TWO ZERO NINER KNOTS. VISIBILITY FOUR THOUSAND ONE HUNDRED METRES, SLIGHT RAIN AND SNOW, MIST. SCATTERED FOUR HUNDRED FEET, BROKEN SIX HUNDRED FEET. TEMPERATURE PLUS TWO, DEW POINT PLUS ONE, QNH ONE ZREO TWO FIVE. RUNWAY WET WET WET. THE GLIDEPATH IS UNSERVICEABLE. ACKNOWLEDGE RECEIPT OF INFORMATION QUEBEC AND ADVISE AIRCRAFT TYPE ON FIRST CONTACT".

1.8 Aids to navigation

1.8.1 Instrument Landing System

Runway 33 is equipped with an ILS, which was approved for approaches down to CAT III. The localiser beam is centred on a QDM of 329º with the glide slope set at 3°. The ILS radiates on 110.1 Mhz and carries the morse code identification of I-BM. The aerodrome has a DME, which is frequency paired with the ILS and indicates zero at the displaced threshold. The morse code identification is I-BM. The glide slope for Runway 33 was not available for the approach of F-OJHI on 23 February 2006.

Runway 15 is equipped with an ILS that radiates on 110.1 Mhz (the same frequency as Runway 33) and has the morse code identification I-BIR.

1.8.2 Honiley VOR/DME

The HON VOR/DME is located at N 52°21'24" W 001°39'49" and radiates on a frequency of 113.65 Mhz. The morse code identification is HON, and has a Distance of Cover of 60 nm. It is frequency paired with a co-located DME, also with a morse code identification of HON. The elevation of the facility is 435 ft amsl, and it is positioned on a bearing of 152°T, 6 nm from the displaced threshold of Runway 33.

1.9 Communications

Thee Radio Transmission (RT) recordings were reviewed, in order to follow the progress of the flight and the approach into Birmingham International Airport.

Initial contact was made with Birmingham Approach on frequency 118.05 Mhz. The Radar controller operated on the frequency 131.325 Mhz and Birmingham Tower was on frequency 118.3 Mhz.

1.10 Aerodrome information

1.10.1 Physical characteristics

Birmingham International Airport is a major civil airport located at N 52°27'14" W 001°44'53". It has two Runways orientated 33/15 and 24/06. The airport elevation is 327 ft amsl.

Runway 33/15 is the main runway and is 2,605 metres long by 46 metres wide and is constructed of grooved asphalt. When operating on Runway 33, the available landing distance is 2,304 metres. It is equipped with the lighting required for CAT III ILS operations, which includes a Calvert five-bar High Intensity Approach Lighting System, runway edge and centre line lighting and Precision Approach Path Indicators set to 3°. The elevation of the displaced threshold is 325 ft.

1.10.2 Instrument approach procedures

1.10.2.1 General

Approach procedures for Birmingham International Airport are designed and approved by the UK CAA. The procedures comply with the requirements set out in ICAO document 8168-OPS/611, *Procedures for Air Navigation Services-Aircraft Operations (PANS Ops) Volume 2, Construction of Visual and Instrument Flight Procedures*. Protected areas for the localiser are also defined in this document. The horizontal and vertical procedures are promulgated in the United Kingdom Aeronautical Information Publication (AIP). Commercial organisations reproduce this information in the form of Instrument Approach Charts (IAC). The IAC being used by the crew of F-OJHI was produced by Jeppesen and was the version current at the time of the incident. The aircraft was being radar vectored for the Localiser/DME approach for Runway 33 at the time of the incident.

1.10.2.2 Noise abatement procedures

The Noise Abatement procedures for the airport set out the following requirement in the UKAIP:

> *ILS Approaches*
>
> *'Unless otherwise instructed by ATC, aircraft using the ILS in IMC or VMC shall not descend below 2,000 ft QNH before intercepting the glidepath nor fly below the glidepath thereafter. An aircraft approaching without assistance from ILS or radar shall follow a descent path which will not result in its being at any time lower than the approach path which would be followed by an aircraft using the ILS glidepath'.*

1.10.2.3 Glideslope availability

Birmingham International Airport Ltd identified the need to carry out six areas of major works to the airport surface structures. A supplement to the UKAIP (S34/2004) was issued on 28 September 2004. This document provided a comprehensive description of the intended work and the anticipated effect it would have on airport operations and the facilities available.

A new exit for Runway 15 was to be constructed, the position of which was within the Runway 33 glideslope transmitter critical area. During the construction of this taxiway, and the landscaping of the adjacent area, the Runway 33 glideslope was withdrawn from service. The work was scheduled to commence on 15 November 2004 and be completed on 30 September 2005. Due to overruns in the work schedule the activity in the Runway 33 glideslope transmitter critical area was still ongoing and the Runway 33 glideslope was not available for the approach of F-OJHI on 23 February 2006. This information had been promulgated by NOTAM.

1.10.2.4 Localiser DME approach procedure

The flight crew used the Jeppesen NDB/ILS/DME approach chart for Runway 33, which is shown at Figure 1 (page 4). This chart provides the necessary information to conduct a Localiser/DME approach.

1.10.2.5 Vertical profile

The vertical profile for the approach to Runway 33 at Birmingham, with the ILS glide slope not available, is shown at Figure 4. The vertical profile is based on the mean sea level pressure (QNH) and commences with the aircraft established on the final approach track of 329° at an altitude of 2,000 ft. At the Final Approach Fix (FAF), located 5.1 DME from the I-BM, the aircraft is descended at a Constant Descent Angle (CDA) of 3° to an MDA of 740 ft. The Missed Approach Point is at 0 DME, which is coincident with the threshold for Runway 33. Altitude cross checks are provided at 5, 4, 3, and 2 nm to assist the pilot in maintaining a 3° glide path. The HON VOR is not part of the approach procedure.

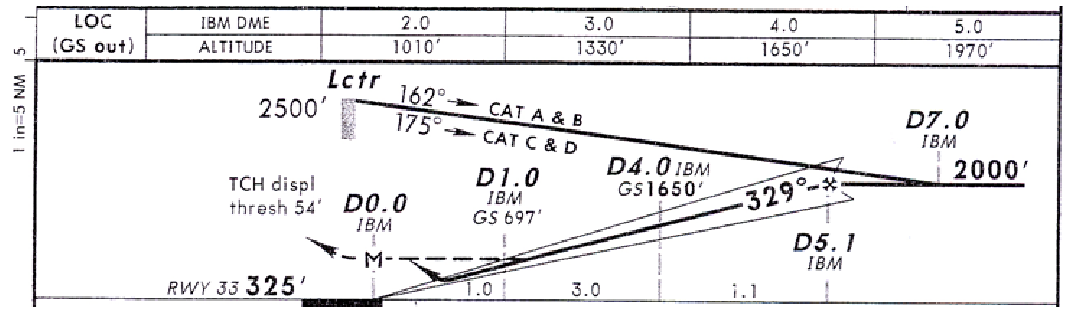


Figure 4

Vertical approach profile

1.11 Flight recorders

1.11.1 Radar data

Recorded radar data was available from the Clee Hill radar site, located about 32 miles to the west of Birmingham International Airport. Aircraft position and Mode C altitude data was recorded every eight seconds. The ground tracks of the aircraft during the two approaches were derived from the ground based radar. They are presented at Appendix A and B with timings overlaid to assist interpretation.

1.11.2 Cockpit Voice Recorder

The aircraft was installed with a 30-minute duration Cockpit Voice Recorder[4] (CVR) which recorded four channels of audio[5]. The system was not equipped with 'hot' [6] boom microphones; this was not a regulatory requirement.

The CVR was removed from the aircraft and replayed at the AAIB. Thirty two minutes and nineteen seconds of audio was recorded. The beginning of the recording coincided with Birmingham Director instructing the crew to turn onto a base leg heading, prior to the initial approach. The end of the recording[7] occurred when the aircraft parked at Stand 52.

The majority of the crew conversation was in their native language Fārsi[8]. With the assistance of the flight crew and a translator (seconded to the investigation), a transcription was made in English.

1.11.3 Flight Data Recorder

The aircraft was installed with a Universal Flight Data Recorder (UFDR)[9], which recorded the last 25 hours of flight data.

The UFDR was removed from the aircraft and disassembled at the AAIB in preparation for replay. On inspection, it was found that the majority of both outer edges of the tape had suffered mechanical damage; this is indicative of the tape not layering correctly during operation. Although replay revealed that a less than ideal signal had been recorded, the majority of the incident flight was successfully recovered.

The UFDR recorded a total of 113 parameters. Salient parameters included: localiser deviation[10], roll attitude[11] and autopilot engagement modes; command

[4] L-3 Communications manufactured Cockpit Voice Recorder (CVR): part number 93A100-80, serial number 58632. This is an endless-loop magnetic tape device that records an audio signal for a minimum period of 30 minutes of continuous operation; voice recordings beyond 30 minutes of continuous operation are erased just before being overwritten with new audio.

[5] The four CVR channels consisted of: one channel connected to an open cockpit area microphone (CAM), with the three remaining channels connected to the audio selector panels of the commander, first officer and jump seat position. The CAM recorded both ambient sound and speech in the cockpit, while the three remaining channels predominantly recorded speech from radio communications.

[6] A CVR 'hot' boom microphone system will permanently record sound from the crew's boom or oxygen-mask microphones, regardless of communication switch selections.

[7] As per design, the CVR recording was stopped automatically five minutes after the last engine shutdown.

[8] Persian, known variously as Fārsi, is a language spoken in Iran and neighbouring countries.

[9] Honeywell manufactured Universal Flight Data Recorder (UFDR): part number 980-4100-DXUS, serial number 7551. A recycling recorder that records eight tracks of digital data onto a magnetic tape.

[10] Localiser deviation was recorded from the number one ILS receiver.

[11] The roll attitude parameter recorded on the FDR was recorded from the inertial reference system, via the symbol generator unit (SGU). The parameter accuracy stated by the manufacturer was +/- 0.3% and the resolution was to 0.3515625º.

(CMD) mode, Control Wheel Steering (CWS), Land-track[12], pressure altitude[13], radio altitude[14]; however, the status of the two VOR/NAV/ILS switch positions and automatic thrust engagement was not recorded nor were the altitude/height selections. Data from the FDR is presented at Appendix D and Appendix E.

1.11.4 Relevant recorded data

The chronology of events is detailed below. Extracts from the CVR are shown as "*ITALIC CAPITAL LETTERS*". It should be noted that radio communications were audible through the flight deck speakers during the CVR recording period. Unless otherwise stated, altitudes are above mean sea level (amsl). Speeds are knots calibrated airspeed (KCAS) and headings are magnetic.

Descent

1144:23 The aircraft, referred to by its call sign Mahan 5020, commenced a descent from FL360.

Start of CVR recorded data.

1207:53 Mahan 5020 was descending through 4,500 ft when the approach checks were completed; during which the commander and FO confirmed the altimeter QNH setting as 1025 hPa. AP 2 was engaged in command (CMD) mode and the aircraft was configured with Slat/Flap at 15/15 and with the landing gear retracted.

1208:03 The supernumerary captain said "*I THINK HE WILL TELL YOU TO GO TO THE RIGHT*". The commander corrected him by saying "*NO I THINK HE TURNS US AROUND*", to which the supernumerary captain responds "*I THINK IT WAS CLOSER*".

1208:20 Mahan 5020 was instructed by Birmingham Director to turn left onto a base leg heading of 065º.

1209:05 Mahan 5020 levelled at 4,000 ft, the Slat/Flap was then set to 20/20, the speed was 188 kt.

[12] The FDR Land-track parameter indicates whether the aircraft is in the LAND mode below 400 ft (LAND green on FMA), which is a combined mode which engages at 400 ft agl or below, provided GS and LOC modes are engaged in the tracking phase (GS and LOC green on FMA).

[13] Pressure altitude: the altimeter reading when the pressure setting is set at 1013.2 hPa. Below 5,000 ft, the accuracy is +/- 50 ft.

[14] Radio Altitude was recorded from the number one transceiver; accuracy is dependant upon aircraft roll attitude and height. For roll attitudes below 20º the following is applicable: +/- 5% between 500 ft and 2,500 ft, +/- 3% between 100 ft and 500 ft and +/- 3ft below 100 ft. For roll attitudes between 20º and 30º the accuracy was between +/- 20%.

1209:26 Mahan 5020 was instructed to descend to 2,000 ft and to reduce speed to 160 kt.

First approach

1209:41 Mahan 5020 commenced a descent from 4,000 ft.

1210:00 The controller instructed Mahan 5020 to turn left onto a localiser intercept heading of 015° and report when established. This heading resulted in a localiser intercept angle, from the left, of 48º.

1210:24 The following conversation commenced when the aircraft was about 11 nm from the runway threshold and about 5 nm from the HON VOR.

- Commander "*WELL WE ARE TWO THOUSAND…HOW MANY DME ARE WE*".
- First officer "*FROM THE BEGINNING OF THE RUNWAY WE ARE ELEVEN DME*".
- Commander "*NOW WE ARE FIVE DME*"
- Supernumerary captain "*APPROACHING FIVE DME…FOUR AND ABOUT FIVE DME*"
- First officer "*FROM THE BEGINNING OF THE RUNWAY WE ARE ELEVEN DME*"
- Supernumerary captain "*FOUR AND ABOUT FOUR AND A HALF* "
- First officer "*DISTANCE FROM THE BEGINNING OF THE RUNWAY IS ELEVEN*"

  "*WE CAN KEEP IT UP TO FIVE DME*"

- Commander "*BECAUSE WE DO NOT HAVE GLIDESLOPE WE SHOULD GO DOWN NOW*"
- Supernumerary captain "*YES*"
- First officer "*WE SHOULD KEEP IT UP TO FIVE DME*"
- Commander "*ESTABLISHED*"
- First officer "*MAHAN FIVE ZERO TWO ZERO ESTABLISHING LOCALIS*ER"
- ATC "*MAHAN FIVE ZERO TWO ZERO THANKYOU YOUR RANGE IS TEN MILES DESCEND WITH THE LOCALISER DME PROCEDURE AND CALL TOWER ONE ONE EIGHT DECIMAL THREE*"
- First officer "*ONE ONE EIGHT DECIMAL THREE GOOD DAY MAHAN FIVE ZERO TWO ZERO*"

1210:57 The aircraft started to turn onto the localiser; the aircraft was 1.5 dots[15] left of the localiser (Appendix D, Point A).

1211:07 Mahan 5020 progressively rolled to about 30º of left bank (Appendix D, Point B), before reaching a maximum of about 36º (Appendix D, Point C); the aircraft deviation was 0.4 dots left of the localiser. As the left turn had commenced the aileron positions were seen to progressively increase until the aircraft reached about 15º of left bank, at which time the aileron deflection

[15] Deviation from the runway centre line is displayed on the primary flight displays (PFD) using dots of deviation. If two dots deviation was displayed on the PFD the aircraft would be displaced about 106 metres (about 349 ft) from the runway centre line if the aircraft was at the runway threshold position. As the aircraft approaches the runway the deviation indication becomes more sensitive: at the runway threshold, one dot deviation would result in being displaced about 53 metres from the runway centre line; at 0.5 nautical mile from the runway threshold one dot deviation would result in a displacement of about 70 metres from the runway centre line, and at four nautical miles one dot deviation would result in a displacement of approximately 180 metres.

angles started to reduce, and a subsequent reduction in roll rate was observed. After about three seconds, the aileron angles then started to increase again. The aileron deflections continued to be increased for about 3 seconds before they started to rapidly reduce; the aircraft was then banked to the left at about 27º. When the aircraft reached about 30º of left bank the rate of change in aileron deflection rapidly reduced and the aircraft then continued to roll to about 36º of left bank.

1211:22 Mahan 5020 started to roll to the right, towards the localiser; deviation was one dot left.

1211:25 The FO advised Birmingham Tower that they were on the ILS and the controller instructed them to continue with the approach for Runway 33. Shortly afterwards the aircraft levelled at 2,000 ft at an airspeed of 160 kt. Almost coincident with the FO making the radio call, the commander asked "*WHAT'S THE PROCEDURE",* the supernumerary captain advised the first check altitude, which was 1,650 ft at 4 DME, before adding "*FROM FOUR DME WE CAN GO TO MINIMUM"*. The commander inquired what the minimum was and the FO and supernumerary captain both advised that it was 740 ft. The commander repeated "*MINIMUM SEVEN FOUR ZERO.....WE GO FOR FIVE HUNDRED",* before asking for the gear to be selected down.

1211:46 Mahan 5020 was about two dots left of the localiser at about the same time that the aircraft started to descend (Appendix D, Point D); the aircraft was about 8.5 nm from the runway and about 2.5 nm from the HON VOR. The rate of descent stabilised at about 1,500 ft/min and airspeed stabilised at about 164 kt.

1211:57 The commander asked "*WHY DOESN'T IT CAPTURE"*; the aircraft was two dots left of localiser and the localiser deviation was slowly increasing.

1212:00 The controller asked if Mahan 5020 was established on the localiser and advised the crew that they were left of the approach track; the aircraft was now 2.2 dots left.

The commander acknowledged and the FO advised the controller they were turning to the right (Appendix D, Point E). The commander then said "*I CAME…IT SHOULD DO IT ITSELF….WE ARE ADJUSTING*"

1212:04 The landing gear locked down.

1212:22 At 1,160 ft and 164 kt the commander asked for full flap.

1212:29 At 1,020 ft (516 ft agl) the supernumerary captain said "*NOW THE GROUND CAN BE SEEN…..JUST INTERCEPT IT…. I WILL TELL YOU WHEN TO DISCONNECT IT";* the speed was 164 kt and the aircraft was 1.7 dots left of the localiser beam.

1212:33 The height was 400 ft agl.

1212:38 At about 300 ft agl, with a descent rate of about 1,440 ft/min, a GPWS mode 1 "SINK RATE" warning occurred (Appendix D, Point F).

1212:39 At 258 ft agl the autopilot was disconnected (Appendix D, Point G), this was just as a second and final GPWS *"*SINK RATE*"* warning occurred.

1212:40 The descent rate started to reduce as both the nose-up pitch attitude and engine thrust were increased; the throttle resolver angle gradually advanced from about 41º (35% N_1) to about 56º (70% N_1).

1212:41 The controller transmitted "*MAHAN FIVE ZERO TWO ZERO CLIMB TO THREE THOUSAND FEET IMMEDIATELY*"; the FO acknowledged this transmission. The commander said "*WHERE WERE WE I DIDN'T CATCH IT",* to which the supernumerary captain replied "*I DIDN'T SEE THE RUNWAY…VOR DROPPED BUT WE DIDN'T SEE THE RUNWAY";* the aircraft was now about 0.5 nm North-East of the HON VOR beacon.

1212:42 Mahan 5020 started to level off at an altitude of about 660 ft.

1212:45 The height above terrain reached a minimum of 164 ft radio altitude (Appendix D, Point H).

Go-around

1212:52	The aircraft commenced a climb and the engine thrust increased; the throttle resolver angle increased from 56º (70% N_1) to 75º (92% N_1); the airspeed was 144 kt.
1212:53	The autopilot disconnect warning ceased.
1212:57	The commander said "*FLAP FULL*", followed by "*RETRACT IT*". The throttle resolver angle reached 75º (92% N_1), which was the maximum recorded value during the go-around. Between 1212:53 and 1213:26 (when an autopilot disconnect warning was again recorded on the CVR) the autopilot had been re-engaged. The time of the re-engagement could not be determined due to the degraded quality of FDR data during this time period.
1212:59	The flaps started to retract, followed almost immediately by the landing gear being selected up; altitude 760 ft, speed 148 kt.
1213:04	At an altitude of 930 ft and an airspeed of 155 kt the thrust levers began to retard.
1213:06	The FO asked "*WHY DIDN'T IT CAPTURE*" to which the commander responded "*NOW IT IS GOING TO CAPTURE*"; the aircraft was 1.4 dots left of localiser.
1213:08	The Slat/Flap reached 15/15 at an airspeed of 152 kt at 1,140 ft.
1213:15	The FO advised the controller that a missed approach was being performed, which was acknowledged, shortly afterward the supernumerary captain said *"GO THREE THOUSAND…SPEED"*.
1213:21	At about this time the flaps started to retract towards the Slat/Flap 15/0 position; the airspeed was approximately 150 kt at 1,500 ft.
1213:22	The FO asked the controller if they were clear to climb to 3,000 ft.

1213:26 The Slat/Flap reached the 15/0 position when the aircraft was about 1,650 ft at an airspeed 150 kt. The autopilot was disconnected; the pitch attitude then started to reduce and the airspeed started to increase.

1213:29 The controller, responding to the FO's request for altitude clearance, instructed the crew to climb to 3,000 feet. The FO acknowledged and read back the instruction to the commander. Shortly after the commander said "*WHY DOESN'T THREE THOUSAND COME ABOUT*".

1213:34 The aircraft levelled off at about 1,750 ft at an airspeed of approximately 162 kt.

1213:35 The autopilot disconnect warning ceased.

1213:47 The aircraft commenced a descent at an airspeed of about 163 kt as the thrust levers progressively retarded.

1213:56 AP 2 was engaged in the CMD mode as the thrust levers reached idle power; the throttle resolver angle was about 42º (35% N_1); the speed was 166 kt.

1214:02 The FO requested radar vectors and the controller instructed them to climb to 3,000 ft and continue on their present heading, which was 330º. They were then instructed to change radio frequency to Birmingham Director.

1214:12 The thrust levers started to advance.

1214:20 The FO advised the commander to climb to 3,000 ft and the commander acknowledged, however shortly after the FO said "*WE ARE DESCENDING*".

1214:23 Mahan 5020 descended to 1,300 ft, (860 ft agl) before commencing a climb; the commander said "*WE ARE GOING UP NOW…EVERYTHING IS RIGHT*".

1214:29 The controller asked "*JUST CONFIRM YOU ARE CLIMBING TO THREE THOUSAND NOW*", the FO confirmed "*OUT OF ONE THOUSAND FIVE HUNDRED FOR THREE THOUSAND*". The controller then requested a left turn onto 245º when level at 3,000 ft.

1214:30 The commander asked "*WHY DIDN'T IT CATCH IT*". The following conversation then took place:

- Supernumerary captain "*MAYBE WE WERE TOO NEAR*"
- Commander "*MAYBE WE WERE HIGH*"
- Supernumerary captain "*TWO DOT.. NO WE WERE NEAR.....FOUR DME AND FIVE DME....SHOULDN'T BE TWO DOT*"
- Commander "*I TOLD YOU FOUR DME... YOU SAID ELEVEN DME*"
- Supernumerary captain "*FOUR DME IS RIGHT... FOUR DME WAS RIGHT*"
- First Officer "*THIS IS FROM THE BEGINNING OF THE RUNWAY*"
- Supernumerary captain "*NO THIS IS THE DME*"
- First Officer "*THIS IS FROM RUNWAY THREE THREE*"
- Supernumerary captain "*NO PROBLEM*"

1216:34 The FO advised Birmingham Director that the aircraft was at 3,000 ft and making a left turn onto a heading of 245º.

1217:39 The aircraft was then vectored onto a downwind heading of 145º. The crew discussed DME distance and check altitudes, during which the supernumerary captain said "*WHAT DID YOU GET THE DME FROM*", however, his question went unanswered. The following conversation then took place:

- Supernumerary captain "*WE CAN GET DME FROM LOCALISER ONE ONE ZERO...*

  WE ARE GOOD WE CAN GET DME NOW"

- Commander — "*WE CAN GET FIVE DM*E"
- Supernumerary captain — "*WE CAN GET FIVE DME FROM THE LOCALISER… NOW WE CAN GET DME FROM WHAT WE SELECTED…NOW WE ARE NINE DME FROM THE RUNWAY" (PAUSE)"IT DOESN'T HAVE DME*"
- First Officer — "*IT DOESN'T HAVE VOR*"
- Supernumerary captain' — "*RIGHT*"
- First Officer — "*ONE FOUR FIVE…SPEED ALT HEADING SELECT THREE THOUSAND…..WE ARE LEFT DOWN WIND*"
- Supernumerary captain — "*FROM VOR NUMBER ONE YOU CAN BEGIN DESCENT*"

1220:01 The supernumerary captain said "*NOW IT IS COMING TO SIX DME, AT SEVEN DME HE WILL TURN…HE WILL ALLOW YOU TO DESCEND*". The aircraft was just over 6 nm from HON VOR and about 11 nm from the runway.

1220:34 The aircraft was vectored onto a base leg heading of 095º and descended to 2,000 ft. The controller re-confirmed that the approach procedure would be localiser DME and asked if they had the procedure, the FO confirmed "*ROGER LOCALISER DME PROCEDURE*". The commander asked the crew if they had the correct procedure, and the other flight deck occupants confirmed that they were using the correct approach chart.

1221:48 Mahan 5020 was instructed to turn left onto a base leg heading of 065º. The commander again queried if the procedure they had was correct, "*MAYBE IT HAS ANOTHER PROCEDURE", the FO responded "WE DON'T HAVE"*.

Second approach

1222:29 Mahan 5020 was instructed to "*TURN LEFT ONTO A HEADING OF THREE SIX ZERO, YOU CLOSE THE LOCALISER FROM THE LEFT REPORT ESTABLISHED YOU HAVE TWELVE TRACK MILES TO RUN*". The FO acknowledged and read back to the crew "*CLEAR FOR LOCALISER*"; although he did not read back that they had 12 track miles to run the controller's transmission was clearly audible over the flight deck speakers.

1222:49 The commander said "*MAYBE BECAUSE LAND MODE WAS SOONER*". The supernumerary captain suggested "*WAIT UNTIL WE ARE IN THE CONE OF THE LOCALISER*". The FO sugested "*CAPTURE IT MANUALLY*".

1222:58 The following conversation commenced:

- Supernumerary captain "*NOW YOU ARE SIX DME"*
- Commander "*NOW GO DOWN"*
- Supernumerary captain "*AT FIVE DME YOU CAN GO ONE THOUSAND SIX HUNDRED AND FIFTY…ONE SIX FIVE ZERO UP TO FOUR DME AND THEN GO TO MINIMUM. IF YOU DON'T GO DOWN NOW WE ARE TOO HIGH…FOUR DME ONE SIX FIVE ZERO",*
- Commander *"FOUR DME ONE SIX FIVE ZERO"*.

1223:07 The aircraft commenced a descent (Appendix E, Point A); the aircraft was about 5 nm from HON VOR and about 11 nm from the runway threshold.

1223:29 Both the FO and the supernumerary captain were heard to say "*GO TO SEVEN HUNDRED AND FORTY"*; the aircraft was now about 4 nm from HON VOR and about 10 nm from the runway threshold.

1223:40 The aircraft was descending through 1,600 ft at about 160 kt when the controller transmitted "*MAHAN FIVE ZERO TWO ZERO JUST CONFIRM YOU ARE MAINTAINING TWO THOUSAND FEET*". The FO advised they were descending and the controller instructed them to climb and maintain 2,000 ft. The supernumerary captain said "*YOU ARE THREE DME THEN YOU WANT TO DIVE.....SPEED FOR GEAR AND FLAPS*". The FO asked if the gear was to be lowered, but the commander instructed him to wait.

1223:57 The aircraft commenced a climb from an altitude of about 1,400 ft; the terrain clearance was about 1,000 ft.

1224:12 The commander said "*WE ARE NINE DME*". The supernumerary captain said *"FROM",* but there was no response; at this stage the aircraft was about 9 nm from the runway threshold.

1224:18 The FO and supernumerary captain said "*LOCALISER*" almost simultaneously and the commander acknowledged; the aircraft was 1.7 dots left of localiser.

1224:21 The Slats/Flaps were set to 15/15.

1224: 23 When Mahan 5020 was one dot left of the localiser it commenced a left turn (Appendix E Point B).

1224:31 The Slats/Flaps were set to 20/20.

1224:33 The aircraft rolled progressively to about 38º (Appendix E, Point C), closing to within 0.27 dots left of the localiser, before starting to roll to the right. The aileron deflection angle had both increased and decreased as the aircraft had banked to about 30º, at which time the rate of change of aileron deflection had reduced and the aircraft continued to roll to about 38º.

1224:42 The commander said "*AGAIN IT DOESN'T CAPTURE*" and the FO suggested *"CAPTURE IT MANUALLY... GO TO THE RIGHT";* the aircraft was one dot left of the localiser when the aircraft started to turn to the right.

1224:54 Mahan 5020 was 1.8 dots left of localiser when the controller asked if the localiser was established.

The commander said "*NO NOT ESTABLISHED*" and disconnected the autopilot (refer to Appendix E). The FO advised the controller, "*WE ARE TWO DOT LEFT OF COURSE*". The controller responded "*IF YOU ARE ON THE LOCALISER YOU CAN DESCEND WITH THE LOCALISER DME PROCEDURE BUT REMAIN THIS FREQUENCY*".

1225:11 The aircraft climbed to 2,200 ft before starting its final descent (Appendix E, Point D). The commander called for gear down before saying "*WE ARE TOO HIGH UP*".

1225:23 At 1,950 ft and an airspeed of 165 kt the Slat/Flaps were set to 30/40.

1225:27 The landing gear locked down.

1225:34 The FO confirmed that the landing check list had been completed.

1225:49 The aircraft was 5 nm from the runway threshold at an altitude of 1,650 ft.

1225:53 The aircraft stabilised about 0.4 dots left of the localiser.

1225:54 The FO called "*ONE THOUSAND*".

1226:09 As the aircraft descended through 1,000 ft the controller asked "*WHAT LEVEL ARE YOU DESCENDING TO*". The FO replied "*WE ARE DESCEND TO SEVEN FORTY*". At about this time AP 2 was engaged in the CMD mode (see Appendix E).

1226:23 At an altitude of 930 ft (550 ft agl) the autopilot was disconnected (see Appendix E); localiser deviation was less than 0.1 dot.

1227:04 The controller cleared the aircraft to land on Runway 33 and passed the surface wind as 320º at 8 kt.

1227:22 At an altitude of 850 ft (470 ft agl), when about 2 nm from the threshold, the FO and supernumerary captain said "*RUNWAY IN SIGHT*".

1227:47 The supernumerary captain said *"WE ARE FIVE DME PAST.....WE ARE PASSED IT..IT IS SHOWING WE ARE PAST"*; the aircraft was about 5 nm from the HON VOR.

1228:32 The aircraft touched down.

1228:50 The crew initially contacted Birmingham Tower before then being instructed to contact ground control. They were advised to taxi to Stand 52.

As the aircraft taxied to the stand the supernumerary captain referred to being 5 to 6 DME past. A short time later he referred to 7 DME, to which the FO responded "*SEE......THIS IS THE DISTANCE FROM RUNWAY THREE THREE"*. The crew then had the following conversation concerning the autopilot:

- Supernumerary captain "*SEE YOU SHOULD INTERCEPT*"
- Commander "*IT DIDN'T INTERCEPT*"
- Supernumerary captain "*MANUALLY IT DIDN'T INTERCEPT*"
- First Officer "*BECAUSE IN LOC STAR PHASE SO WE HAD SUPERVISORY FORCE*"
- Commander "*HUH*"
- First Officer "*CWS.. BECAUSE IN LOC STAR IT COULD BE CWS*"

1239:30 The FDR and CVR both ceased recording.

1.12 Aircraft examination

Between the incident flight on 23 February 2006 and 4 April 2006 the aircraft continued to operate into Birmingham and on other routes without any reported faults with the AFS or problems capturing the localiser. On 4 April the aircraft was prepared for a scheduled "C" maintenance check. Since all the aircraft's systems relevant to the incident flight continued to perform without faults, no aircraft components were removed for further examination.

1.12.1 Dynamometric rod test

The dynamometric rods are rods within the control wheel system that measure the force applied by the pilot when turning the control wheel left or right. The measured wheel force is used by the AFS in CWS mode and when the pilot is employing 'Supervisory Control Wheel' in CMD mode. A force of at least 4.5 lb is required to be applied to the wheel to initiate a 'Supervisory' input when in CMD mode. A fault with the dynamometric rods could result in a lower force activating a 'Supervisory' input in one direction – the consequence of this would make an accidental control input by the pilot more likely, thereby inadvertently overriding the AFS attempts to capture the localiser. The aircraft operator carried out the dynamometric rod test using the A310 Trouble Shooting Manual on 25 May 2006 and reported that the system was "found satisfactory with no defects".

1.13 Medical and pathological information

Not relevant.

1.14 Fire

None.

1.15 Survival aspects

Not relevant.

1.16 Tests and research

In order to understand the behaviour of both the aircraft and the flight crew during the approaches into Birmingham the investigation requested the assistance of the manufacturer's Safety Services support department. The manufacturer provided the use of the Airbus A310 engineering simulator together with an experimental test pilot and technical support from their engineering staff. Representatives from the AAIB had extensive discussions with the manufacturer and carried out a series of 'flights' using the Airbus A310 engineering simulator.

The investigation used these facilities in an attempt to understand the following specific issues:

1. Why did the AFS not track the Runway 33 localiser with AP 2 selected?
2. Why did the aircraft's bank angle exceed the 30° AP limit during the localiser capture phase on both approaches?
3. What was the effect of the HON VOR on tracking, during both the approach and the go-around?
4. Why did the aircraft not enter a continuous climb during the go-around?

An outline programme of test points was provided by the AAIB to the manufacturer prior to the tests in order to provide a framework for the assessment.

1.16.1 Failure to capture the localiser

Using the engineering simulator, the appropriate frequencies for the approach were selected for the ILS and navigation controls. The final approach track of 329° was set on all three controls and the three-position switches placed in the ILS position. On each approach the localiser intercept was flown in HDG using AP 2 in CMD and with the LAND mode armed. On all approaches the AP captured the localiser and then tracked the centreline accurately.

Using the same frequency and navigation selections, a course of 285º was set instead of the required course of 329° for Runway 33 at Birmingham; the course of 285° represented the final approach course for the previous landing, which had been at Tehran. The simulator was again positioned on the intercept heading with the LAND mode armed. On both approaches the simulator captured the localiser but then adopted a parallel course, displaced 2 dots to the left of the centreline, and never achieved the localiser track phase.

1.16.2 Overbanking during the initial localiser capture

The angle of bank never exceeded the normal 30° limit on any of the approaches flown in the simulator either in HDG mode or when the AFS captured the localiser. The only manner in which it was possible to replicate the aircraft behaviour was through operation of the Supervisory Control Wheel mode. Furthermore, the manufacturer considered that the aileron movement shown on the FDR was responsible for the increase in bank beyond the AP normal limit of 30° and they believed that this movement was probably due to Supervisory Control Wheel operation rather than any turbulence upset, since there was no indication of AP 2 attempting to correct such an upset.

1.16.3 Effect of the Honiley VOR

During the approaches flown in the simulator, the three-position switches were placed in the VOR and NAV positions both prior to and during localiser capture. The AFS remained engaged and the appropriate mode alert activated on the relevant PFD. The simulator captured and tracked the localiser or paralleled the centreline depending on the course selected. The HON VOR had no influence on the aircraft track.

1.16.4 Go-around

The vertical profile for the first approach was reproduced in the simulator with AP 2 engaged in CMD and the A/THR engaged. A go-around altitude of 3,000 ft and target speed of 140 kt were selected. When the go-around mode was activated using the throttle go-levers, both engines increased thrust to 100% N_1. A nose up pitch attitude of 18º was commanded and the rate of climb and thrust achieved were maintained until altitude capture (ALT*). The target speed of 140 kt was maintained unless the selected target speed was altered.

A second go-around was flown, but without activating the go-levers. Instead, the AP was disconnected and a nose-up pitch attitude was selected using the control column. The engine thrust increased to maintain the target speed of 140 kt and the aircraft climbed at a rate dependant on the degree of nose-up pitch attitude. If, during this manoeuvre, AP 2 was re-engaged the situation was maintained and the stabiliser automatically trimmed for the speed and power setting. The flaps were then retracted to 20° and the landing gear was selected UP. This caused the Lowest Selectable Speed (V_{LS}) amber strip and Stick Shaker Speed (V_{SS}) black and red strip on the speed scale to move rapidly towards the 140 kt target speed. The narrowing margin between target speed and V_{SS} was compelling. The instinctive response to the situation was to disconnect the AP and pitch the aircraft nose-down to maintain the speed margin.

As the pitch attitude reduced, the thrust reduced in order to maintain the target speed. This, when combined with the attendant nose-down trim change, allowed the aircraft to commence a descent. During this descent, the AP was re-engaged and with a target altitude of 3,000 ft set the Flight Level Change (FLC) mode was selected. The engine thrust increased and the aircraft climbed to the selected altitude.

When the AP was re-engaged in the simulator, the lateral guidance reverted to the LOC* mode, if the HDG mode was then selected a landing mode capability audio warning sounded.

1.17 Organisational and Management Information

1.17.1 General

Mahan Air was incorporated in 1992 as the first private airline in Iran. At its operational launch in May 1993, Mahan Air had a fleet comprising two Tupolev 154 aircraft, a staff of 99 and a route network from Tehran to two domestic destinations.

Mahan Air's major expansion commenced with the addition of Airbus A300 wide-body equipment in 1999 and the A310 in 2001. This enabled the airline to fly beyond the regional destinations it served at that time. Currently, the route network spans 21 destinations in 10 countries and the airline has a modern fleet of 11 Airbus aircraft and 1,400 members of staff. Mahan Air is a member of the International Air Transport Association (IATA).

1.17.2 Management structure and flight training

The management structure conformed to the requirements of the Regulating Authority of Iran.

The operator is a Type Rating Training Organisation (TRTO) and all three pilots attended an Airbus A310 type rating course provided by the operator, the course followed the manufacturer's syllabus. All three pilots had received training in the conduct of non-precision approaches, including Localiser/DME approaches, and had passed the required proficiency check. They had all flown the Runway 33 Localiser/DME approach at Birmingham International Airport on a number of occasions.

The operation of the aircraft was based on a two-crew concept with an aircraft commander and co-pilot. There was no specific training or procedures for three crew flight deck operations.

The type rating course included 35 hours of Crew Resource Management (CRM) training. The content of the CRM syllabus is included at Appendix F.

1.18 Additional information

1.18.1 Crew procedures

1.18.1.1 Localiser/DME approach - Standard Operating Procedures

The operator had adopted the SOPs set out by the manufacturer in the Flight Crew Operating Manual (FCOM).

The company Flight Operations Manual (FOM) Part 1, Section 3.11 permitted non-precision Localiser (G/S out) approaches. The requirements stated were:

AUTHORISED INSTRUMENT APPROACHES AND WEATHER MINIMA

3.11.1 FACILITIES

The approach procedures published in the Jeppeson Airway Manual for ILS, VOR, VOR/DME, PAR, ASR, NDB are authorized provided all the required elements of the navigation aids, as specified in the heading of the approach chart, are available at the appropriate point of the approach.

The planning weather minima requirements for the destination aerodrome are also included in Section 3.11. They are:

3.14 DESTINATION TAKE-OFF AND ALTERNATE MINIMA

3.14.1 PLANNING MINIMA FOR DESTINATION AERODROME

The appropriate weather and forecast or any combination thereof indicate that during a period commencing 1 hour before and ending 1 hour after the estimated time of arrival at the destination aerodrome, the weather conditions will be at or above the specified minima (RVR/Visibility and in addition for non-precision approach, the ceiling must be at or above MDA/H) for the type of approach to the runway of intended landing.

The term 'Ceiling' is defined in Section 3.10.2 under the heading of Terminology which states:

Ceiling/Vertical Visibility (VV)- The height of the base of the lowest layer of clouds covering more than half the sky or, in the case of fog, mist, blowing snow and similar phenomena, the vertical distance at which an object, such as a meteorological balloon, ceases to be visible. Note – "height" is the distance measured vertically from the notified elevation of the airfield.

When the approach is not stored in the Navigation database of the FMC, guidance for the auto flight system should be manually selected. HDG SEL mode should be used down to MDA (lateral) or until localizer interception. V/S mode should be used after leaving the FAF down to MDA (vertical).

The standard speed technique is a stabilized approach using AP engaged in CMD mode and A/THR engaged in SPD mode. This enables the aircraft to intercept the final descent path in the landing configuration and at V_{APP}, with the thrust stabilised.

The Standard Approach checks to prepare the aircraft for landing (landing gear down, spoilers armed, Flaps 40 and speed V_{APP}) should be performed before reaching the FAF.

The ILS/DME frequency and Course (CRS) should be set on the dedicated ILS/DME navigation control panel. The ILS/DME or VOR/DME frequency and CRS can be set on the two VOR/DME navigation control panels as required.

The Minimum Descent Altitude (MDA) is to be set on the altimeter using the amber index provided. The radio altimeter DH should be set to -5 feet on the EFIS control panel to cancel the automatic "MINIMUM" call out.

The NDs should be set to ROSE or ARC for the PF and MAP, ROSE or ARC for the PNF. The positions of the NAV/VOR/ILS switches are defined by the outcome of the navigation accuracy check. If the check is positive FMS guidance is recommended and the switches should be in NAV. If the check is negative then the switches should be in the VOR or ILS position for both the handling pilot and non-handling pilot. At the FAF or top of descent, the pre-calculated V/S required to maintain the vertical profile of the procedure should be set.

The approach is considered to be stabilized providing none of the following conditions exist:

- *Pitch attitude becomes lower than -2.5° or greater than 10° nose up*

- *Bank angles become greater than 7º*

- *V/S greater than 1,000 feet per minute*

- *Airspeed deviations of more than +10 kt or -5 kt*

- *Localiser deviation greater than one dot*

- *Any significant changes in ground speed that might indicate windshear*

If any of the above conditions exist and if the aircraft is at or below 1,000 ft AGL on the final approach in IMC, the PF should initiate a go-around.

To initiate a go-around the handling pilot should simultaneously announce 'go-around' and the required flap setting. The go-levers should be activated and the aircraft should be rotated to 18 degrees nose-up pitch attitude, at about 3 degrees per second. The FMA indications should then be confirmed (THR, GO AROUND) and once a positive rate of climb is assured the landing gear should be selected to UP.

1.18.1.2 Standard calls

The standard calls to be made during multi-crew operations, when conducting a non-precision approach are set out in the company Flight Operations Manual (FOM). Once established on an intercept heading the calls should be as follows:

EVENT	PILOT FLYING	PILOT NOT FLYING
Interception heading	ARM LAND	LAND ARMED
Localiser capture	LOC* SET RUNWAY HDG	XXX° SET
Lower the landing gear	GEAR DOWN	GEAR IS DOWN
When the landing gear is down	FLAPS 40 SET V_{APP}	SPEED CHECKED FLAPS 40 V_{APP} SET
FAF or OM if applicable	PASSING FIX NAME	CHECKED
When flaps 40	LANDING CHECK LIST	LANDING C/L COMPLETED
100 feet above MDA	CHECKED	MINIMUM
MDA visual reference	LANDING	MINIMUM
MDA no visual reference	GO-AROUND FLAPS	MINIMUM

1.18.2 Calibration of barometric altitude with radio altimeter height

At the HON VOR the minimum radio altimeter height recorded on the FDR was 164 ft. The Mode C altitude on the radar controller's display was 600 ft (corrected for the local QNH) and the lowest recorded barometric altitude was 640 ft. The elevation of the HON VOR is 435 ft. An evaluation flight was conducted in order to determine the height of obstacles over-flown by the aircraft, which influenced the radio altimeter. A helicopter fitted with a radio altimeter was flown along the aircraft track at specific altitudes using the barometric altimeter and the reduction in radio altimeter height was noted as various obstacles were over-flown. The area around Honiley is generally a sparsely populated, flat rural area with low buildings. A large wooded area incorporating isolated, tall, mature trees was briefly below the aircraft track.

With the barometric altimeter set to the Birmingham Airport QNH of 1022, the helicopter was flown at an altitude of 600 ft. As it approached the area of the lowest recorded height, the radio altimeter indicated a steady 200 ft. As the aircraft passed over the trees the radio altimeter indicated 160 ft.

The helicopter was climbed in the same area to an altitude which indicated a corrected Mode C indication of 700 ft on the radar controller's display. A slow descent was made over an obstacle free area and the radio altimeter heights at which the display indication changed from 700 ft to 600 ft, and from 600 ft to 500 ft, were recorded; these heights were 250 ft and 150 ft respectively.

1.18.3 Safety action

Following the incident, the operator issued an 'Operational Notice' to flight crew. The content of which was:

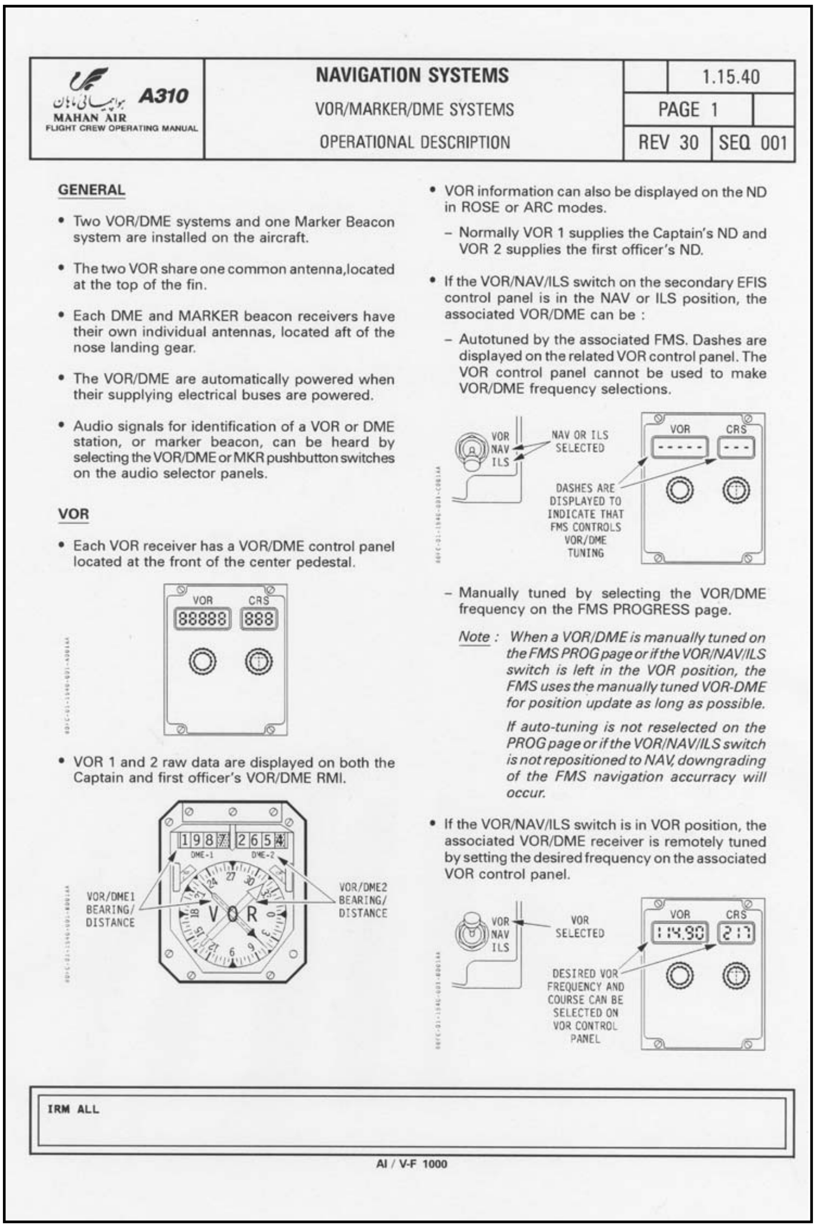
Operational Notice 12/03/2006

In accordance with A/310 FCOM.1-10.24-4, during approach, the ILS/DME is auto tuned by the FMS and the ILS/DME distance is displayed in the lower left corner of both PFDs if:

- *The ILS/DME frequency is set on the ILS control panel. And*
- *The ILS/DME is within 30 nm of the aircraft. And*
- *The VOR/NAV/ILS switch is in the ILS position. And*
- *Mach number is below 0.45 (mach number not displayed on PFD). And*
- <u>*The ILS approach is entered in the F-PLN in the FMC.*</u>

Considering the above, A310 pilots approaching airports such as Birmingham, Manchester, Imam Khomeini, and similar airports for which there is no ILS approach in the FMS data base, the only way to read the DME on the RMIs is to select the DME frequency on the VOR control box(es) and put the VOR/NAV/ILS selector switch in the VOR position.

Also included with this text was a copy of the relevant page from the FCOM shown below as Figure 5. This Operational Notice correctly reflects the Airbus SOPs, which also recommend that raw date for the reference navigational aid should be monitored during the final approach when conducting a non-precision approach.



MAHAN AIR FLIGHT CREW OPERATING MANUAL — A310	NAVIGATION SYSTEMS		1.15.40
	VOR/MARKER/DME SYSTEMS	PAGE 1	
	OPERATIONAL DESCRIPTION	REV 30	SEQ 001

GENERAL

- Two VOR/DME systems and one Marker Beacon system are installed on the aircraft.
- The two VOR share one common antenna,located at the top of the fin.
- Each DME and MARKER beacon receivers have their own individual antennas, located aft of the nose landing gear.
- The VOR/DME are automatically powered when their supplying electrical buses are powered.
- Audio signals for identification of a VOR or DME station, or marker beacon, can be heard by selecting the VOR/DME or MKR pushbutton switches on the audio selector panels.

VOR

- Each VOR receiver has a VOR/DME control panel located at the front of the center pedestal.

- VOR 1 and 2 raw data are displayed on both the Captain and first officer's VOR/DME RMI.

- VOR information can also be displayed on the ND in ROSE or ARC modes.
  - Normally VOR 1 supplies the Captain's ND and VOR 2 supplies the first officer's ND.
- If the VOR/NAV/ILS switch on the secondary EFIS control panel is in the NAV or ILS position, the associated VOR/DME can be :
  - Autotuned by the associated FMS. Dashes are displayed on the related VOR control panel. The VOR control panel cannot be used to make VOR/DME frequency selections.

  - Manually tuned by selecting the VOR/DME frequency on the FMS PROGRESS page.

<u>Note</u> : *When a VOR/DME is manually tuned on the FMS PROG page or if the VOR/NAV/ILS switch is left in the VOR position, the FMS uses the manually tuned VOR-DME for position update as long as possible.*

If auto-tuning is not reselected on the PROG page or if the VOR/NAV/ILS switch is not repositioned to NAV, downgrading of the FMS navigation accurracy will occur.

- If the VOR/NAV/ILS switch is in VOR position, the associated VOR/DME receiver is remotely tuned by setting the desired frequency on the associated VOR control panel.

IRM ALL

AI / V-F 1000

Figure 5

Relevant FCOM guidance

2 Analysis

2.1 General

This serious incident occurred when the aircraft was carrying out the Localiser/ DME approach procedure to Runway 33 at Birmingham International Airport. Due to work in progress, the glide slope for Runway 33 was not available on 23 February 2006; this information had been promulgated by NOTAM and the crew were aware of the correct status of the approach aids. The remaining navigation aids were serviceable and available for the approach. The FMC database did not contain the approach procedure in use so the I-BM DME was not displayed in the normal way on the PFD. Following the incident, the operator issued an 'Operational Notice' to flight crew to re-iterate the guidance on how such approaches should be organised.

The supernumerary captain reinforced the commander's mis-interpretation of the HON VOR DME whilst the aircraft was following radar vectors for a 15° localiser intercept. This appeared to initiate a breakdown in CRM which, in turn, led to non-compliance with the operator's SOPs and deviations from the published approach and go-around procedures. The AP captured the localiser beam but did not achieve the track mode. This further increased the workload of the crew and aggravated the already deteriorating CRM.

2.2 Human Factors

This serious incident was the result of a combination of human factors and loss of situational awareness, combined with a breakdown in CRM. Four main areas of the crew activity, which resulted in the abnormal flight path during the approaches are considered. They are:

- On the first approach, the descent was initiated early.
- On the first approach, the aircraft descended to 164 ft agl (660 ft QNH) 5 nm before the threshold of Runway 33. The MDA was 740 ft QNH.
- During the go-around, the climb was interrupted at 1,740 ft and the aircraft descended to 1,300 ft before recommencing the climb.
- On the second approach, the descent was initiated early.

Contributing to the difficulties experienced by the crew were:

- The crew did not select the RWY 33 ILS/DME frequency in the VOR control panel and did not put the VOR/NAV/ILS switch in the VOR position. As a result, the Honiley VOR/DME was autotuned by the FMS and the paired DME was displayed on the DME/RMI instrument.

- The commander's inputs in Supervisory Override contributed to the AFS failing to track the localiser beam on both approaches.

2.2.1 Early descent on the first approach:

The CVR provided a clear indication that there was confusion and disagreement amongst those on the flight deck about the execution of the approach procedure. Had the crew members not been familiar with the approach being flown the confusion would have been easier to understand. All the crew members had flown this non-precision approach, both as the PF and PNF, and were familiar with the absence of the DME display on the PFD.

A significant factor was that the crew approach briefing was conducted between the commander (PF) and FO (PNF) some 30 minutes prior to the first approach without the supernumerary captain being present. Both the PF and the PNF reported that they were clear about the navigation aids to be set and selected and that the distances relating to the procedure would be taken from the FMS CDU. The supernumerary captain entered the flight deck at some point during the descent, probably during the downwind radar vectoring for the first approach.

Initially the PF appears to have had the correct situational awareness of his position relative to the approach, whilst the supernumerary captain appears to have had an incorrect orientation. Shortly before ATC cleared the aircraft onto the base leg, the supernumerary captain said "*I THINK HE WILL TELL YOU TO GO TO THE RIGHT*". The PF corrected him by saying "*NO I THINK HE TURNS US AROUND*", to which the supernumerary captain responds "*I THINK IT WAS CLOSER*". The reason for the difference was never resolved.

When the aircraft was turned onto the intercept heading of 015°, and prior to the AFS failure to track the localiser, the crew develop two understandings of the distance to the runway. The PF initially asked for the range, "*HOW MANY DME*" and was correctly told by the PNF "*FROM FIRST (BEGINNING) OF THE RUNWAY WE ARE ELEVEN DME*". The PF stated "*NOW WE ARE FIVE DME*", probably using information from his DME/RMI. This was supported by the supernumerary captain, who may also have been reading from the DME/RMI indication. He responded "*APPROACHING FIVE DME... FOUR AND ABOUT FIVE DME"*. Both the PF and the supernumerary captain appear to have forgotten that the distance information in use was that provided by the FMS CDU.

On two further occasions in short succession the PNF and the supernumerary captain provided the PF with conflicting ranges. The PNF was correct but was ignored by the PF. Two factors may have influenced the PF: a natural tendency to focus on evidence confirming one's expectations (confirmation bias): and the status of the supernumerary captain. The conflict was still not resolved as the aircraft began to become established on the localiser. At this point the PNF was given a frequency change but importantly he was also told "*YOUR RANGE IS 10 MILES*". This information went unnoticed or ignored by the PF and the supernumerary captain but created no concern in the PNF as it fitted with his mental model of the distance to the runway.

Whilst the PNF was in the process of changing frequency and contacting the tower controller, the AFS failed to track the localiser. This added to the workload of the PF at a time when he was attempting to resolve the approach procedure. The supernumerary captain endeavoured to assist the PF by providing range and altitude information and encouraging him to descend. The PF at this stage was fully occupied trying to correct the vertical and horizontal flight path of the aircraft in an attempt to regain the approach profile. He was not able to review the chart and had to ask for the MDA which was passed to him by the PNF. This should have been set on his altimeter bug prior to the approach.

The exchange between the crew during the first approach did not resolve the different interpretations of the displayed information. In the two minutes preceding the go-around initiation, the PF made four utterances querying the range or the position with respect to the glideslope or seeking confirmation of the range, and once asking "*WHAT'S THE PROCEDURE*". He also asked four questions indicating that he did not understand why the localiser had not captured.

During this period, the PNF provided five statements concerning the DME range, including two indicating that altitude should be maintained. In the same period, the supernumerary captain made eight statements tending to confirm the commander's erroneous assessment of the DME range and the need to descend.

The reasons for the commander's initial uncertainty are a matter of speculation. The approach brief does not appear to have been effective in preparing him for the procedure. His expectations about the sequence of the approach procedure may have been insufficiently detailed, particularly in respect of the instrument indications to anticipate. Once he became uncertain, and his workload increased, he may not have had the capacity to widen his attention, cross-check the instrument indications and the configuration of the radio aids and FMS, or to formulate an effective request to the PNF for clarification. It is also conceivable that the presence of the supernumerary captain, particularly if his perceived status or known level of competency was high, may have inhibited the commander from making such a request.

The fact that the supernumerary captain had not heard the approach brief was probably an important factor in his erroneous appreciation of the situation. Clearly, he intended to help the commander resolve his uncertainty, but his expectations in respect of instrument indications had no sound basis. As the approach continued, however, he became more assertive and ignored evidence contradictory to his view of the situation from both the PNF and from ATC.

A significant feature of this period is the fact that, although a disagreement about the navigation of the aircraft was apparent, none of the pilots attempted to resolve it. Their utterances were either questions or simple assertions. The commander did not identify the discrepancy and seek a positive resolution of the disagreement. Neither the PNF nor the supernumerary captain helped the PF by drawing the discrepancy to his attention or seeking to resolve the disagreement by identifying its origins. Range information from an independent source, ATC, passed un-remarked.

The crew and the supernumerary captain had all attended a CRM course but their behaviour suggests a lack of familiarity with CRM concepts or, probably more precisely, a lack of facility in implementing such concepts.

The fact that there were no company guidelines concerning supernumerary crewmembers on the flight deck probably had two relevant effects:

1. The supernumerary captain was not restrained from intervening even though he had not heard the approach brief.

2. The FO's attempts to resolve the commander's confusion were confined to simple assertions of fact; he may have been constrained from confronting the issue by differences in rank or other status between himself and the supernumerary captain. He may also have been aware of the PFs workload and reluctant to increase it, or influenced by the PFs apparent deference to the supernumerary captain's opinions.

2.2.2 Descent below MDA

The early initiation of the descent was a mistake separate and distinct from the later error of descending below the MDA. No explanation is available on current evidence for the PF's declaration "*WE GO FOR 500"* immediately after being told the MDA was 740 ft. (On the second approach, he declared "*WE GO TO ONE THOUSAND FIVE HUNDRED"* after being told "*YOU CAN GO TO 1650"*. It is not clear whether these events are a symptom of confusion or indicate a disregard for limits.)

Several factors may have contributed to the PFs perseverance in descending below MDA; the CVR indicates his pre-occupation with capturing the localiser. Undoubtedly, the failure to capture would increase both his uncertainty and his workload and, possibly, reduce the attention he paid to altitude. He was, apparently, encouraged to descend by the supernumerary captain and did not receive calls at MDA plus 100 ft or MDA from the PNF. Conceivably, the PNF may also have been concentrating on the localiser problem or, possibly, was distracted by looking for the runway as the ground came into view. These speculations are necessarily tentative, based, as they are, on the limited evidence provided by the CVR.

2.2.3 Descent during the go-around procedure

As the go-around was initiated the PNF asked "*WHY IT DIDN'T INTERCEPT*". The PF also indicated some preoccupation with the failure to capture the localiser. This may explain why the PF's execution of the go-around did not comply with the standard go-around procedure stipulated by the FCOM, in particular he did not use the 'go-levers' and thus the go-around modes were not triggered. He appears to have reacted to indications of increasing stall speed (caused by flap retraction) by disconnecting the autopilot and decreasing the pitch attitude, causing the A/THR to decrease thrust and the aircraft to start descending. His next question "*WHY DOESN'T 3000 FEET COME ABOUT*" suggests that he was not aware of these changes and it was only after the PNF declared "*WE ARE DESCENDING"* that the situation was rectified. Conversation then returned to the issue of localiser capture. Had the crew believed they were in 'Go-around' mode as opposed to 'Speed' mode the comments would have been understandable. In 'Go-around' mode the AFS and A/THR would have sustained the climb to 3,000 ft and carried out the level off.

At the start of the go-around, it is likely that the PF and the PNF were struggling to understand the lateral and vertical anomalies in their first approach attempt. They were probably somewhat confused and uncertain and this may have contributed to the non-adherence to SOPs in the execution of the manoeuvre; in particular the PF did not use the 'go-levers' The supernumerary captain made no significant contribution during the critical phase of the go-around procedure.

2.2.4 Early descent on the second approach

As the aircraft was positioned for the second approach, there was some discussion about the problems encountered on the first. The PF at last confronted the discrepancy in DME interpretation: "*I TOLD YOU 4 DME, YOU SAY 11 DME*". His remark was clearly directed to the PNF but, before he could reply, the supernumerary captain asserted "*4 DME IS RIGHT... 4 DME WAS RIGHT*". There was then a brief exchange between the PNF and the supernumerary captain about the DME indications ending with the supernumerary captain's declaration: "*NO PROBLEM*". It is not clear, however, that the supernumerary captain had gained a proper appreciation of the situation from this exchange.

It is significant that this was the only attempt at a proper discussion between the PNF and the supernumerary captain to resolve the difference of opinion before they landed and that the commander made no effort to contribute to it or draw a definitive conclusion from it. Again, a lack of facility in CRM seems a likely contributory factor.

The supernumerary captain then conducted what was more or less a soliloquy (at 1217:39) on the subject of the DME range, which seems only to exhibit his confusion. The PNF made only one interjection correcting the supernumerary captain's assertion, "*IT DOESN'T HAVE DME*", with "*IT DOESN'T HAVE VOR*", but the PF made no comment.

Shortly after ATC had cleared the aircraft onto 360° to intercept the localiser with 12 miles to run, the supernumerary captain declared "*NOW YOU ARE AT SIX DME*". In the ensuing discussion between the PF and the supernumerary captain, the PF initiated the inappropriate descent. The PNF did not contribute to this decision, although he later offered "*GO TO SEVEN HUNDRED AND FORTY*", when the minimum altitude was under discussion. The situation was rectified when ATC asked for confirmation that they were maintaining 2,000 ft.

From this point on, the supernumerary captain became more interventionist in his efforts to help the PF, eventually providing a continuing commentary, encouragement, and instructions. The PNF confined himself more or less to the routine procedures and factual information.

The same confusion and failures in CRM that are apparent in the first approach are apparent in the second. The PF initiated a debate about DME information but apparently made no attempt to control it or use it to resolve the issue. It is noteworthy that the only attempt at a real discussion between the PNF and the supernumerary captain followed the commander's question. This suggests that, without the PF's support, the PNF was reluctant to confront the supernumerary captain's confusion. It is natural to suspect that differences in status may have contributed to this reluctance. Such differences may also explain why the PF did not pursue his question to the PNF once the supernumerary captain had intervened.

2.2.5 Failure to capture localiser on either approach

Two factors are conceivably relevant. First, the roll angles recorded during both approaches indicate manual over-riding of the AP through SCWO. If sustained, these inputs may have contributed to the AP's failure to track the localiser. This may have been what prompted the FO to say, after landing, "*BECAUSE IN LOC STAR PHASE SO WE HAD SUPERVISORY FORCE*", and later "*CWS.. BECAUSE IN LOC STAR IT COULD BE CWS*". Second, simulator tests showed that selecting an incorrect course could prevent localiser capture by the AP. This is a plausible and adequate cause, but is not supported by the selection found on examining the flight deck shortly after the landing. The aircraft's failure to track the localiser can therefore be explained.

Twice during the first approach, and once immediately after acknowledging the ATC go-around command, the PF spoke, indicating concern over the failure to capture the localiser. He received no answer from the PNF. It is possible the supernumerary captain said *"DON'T WORRY"* in response to the first query. The PNF may have been preoccupied with responding to ATC transmissions and monitoring progress. In any event, he appears not to have diagnosed the cause of the problem because, after the go-around was initiated, he asked "*WHY DIDN'T IT INTERCEPT"*.

Throughout the remainder of the flight, the failure to capture the localiser remained a major cause of concern and, intermittently, a topic of discussion. It is likely that this contributed to the workload and, possibly, some disquiet, particularly for the PF. These factors would have degraded the efficiency of the crew to some degree.

2.2.6 Summary comments

The approach brief appears to have been inadequate in that the PF's understanding and expectations were not detailed and accurate. This, and his handling of the go-around procedure, might be indicative of a lack of currency or aptitude. The ongoing confusion, particularly about localiser capture, certainly increased his workload and possibly caused some anxiety that may have degraded his performance. However, CRM issues made a significant contribution to the unnecessary risks involved in this flight.

The absence of company guidelines for supernumerary crewmembers on the flight deck created an opportunity for generating confusion. It is possible that the supernumerary captain's rank or perceived status inhibited both the commander and the FO from resolving the confusions. Without the supernumerary captain's intervention, the confusion about the approach procedure might well have been resolved and the early descents on both approaches and the descent below MDA on the first approach might have been avoided.

> It is recommended that Mahan Air should develop operating procedures for the presence of additional flight crew members occupying a seat on the flight deck. (Safety Recommendation 2007-109)

Although CRM training is widespread throughout aviation, its effectiveness is not often measured and it is likely that its concepts are more easily adopted in some cultures than in others. Even in societies that are naturally more open to flatter authority structures, it takes more than a few hours of classroom training to cultivate effective CRM behaviours. The standard of CRM evident in the CVR for this flight was inadequate.

> It is recommended that Mahan Air should conduct a thorough review of its CRM training programme to ensure that it is both appropriate for their needs and produces consistent and acceptable results. (Safety Recommendation 2007-110)

ATC intervention during the two approaches was timely and sensitive. Without it, the risks arising from the confusion on the flight deck might well have resulted in an accident.

2.3 Aircraft operation

2.3.1 Terrain Awareness Warning System

The aircraft was not equipped with a TAWS as required by the UK CAA regulations. Had the aircraft been equipped with the required TAWS an earlier warning of the premature descent would have been available to the flight crew.

2.3.2 Navigation database

The FMC database did not contain the ILS/DME approach to Runway 33 at Birmingham International airport. The FMS auto-tuned the HON VOR/DME and displayed this distance on the DME/RMI instrument because the crew did not put the VOR/NAV/ILS switch in the VOR position. The FMC database is routinely updated in a period which corresponds to the updating of navigation charts. The operator could use these updates to ensure that all approaches relevant to their route structure are incorporated in the database and thus available to the flight crews.

> It is recommended that Mahan Air should expand its FMS database to include all approaches relevant to their route structure. (See Safety Recommendation 2007-111)

2.3.3 Unstable approaches

During the first approach the rate of descent stabilised at about 1,500 ft/min and the aircraft was two dots left of the localiser centre-line, with the localiser deviation slowly increasing. The aircraft maintained these parameters throughout the descent, which was flown in IMC.

The operator's SOPs define this as an un-stabilized approach in that the rate of descent was greater than 1,000 fpm and the localiser deviation was greater than 1 dot. If either of these occur whilst the aircraft is at or below 1,000 ft agl on the final approach in IMC, a go-around should be initiated.

During the approach the ongoing confusion, particularly concerning the localiser capture, increased the crew's workload and possibly caused some anxiety that may have contributed to their degraded performance. This may well have been the reason that they did not detect any excessive parameter deviation; certainly, the crew made no comments in this regard.

In this instance, no corrective action was taken until after the GPWS *"SINK RATE"* warning occurred, when the engine thrust was increased to 70% N_1

and the pitch attitude was increased. The failure to recognise the need for, and correctly execute, a go-around, is a major cause of approach and landing accidents. This is the final opportunity for the crew to correct a poor approach, and even if the un-stable approach had not been detected the GPWS warning should have prompted an immediate and correct response by the PF.

2.4 Aircraft maintenance

The AP 1 system, which is normally used to control the aircraft when the AFS is engaged and the commander is the PF, disconnected when the wing slats/flaps extended. No reason for this had been identified and flight crew simply used AP 2 instead of AP 1, since this was not affected by extending the wing slats/flaps. However, this known defect had not been entered into the aircraft's Technical Log. This meant that the maintenance organisation would not be aware of the fault and would thus take no steps to correct the defect. It also meant that other flight crews might not be aware of the problem until they extended flaps on an approach; this would be of particular concern if that approach required the use of both auto-pilots, such as an auto-land.

3 Conclusions

(a) Findings

1. The flight crew were properly licensed and qualified to conduct the flight, and were well rested. Their training, including CRM training, was in accordance with the operator's requirements.

2. The aircraft was certified, equipped and maintained in accordance with existing regulations and approved procedures. At the time of the incident there were no recorded Acceptable Deferred Defects that might have contributed to the incident.

3. The defect relating to AP 1 had not been entered into the aircraft's Technical Log.

4. The ATCO at Birmingham International Airport was properly licensed and qualified.

5. The flight crew had the relevant meteorological information, and the conditions during the approach were above the required minima.

6. The glide slope element of the ILS to Runway 33 was not available due to work in progress and the flight crew had been notified correctly.

7. The flight crew were familiar with the Localiser/DME approach to Runway 33.

8. The commander and FO had briefed the approach prior to the top of descent in accordance with their SOPs.

9. The supernumerary captain joined the handling crew at some point during the initial approach phase; he had not been a party to the approach brief.

10. The FMC database did not contain the ILS/DME approach to Runway 33 at Birmingham International Airport.

11. The FMS auto-tuned the Honiley VOR/DME and this distance was displayed on the DME/RMI instrument because the crew did not put the VOR/NAV/ILS switch to the VOR position.

12. The commander and supernumerary captain used the DME/RMI distance display as the primary source to fly the procedure.

13. The aircraft was radar vectored for the Localiser/DME approach procedure and positioned on an intercept heading, but the AFS did not track the localiser. However, the commander manually over-rode the AP, turning the aircraft to the left with up to 36º angle of bank.

14. The MDA of 740 ft was incorrectly set.

15. The crew initiated an early descent, based on the Honiley VOR/DME distance, this was 5 nm before the correct descent point.

16. The aircraft was not equipped with a TAWS as required by the UK CAA regulations.

17. No standard calls were made during the approach.

18. The radar controller identified the early descent and contacted the tower controller, who instructed the aircraft to climb immediately to 3,000 ft.

19. The GPWS 'SINK RATE' warning sounded as the aircraft descended to a minimum height of 164 ft whilst 5 nm from the runway threshold.

20. The commander disengaged the AFS and increased both the pitch attitude and the power just prior to receiving the climb instruction from the tower controller.

21. The go-around was not flown in accordance with the operator's SOP, and during this manoeuvre the aircraft descended from 1,750 ft to 1,300 ft, before eventually stabilising at 3,000 ft.

22. The flight crew did not identify the reason for the early descent during their discussions following the first approach.

23. The aircraft was radar vectored for a second Localiser/DME approach procedure and positioned on an intercept heading, but the AFS did not track the localiser. Once again, the commander had over-ridden the AP, turning the aircraft to the left and exceeding 31º angle of bank.

24. An early descent was again initiated, using the distance from the Honiley VOR/DME.

25. The Radar controller observed the early descent and instructed the crew to return to 2,000 ft.

26. The PF flew the approach without the AFS and landed the aircraft safely.

(b) Contributory factors

The investigation identified the following contributory factors:

1. The primary cause of the incident was the use by the crew of the incorrect DME for the approach at Birmingham International Airport.

2. There was also a substantial breakdown in CRM, which was partly due to the presence of a third flight crew member on the flight deck. He was not present during the approach briefing nor when the navigation information displayed was selected. He attempted to support the crew in their efforts to fly the approach but inadvertently re-enforced the commander's misinterpretation of the DME indications. This occurred despite the first officer initially recognising the discrepancy between the distance to the threshold and the distance displayed on the VOR/DME, and attempting to communicate this to the other members of the flight crew.

4 Safety Recommendations

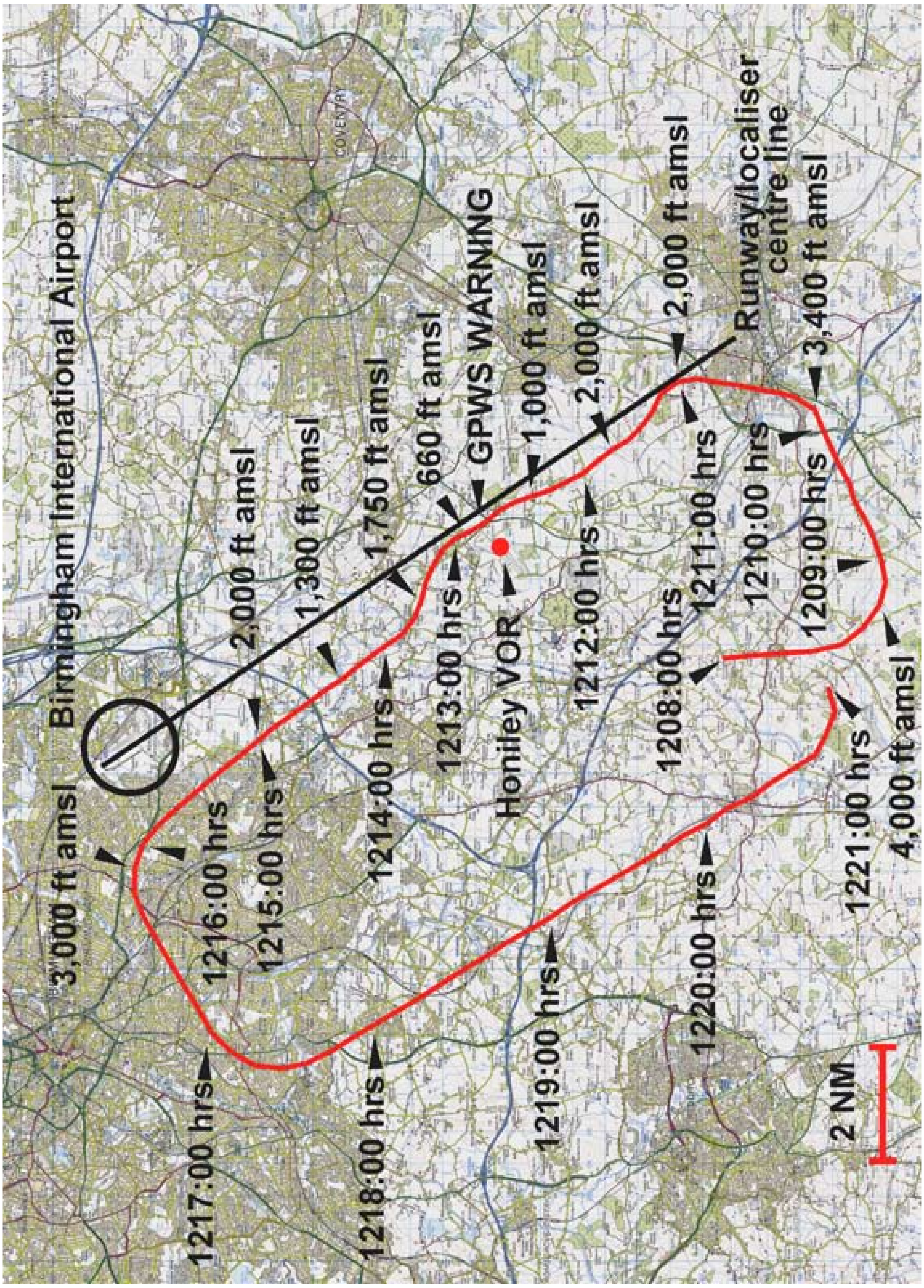
The following safety recommendations were made:

4.1 **Safety Recommendation 2007-109:** It is recommended that Mahan Air should develop operating procedures for the presence of additional flight crew members occupying a seat on the flight deck.

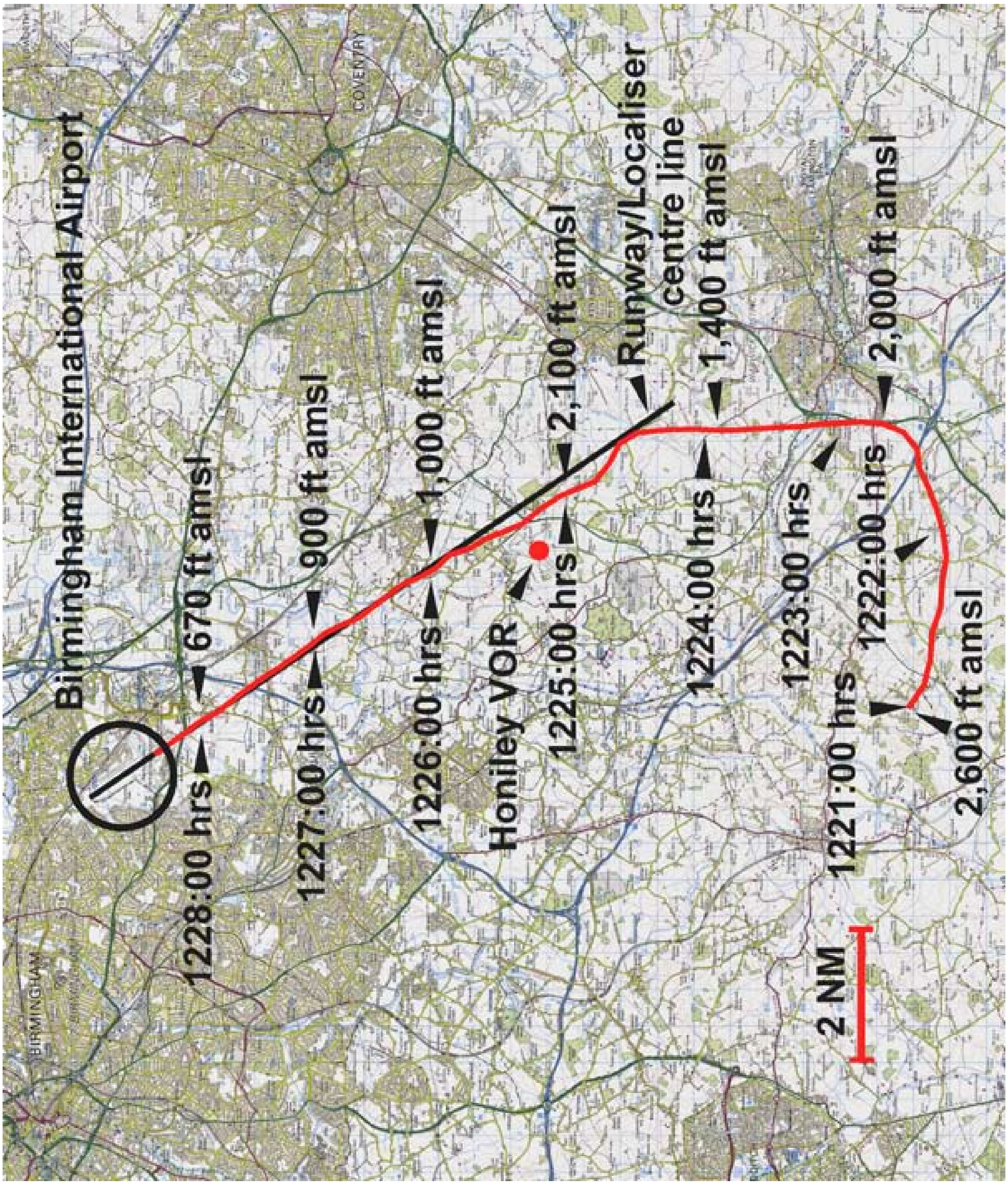
4.2 **Safety Recommendation 2007-110**: It is recommended that Mahan Air should conduct a thorough review of its CRM training programme to ensure that it is both appropriate for their needs and produces consistent and acceptable results.

4.3 **Safety Recommendation 2007-111:** It is recommended that Mahan Air should expand its FMS database to include all approaches relevant to their route structure.

R J Tydeman
Principal Inspector of Air Accidents
Air Accidents Investigation Branch
Department for Transport
November 2007

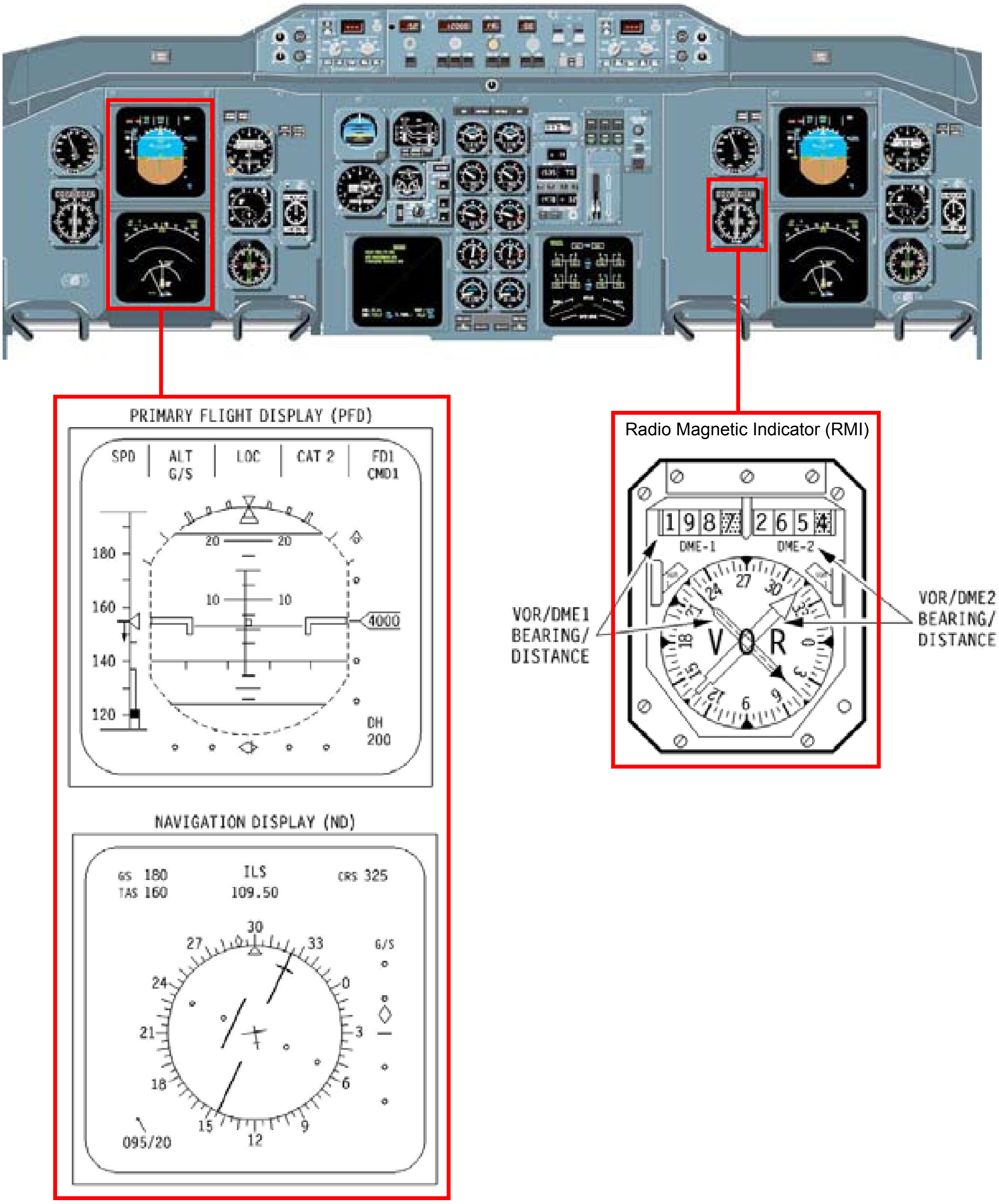


Aircraft ground track during first approach

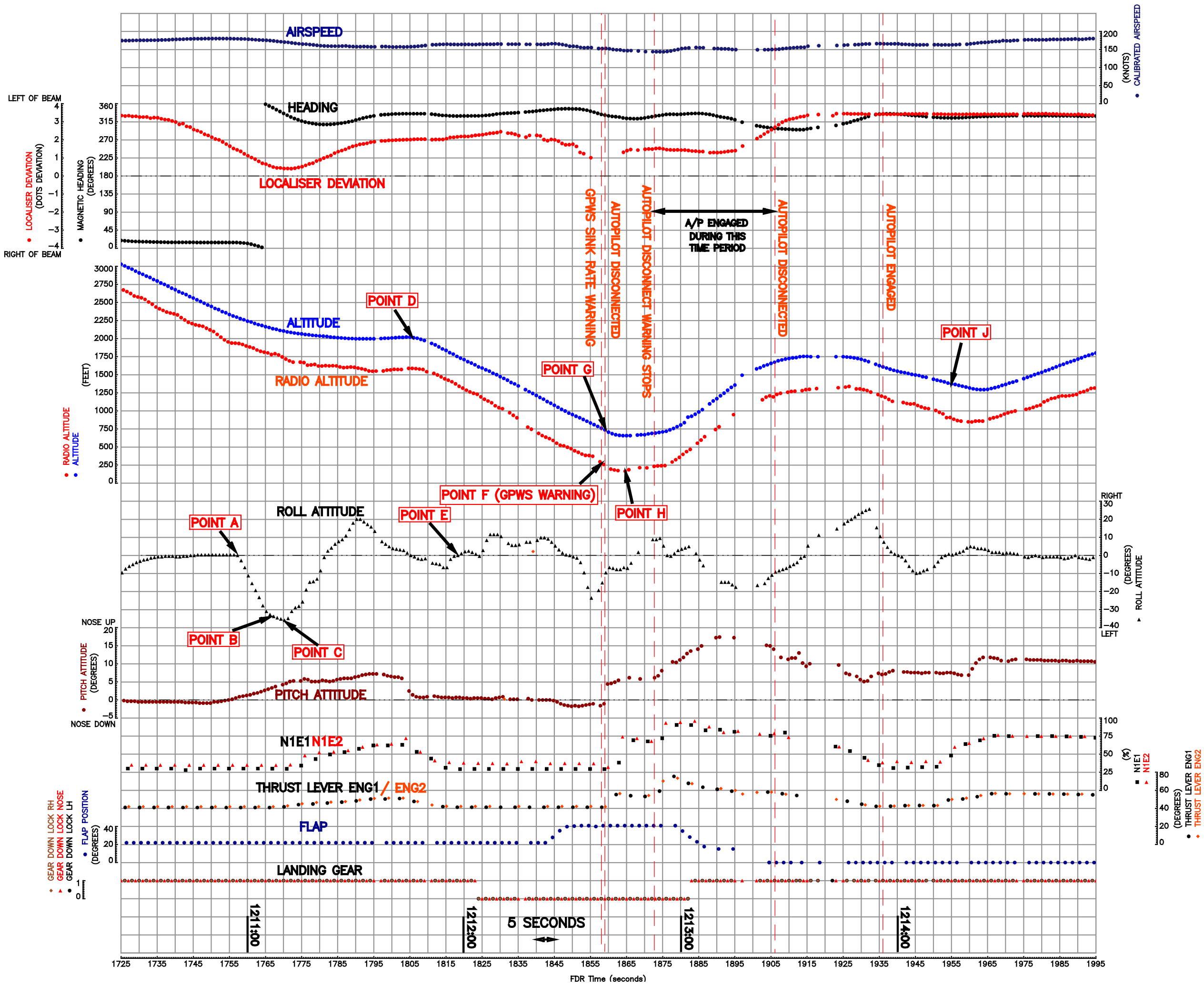


Aircraft ground track during second approach

Appendix C



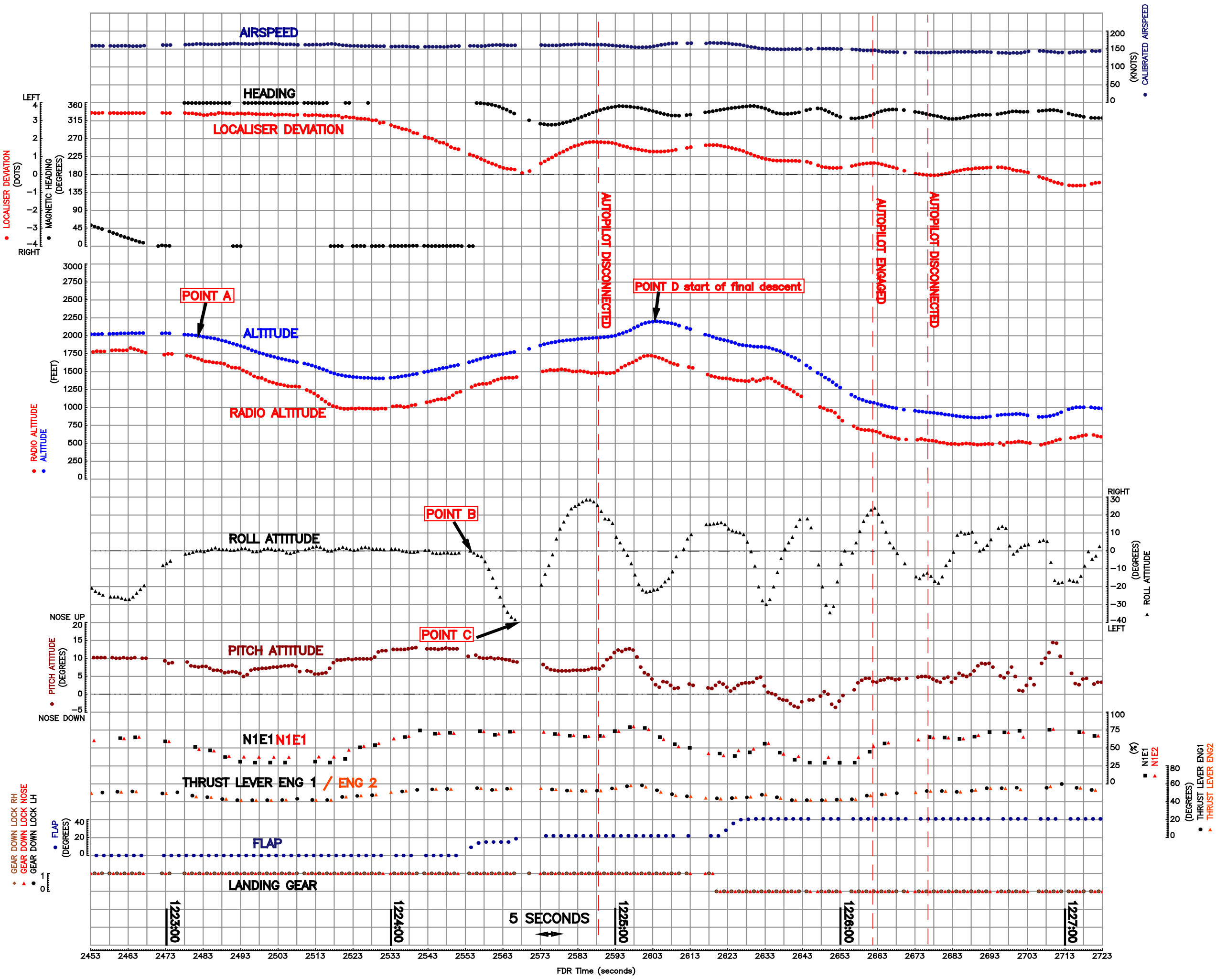
Aircraft instrumentation



Salient FDR Parameters during first approach

(Incident to F-OJHI on 23 February 2006)

Appendix E



Salient FDR Parameters during second approach

(Incident to F-OJHI on 23 February 2006)

Appendix F

Human Factors (HF)/Crew Resource Management (CRM) Syllabus

A - History of HF/CRM development and its implementation in airlines.

B - Human Factors

1. Human factors elements
2. SHEL model
3. Required human factors skills

C - Aviation physiology

1. Hypoxia/hyperventilation
2. Limitation of senses
3. Disorientation
4. The human information processing system
5. Fatigue
6. Human errors and reliability
7. Human errors in incidents and accidents
8. Error management
9. Workload and its management

D - Aviation psychology

1. Attitudinal factors
2. Disruptive attitudes
3. Constructive attitudes
4. Personality
    a. Social personality
    b. Invisible personality
5. Behaviour
6. Motivation
7. Abraham Maslow's hierarchy of needs
8. Boredom
9. Complacency
10. Culture
    a. National
    b. Organisational
    c. Occupational
11. Stress
    a. Types of stresses
    b. Sources of stress
    c. Effects of stress
        1. Short term
        2. Long term
    d. Stress management
12. Fitness for duty

E - Resource management

1. Basics of resource management
2. Rules of the game
3. What CRM training is not
4. What CRM training is
5. The nature of accidents and incidents
    a. Searching for why
6. James Reason's complex productive system
    a. Decision makers
    b. Line management
    c. Preconditions
    d. Productive activities
    e. Defences
7. Types of failure
    a. Active
    b. Latent
8. Why CRM
9. Major problem areas covered by CRM
    a. Poor group decision making
    b. Ineffective communication
    c. Inadequate leadership
    d. Poor management
    e. Domains of CRM

F - Six major skills

1. Communications and inter personal skills
2. Situational awareness
3. Problem solving/decision making/ judgement
4. Leadership/follow ship
5. Stress management
6. Critique

G - Effects of synergy

H - Rules of success

I - Guidelines for flight deck automation