AIRCRAFT ACCIDENT REPORT 4/94

Air Accidents Investigation Branch

Department of Transport

Report on the incident to Boeing 747-243, N33021 at London Gatwick Airport on 7 February 1993

This investigation was carried out in accordance with
The Civil Aviation (Investigation of Air Accidents) Regulations 1989

London: HMSO

First published 1994

ISBN 0 11 551297 7

LIST OF RECENT AIRCRAFT ACCIDENT REPORTS ISSUED BY AIR ACCIDENTS INVESTIGATION BRANCH

5/92	British Aerospace ATP, G-LOGA, at Edinburgh Airport, Scotland, on 5 February 1992	October 1992
6/92	British Aerospace ATP, G-BTPE, at Sumburgh Airport, Shetland Islands, on 23 December 1991	December 1992
1/93	Piper PA-28-161 Cadet, G-BPJT, at Oxford Airport, Kidlington, on 12 July 1992	April 1993
2/93	AS 332L Super Puma, G-TIGH, near the Cormorant 'A' platform, East Shetland Basin, on 14 March 1992	May 1993
3/93	Lockheed 1011 Tristar, 9Y-TGJ, near 'KIRN' VOR, Germany, on 9 March 1992	June 1993
4/93	British Aerospace 146-300, G-UKHP, at Aberdeen Airport, Dyce, Scotland, on 31 March 1992	August 1993
5/93	British Aircraft Corporation/SNIAS Concorde 102, G-BOAB, over the North Atlantic, on 21 March 1992	November 1993
1/94	Aerospatiale AS355F1 Twin Squirrel, G-OHMS, Near Llanbedr Airfield, Gwynedd, on 8 December 1992	January 1994
2/94	RAF Tornado GR1, ZG754 and Bell JetRanger III, G-BHYW, at Farleton Knott near Kendal, Cumbria, on 23 June 1993	June 1994
3/94	Boeing 737-2Y5A, 9H-ABA, at London Gatwick Airport, on 20 October 1993	June 1994

These Reports are available from HMSO Bookshops and Accredited Agents

Department of Transport
Air Accidents Investigation Branch
Defence Research Agency
Farnborough
Hampshire GU14 6TD

2 June 1994

The Right Honourable John MacGregor
Secretary of State for Transport

Sir,

I have the honour to submit the report by Mr M M Charles, an Inspector of Air Accidents, on the circumstances of the incident to Boeing 747-243, N33021 at London Gatwick Airport on 7 February 1993.

I have the honour to be
Sir
Your obedient servant

K P R Smart
Chief Inspector of Air Accidents

Contents **Page**

Contents (continued) Page

Contents (continued) **Page**

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	-	Air Accidents Investigation Branch
ADI	-	Attitude Director Indicator
AFCS	-	Automatic flight control system
agl	-	above ground level
amsl	-	above mean sea level
AP	-	Autopilot
ATC	-	Air Traffic Control
ATCO	-	Air Traffic Control Officer
ATE	-	Automatic Test Equipment
ATIS	-	Automatic Terminal Information Service
BITE	-	Built-In Test Equipment
CAA	-	Civil Aviation Authority
CAS	-	calibrated airspeed
°C, M, T	-	°celsius, true, magnetic
DDM	-	difference in depth of modulation
DME	-	distance measuring equipment
EPR	-	engine pressure ratio
FAA	-	Federal Aviation Administration
FAP	-	Final Approach Point
FAR	-	Federal Aviation Regulations
FD	-	Flight Director
FDR	-	Flight Data Recorder
FMA	-	Flight Mode Annunciator
ft/min	-	feet per minute
hrs	-	hours
Hz	-	Hertz
HSI	-	Horizontal Situation Indicator
ICAO	-	International Civil Aviation Organization
ILS	-	Instrument landing system
kt	-	knot(s)
lb	-	pound(s)
LWD	-	left wing down
mb	-	millibar(s)
MHz	-	Megahertz
NDB	-	Non-directional beacon
nm	-	nautical mile(s)
NTSB	-	National Transportation Safety Board
ODM	-	Operations Duty Manager
RVR	-	Runway Visual Range
RWD	-	right wing down
SRA	-	Surveillance Radar Approach

UFDR	-	Universal Flight Data Recorder
UK	-	United Kingdom
USA	-	United States of America
UTC	-	Co-ordinated Universal Time
VHF	-	very high frequency
VOR	-	VHF omni range

Air Accidents Investigation Branch

Aircraft Accident Report No: 4/94 (EW/C93/2/1)

Operator:	Continental Airlines Ltd
Aircraft Type:	Boeing 747-243
Nationality:	United States of America
Registration:	N33021
Place of Incident:	London Gatwick Airport Latitude: 51° 09'N Longitude: 000° 11'W
Date and Time:	7 February 1993 at 1039 hrs

Synopsis

The incident was notified to the Air Accidents Investigation Branch (AAIB) at 2000 hrs on 7 February 1993, by the Operations Duty Manager (ODM) at London Gatwick Airport. The investigation began on the same day and the AAIB team comprised: Mr M M Charles Investigator-in-Charge, Mr P R Coombs (Engineering), Ms A Evans (Flight recorders) and Mr P N Giles (Operations).

Continental 04 was a scheduled flight from Houston, USA to London Gatwick Airport. On the first approach to Runway 26L at Gatwick, with the automatic flight control system (AFCS) engaged in the LAND mode, the aircraft flew through the localiser at 9½ nm from touchdown and established on an inbound track about 3,000 feet to the right of the centreline. The aircraft was still not established on the centreline at 3 nm from touchdown and a missed approach was initiated.

On the second approach the aircraft again flew through the localiser and established on an inbound track about 2,500 feet to the right of the centreline, at 7¾ nm from touchdown. At 1¾ nm from touchdown and 1,500 feet to the right of the centreline, the commander saw the approach lights, then the runway, to his left. He banked the aircraft left towards the touchdown point, however, he considered it imprudent to carry out the manoeuvres required to achieve a landing and a missed approach was initiated; power was applied at about 500 feet above mean sea level (amsl). The lowest recorded altitude the aircraft reached was 432 feet amsl, at ½ nm from touchdown; it was displaced about 900 feet to the right of the centreline. The published elevation of the highest point on the south terminal building was 316 feet; this point was about 500 feet to the right of the aircraft's track.

The commander elected to carry out a third approach under manual control; this approach was uneventful and Continental 04 landed at 1051 hrs.

The following causal factors were identified:

(i) Failure of the AFCS to capture and establish the aircraft on the localiser.

(ii) Failure of the aircraft crew to appreciate that the navigational information being presented to them on the flight deck was correct.

(iii) Failure of the commander to appreciate the extent of the aircraft's displacement from the centreline, on the second approach, and to take prompt and effective action to regain the correct approach path.

(iv) Failure of the No 2 radar director to appreciate the extent of the aircraft's displacement from the centreline which caused him to pass misleading information to the aircraft commander.

(v) The commander's acceptance of the azimuth guidance given by the radar director and the ILS glidepath information as adequate reference to continue the approach beyond the final approach point.

One safety recommendation was made during the course of the investigation.

1 Factual Information

1.1 History of the flight

The aircraft, callsign Continental 04, left Houston Airport, USA at 0050 hrs on a scheduled flight to London Gatwick Airport. The weather over the United Kingdom (UK) was poor and the commander nominated Madrid Airport, Spain as the alternate airfield; an extra 15,000 lb of fuel was loaded to accommodate this. As the flight progressed the UK weather improved and the commander refiled the flight plan with Prestwick Airport as the alternate airfield.

The final part of the aircraft's flight path was deduced from analysis of the Flight Data Recorder (FDR), Air Traffic Control (ATC) radio transcripts, recorded data from Gatwick Watchman radar and eyewitness accounts, which included a video recording of the final part of the second approach; this was correlated with information given by the flight crew and the Air Traffic Control Officer (ATCO) who was the No 2 Gatwick radar director at the time of the incident. Appendix A shows the radar track for each of the three approaches made by the aircraft to Runway 26L.

At 1003 hrs, Continental 04 called Gatwick Approach, confirmed receipt of Automatic Terminal Information Service (ATIS) "Information Mike" and was told to hold at reporting point WILLO. At 1009 hrs, the aircraft was established in the holding pattern. Shortly afterwards ATC passed radar headings to guide the aircraft on the intermediate approach to Runway 26L. At 1016 hrs, Continental 04 was transferred to Gatwick Radar.

The approach was flown by the first officer, monitored by the commander; this was a company standard operating procedure. The minima used were those for a Category 1 approach; the decision altitude was 395 feet and a Runway Visual Range (RVR) required was 550 metres. At 1019 hrs the touchdown RVR was greater than 1,500 metres.

At 1022 hrs, the aircraft was descending through 3,500 feet on a heading of 300° to intercept the localiser. The 'A' autopilot engage switch was selected to COMMAND and the navigation mode selector was set to LAND. The 'B' autopilot engage switch was then selected to COMMAND; the autothrottle was engaged. Shortly afterwards, the commander asked if he could "...CORRECT ABOUT TEN DEGREES TO THE RIGHT FOR LOCALISER." The radar director replied "...IF YOU WISH. JOINING VERY NICELY. DESCEND NOW TWO THOUSAND FEET FURTHER WITH THE GLIDEPATH. HEADING ENTIRELY AS YOU WISH." At 1023 hrs, the aircraft passed through the localiser and established on an inbound track about 3,000 feet to the right of the centreline at 9½ nm from touchdown. The commander told the radar director that the aircraft had "...JUST OVERSHOT THE LOCALISER A LITTLE BIT" and that a correction was being made.

The radar director then cleared Continental 04 to descend with the glidepath. The crew reported that both Horizontal Situation Indicator (HSI) course deviation bars were displaced about 1⅔ to 1¾ dots to the left and were oscillating slightly; both Attitude Director Indicator (ADI) roll command bars demanded a left roll correction to maintain the desired localiser course. Both green NAV capture and both amber GS armed lights were illuminated on the Flight Mode Annunciator (FMA) display. No warning flags were evident.

The aircraft appeared to close the localiser and at 7½ nm from touchdown the displacement had decreased to about 1,900 feet. It then started to deviate again and when the glideslope descent was initiated at the Final Approach Point (FAP), 5½ nm from touchdown, the aircraft was about 2,500 feet right of the centreline. The first officer attempted to fly the aircraft onto the centreline by making manual aileron inputs with the AFCS still engaged.

At 1025 hrs, the commander changed frequency to Gatwick Tower and he was advised that the radar indicated that the aircraft was right of the centreline. He acknowledged this and said that they were "CORRECTING"; the aircraft was about 3,150 feet to the right of the centreline, abeam the locator non-directional beacon (NDB) at about 1,500 feet amsl. Shortly before 1026 hrs, a missed approach was initiated; the aircraft was 3 nm from touchdown at about 1,210 feet amsl.

Continental 04 climbed to 3,000 feet on the missed approach procedure and, at 1028 hrs, was transferred to Gatwick Radar. The radar director asked if there were any problems that would affect a further approach. The reply was "...NO, WE HAD AN ELECTRONIC MALFUNCTION BUT WE'VE GOT EVERYTHING UNDER CONTROL NOW...". Radar headings were given to guide the aircraft on the intermediate approach to Runway 26L. The commander decided that he would fly the approach but this time only the 'A' autopilot would be used. The 'A' autopilot engage switch was selected to COMMAND and the navigation mode selector to ILS; the autothrottle was engaged.

At 1034 hrs, an ATCO who had just finished a fatigue break took over the position of No 2 radar director. He cleared Continental 04 to descend to 2,000 feet and to turn left onto 300°. At 1036 hrs, the aircraft passed through the localiser and established on an inbound track about 2,500 feet to the right of the centreline at 7¾ nm from touchdown. The first officer called established and the radar director asked if centreline indications were correct; although the question was asked twice, it was unanswered.

The radar director again called Continental 04 and said "...YOU'RE SLIGHTLY NORTH OF THE CENTRELINE. RANGE NOW SIX MILES. ARE YOUR INDICATIONS ON THE CENTRELINE OK." The reply was "...IT LOOKS LIKE WE MAY BE GETTING A FALSE SIGNAL. WE'RE GETTING A GOOD IDENT ON THE LOCALISER BUT IT'S INDICATING A SHARP LEFT TURN TO GET ON CENTRELINE." The radar

director replied "...JUST SLIGHTLY NORTH, COMING BACK ON THE CENTRELINE. NOW MAKE A RIGHT TURN, FLY HEADING TWO SIX FIVE DEGREES AND SUGGEST YOU CONTINUE DESCENT ON A THREE DEGREE GLIDEPATH." The crew reported that at this point both HSI course deviation bars were displaced about 1⅔ to 1¾ dots to the left and were oscillating slightly; both ADI roll command bars demanded a left roll correction to maintain the desired localiser course. Both green NAV capture and both amber GS armed lights were illuminated on the FMA display. No warning flags were evident.

At 1037 hrs, when the glideslope descent was initiated at the FAP, the aircraft was about 2,500 feet right of the centreline. The commander disengaged the AFCS and continued the approach manually. The aircraft was displaced about 2,150 feet to the right of the centreline when it passed abeam the locator NDB. The radar director passed a heading of 260°. The first officer asked him to continue giving headings and the radar director acknowledged with "...JUST SLIGHTLY NORTH OF CENTRELINE. CONTINUE HEADING TWO SIX ZERO DEGREES."

The radar director had his radar display selected to the 30 nm radius range scale and his recollection was that the radar contact appeared to be tracking with its left edge just touching the radar video map centreline. The display appeared to him to be good over the complete final approach sector, however, he considered switching to the 15 nm radius range scale as this was better suited to providing centreline guidance. He decided not to because he thought that the confusion caused by the reorientation of the display and the screen persistence would have been unacceptable at this late stage of the approach.

At 1038 hrs Continental 04 was cleared to land. The aircraft was 2½ nm from touchdown, on the glideslope but displaced about 1,900 feet to the right of the centreline. The commander stated that he had visual contact with the ground at about 1,000 feet amsl and he estimated that the flight visibility was 1½ to 2 nm. He was aware that the aircraft was to the right of the centreline but decided to continue the approach with the intention of carrying out a missed approach at 700 feet amsl if he did not have the required visual references. At 1038:30 hrs the radar director advised that Continental 04 was "STILL SLIGHTLY NORTH OF CENTRELINE JUST INSIDE TWO MILES." At 800 feet amsl, 1¾ nm from touchdown and 1,500 feet to the right of the centreline, the commander saw first the approach lights and then the runway to his left. He banked the aircraft left towards the touchdown point, however, he considered it imprudent to carry out the manoeuvres required to achieve a landing and, at 1039 hrs, a missed approach was initiated; power was applied at about 500 feet amsl. The lowest recorded altitude the aircraft reached was 432 feet amsl at ½ nm from touchdown; it was displaced about 900 feet to the right of the centreline. The published elevation of

the highest point on the south terminal building was 316 feet; this point was about 500 feet to the right of the aircraft's track.

The apron control supervisor monitored the latter stages of the approach on a radar display in the control room on the top floor of the south terminal; the display was fed from the Watchman radar system. He noticed that the aircraft was significantly to the right of the normal inbound track and he went outside onto the adjacent flat roof area to observe it. When the aircraft came out of the cloud it appeared to be heading directly towards him. It then banked left and passed between the terminal building and the runway centreline. He was concerned about the aircraft's proximity to the terminal building and immediately informed the ODM.

As there was sufficient fuel remaining the commander elected to carry out a third approach. He decided not to use the AFCS. At 1043 hrs, the radar director offered Continental 04 "...AN EMERGENCY SURVEILLANCE RADAR APPROACH WHERE I WILL GIVE YOU ADVISORY HEIGHT AND RANGE FROM TOUCHDOWN. I CAN GIVE YOU AN APPROACH DOWN TO ONE NAUTICAL MILE AND ALTITUDE FIVE FIVE ZERO FEET OTHERWISE WE CAN DO AS BEFORE. I'LL GIVE YOU GOOD HEADING GUIDANCE THIS TIME AND YOU MAY USE THE GLIDEPATH. ADVISE." Continental 04 replied that they would like to "...DO IT AS BEFORE, ANOTHER ILS", to which the radar director responded "OKAY UNDERSTOOD THANK YOU. IN THAT CASE I'LL GIVE YOU HEADING GUIDANCE ON THE CENTRELINE BUT YOU'LL BE DESCENDING ON THE GLIDEPATH AT YOUR DISCRETION."

At 1046 hrs, the radar director passed the following message from the ODM: "...UNLESS YOUR EQUIPMENT IS FULLY SERVICEABLE THIS TIME AND YOU CAN ESTABLISH ON THE LOCALISER SAFELY THEN THEY WISH YOU NOT TO MAKE AN APPROACH HERE BUT TO DIVERT TO ANOTHER FIELD WITH BETTER WEATHER." This was acknowledged. He then cleared Continental 04 to turn left onto 300° and to report established on the localiser.

At 1048 hrs, Continental 04 told the radar director that they were "JUST SHOWING ON THE CENTRELINE." The latter replied "YOUR POSITIONING ON THE CENTRELINE LOOKS VERY GOOD FROM RADAR. RANGE SEVEN MILES, ARE YOUR INDICATIONS CORRECT ON THE LOCALISER." Continental 04 replied that they were and the radar director then transferred the aircraft to Gatwick Tower frequency. The approach was uneventful and Continental 04 landed at 1051 hrs.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor/none	18	223	-

1.3 Damage to aircraft

None.

1.4 Other damage

None.

1.5 Personnel information

1.5.1

Commander:	Male, aged 52 years	
Licence:	Airline Transport Pilot's Licence, USA	
Aircraft ratings:	B747	
Instrument rating:	Valid until 10 January 1994	
Base check:	11 December 1992	
Line check:	2 June 1992	
Medical certificate:	Class 1 issued 2 January 1993	
Flying experience:	Total all types:	19,898 hours
	Total on type:	2,468 hours
	Total last 28 days:	61 hours
	Total last 24 hours:	10 hours
Previous rest period:	Off duty:	0030 hrs on 5 February 1993
	On duty:	2340 hrs on 6 February 1993

1.5.2

First officer:	Male, aged 46 years	
Licence:	Airline Transport Pilot's Licence, USA	
Aircraft rating:	B747	
Instrument rating:	Valid until 23 July 1993	
Base check:	24 June 1992	
Line check:	6 July 1989	
Medical certificate:	Class 1 issued 3 December 1992	
Flying experience:	Total all types:	11,178 hours
	Total on type:	2,680 hours
	Total last 28 days:	88 hours
	Total last 24 hours:	10 hours
Previous rest period:	Off duty:	2235 hrs on 5 February 1993
	On duty:	2340 hrs on 6 February 1993

1.5.3	Second officer:	Male, aged 37 years	
	Licence:	Airline Transport Pilot's Licence, USA	
	Aircraft rating:	B747	
	Base check:	19 November 1992	
	Medical certificate:	Class 1 issued 8 December 1992	
	Flying experience:	Total all types:	9,500 hours
		Total on type:	2,500 hours
		Total last 28 days:	64 hours
		Total last 24 hours:	10 hours
	Previous rest period:	Off duty:	2235 hrs on 5 February 1993
		On duty:	2340 hrs on 6 February 1993

1.6 Aircraft information

1.6.1 Leading particulars

Type:	Boeing 747-236
Total airframe hours:	64,400 hours
Total cycles:	12,522 cycles

1.6.2 Aircraft weights

Maximum weight authorised for take-off:	775,000 lb
Regulated take-off weight:	752,000 lb
Actual take-off weight:	748,463 lb
Estimated fuel remaining on landing:	65,000 lb
Estimated landing weight:	494,700 lb

1.6.3 Automatic flight control system

The aircraft is equipped with a Honeywell SPZ 1 automatic flight control system. The system was approved by the Federal Aviation Administration (FAA) for instrument approaches to Category II weather minima.

The automatic flight control system uses three independent computers, designated 'A', 'B' and 'C': the 'A' autopilot/flight director (AP/FD) computer provides signals to the channel 'A' autopilot and both flight directors; the 'B' AP/FD computer provides outputs to the channel 'B' autopilot and both flight directors, and the 'C' flight director (FD) computer is dedicated to the flight directors.

1.6.4 Presentation of ILS information

The localiser and glideslope signals are detected and processed by three navigation receivers and are available to both ADIs and HSIs for display. In

normal operation the commander's flight instruments are supplied from the No 1 navigation receiver and the first officer's by the No 2; the facility exists to supply either but not both sets of instruments from the No 3 navigation receiver.

Localiser deviation is indicated on the ADI by a rising runway symbol located at the bottom of the attitude sphere; it moves horizontally over a fixed scale the limit of which is one dot either side of the centreline. During the final stages of the approach, the symbol also moves vertically in response to radio altitude from 200 feet to touchdown. The runway symbol is in view when an ILS frequency is selected for a front beam approach, a valid localiser signal is being received and the AP/FD localiser capture logic conditions have been satisfied. Invalid localiser and/or radio altitude signals are indicated by a RWY flag; in the former case the runway symbol will be driven out of view while in the latter it will be in view but will not move in the vertical plane.

Glideslope deviation is indicated on the ADI by a pointer on the right side; it moves over a fixed vertical scale, the limit of which is indicated by two dots above and below the on-glideslope mark. The pointer is in view when an ILS frequency is selected for a front beam approach, a valid glideslope signal is being received and the AP/FD localiser capture logic conditions have been satisfied. A GS flag covers the display if the glideslope signal is not valid.

Localiser deviation is indicated on the HSI by a course deviation bar associated with the course pointer; on final approach the pointer would normally be set to the magnetic track of the front beam ILS centreline. Two dots either side of centre, on the face of the instrument, indicate the amount of deviation; the course deviation bar is deflected 2 dots in the appropriate direction when the aircraft is displaced to the limit of the course sector of the ILS. The display availability is neither dependent on the localiser capture logic nor on whether the approach is front or back beam. A NAV flag is displayed if the localiser signal is not valid.

Glideslope deviation is indicated on the HSI by a pointer on the right side. Its appearance and mode of operation is similar to that on the ADI. A flag covers the display if the glideslope signal is not valid. The display availability is neither dependent on the localiser capture logic nor on whether the approach is front or back beam.

1.6.5 The flight director

The flight director display consists of vertical roll and a horizontal pitch bars to the front of each ADI attitude sphere. A switch at each end of the glare shield panel activates the bars which will respond to the output of the computer to which they are connected. The 'C' system computer is dedicated to the flight director, however, a three position switch on both the commander's and the first officer's instrument panels allows each flight director to be connected, independently to

any of the three computers. Normally commander's flight director is fed from the 'C' computer and the first officer's from the 'B' computer. Individual flight director bar retraction should occur in the event of a malfunction in the system controlling its particular mode.

When the autopilot is selected to COMMAND the flight directors can be used to monitor autopilot operation.

The left side of the FMA panel is dedicated to the flight director; except for the addition of a GO-AROUND mode they are the same, and function in the same manner as those dedicated to the autopilot.

1.6.6 Autopilot command operation - LAND mode (dual channel)

Once the aircraft is on the final vector to the ILS approach, with one autopilot selected to COMMAND and the mode selector set to LAND, the autopilot warning light will flash amber and the NAV and GS flight mode annunciators will illuminate amber. The second autopilot selector can then be set to COMMAND at which time the autopilot warning light will go out. At any time prior to localiser capture, the aircraft heading can be changed by moving the heading selector. At localiser capture, the NAV annunciator will change to green and localiser tracking will begin; movement of the heading selector will have no effect. Once the NAV annunciator has indicated capture, it is latched in this condition. The only way to break the latch is to select a mode other than LAND or ILS. At glideslope capture, the GS annunciator will change to green and glideslope tracking will begin.

As the aircraft descends through 1,500 feet radio altitude, the automatic flare system will arm and the FLARE annunciator will illuminate amber. Dual autopilot operation will start at this point, and autopilot system monitoring will be activated.

At 53 feet radio altitude, the FLARE annunciator will change to green and the autopilot will flare the aircraft.

1.6.7 Automatic pilot command operation - ILS mode (single channel)

Once the aircraft is on the final vector to the ILS approach, with one autopilot selected to COMMAND and the mode selector set to ILS, the NAV and GS annunciators will illuminate amber. At any time prior to localiser capture, the aircraft heading can be changed by moving the heading selector. At localiser capture, the NAV annunciator will change to green and localiser tracking will begin; movement of the heading selector will have no effect. Once the NAV annunciator has indicated capture, it is latched in this condition. The only way to break the latch is to select a mode other than LAND or ILS.

At glideslope capture, the GS annunciator will change to green and glideslope tracking will begin.

There is no flare control or autopilot system monitoring in single autopilot operation and the autopilot should be disconnected before landing.

1.6.8 Autothrottle operation

A reference airspeed is selected using either the command airspeed knob on the commander's airspeed indicator or the autothrottle speed selector on the glare shield panel. The autothrottle system automatically moves all four throttles to enable the aircraft to acquire and maintain this selected airspeed. The autothrottle computer input is derived from the commander's airspeed indicator only. During the landing phase, if two autopilots are engaged in the LAND mode, the autothrottle system will retard the throttles as the aircraft descends through 30 feet radio altitude.

1.6.9 Automatic flight control system status for Category II operation

Each autopilot channel was individually graded for operation in Category II conditions. The status of the 'A' and 'B' channels was indicated respectively on a status annunciator below the commander's and the first officer's vertical speed indicators. The annunciator options with their implications are:

CAT II 1200:	Aircraft qualified for Category II approaches with an RVR of 1,200 feet (350 metres) to a decision height of 100 feet agl.
CAT II 1600:	Aircraft qualified for Category II approaches with an RVR of 1,600 feet (500 metres) to a decision height of 150 feet agl.
NOT CAT II:	Aircraft equipment is not qualified for Category II approaches.
CHECK CAT II 1600:	A flight check of the Category II status is required. This check is prohibited in conditions below Category 1 minima.
CHECK CAT II 1200:	A flight check of the Category II status is required. Similar conditions applied as in the CHECK CAT II 1600 with the addition that both autopilot channels and autoland are required.

The system is downgraded as a result of either a malfunction in flight, a component change, or failure of a 'ramp-down' check while the aircraft is on the ground, however, it can only be upgraded by a flight check.

At the time of the incident, the 'A' channel had the status CAT II 1600 and the 'B' channel CHECK CAT II 1600.

1.7 Meteorological aspects

1.7.1 Synoptic situation

There was a ridge of high pressure established across southern England.

1.7.2 The routine meteorological report for 1045 hrs was:

Surface wind:	340°/4 kt
Visibility:	800 metres
RVR:	1,400 metres on Runway 26L
Weather:	Fog patches
Cloud:	5 oktas stratus base 100 feet
	4 oktas stratus base 900 feet
	8 oktas stratocumulus base 1,800 feet
Temperature/Dewpoint	9°C/8°C
QNH/QFE (26L)	1037 mb/1029 mb

1.7.3 The Automatic Terminal Information Service

On first contact with Gatwick Approach Continental 04 acknowledged receipt of "Information Mike"; it was timed at 0945 hrs and contained the following:

Surface wind:	035°/2 kt
Visibility:	800 metres in drizzle
Cloud:	2 oktas base below 100 feet
	8 oktas base 100 feet
Temperature/Dewpoint	8°C/8°C
QNH/QFE(26L)	1036 mb/1029 mb

"Runway in use 26L. Be advised ATC low visibility procedures are in operation. Departing aircraft are to use the Category III holding point at alpha north. Arriving aircraft on first contact with Gatwick report "Information Mike" received and state aircraft type."

This was superseded at 1002 hrs by "Information November"; it was timed at 0959 hrs and the only significant difference was the reported cloud cover. This was:

Cloud:	6 oktas base 100 feet
	8 oktas base 1,000 feet

1.8 Aids to navigation

The aircraft was positioned for the ILS/DME approach to Runway 26L by reference to the Gatwick Watchman radar.

1.8.1 Gatwick Watchman radar

The installation consisted of a Plessey Watchman 10 centimetre primary radar with a collocated Cossor 950 monopulse secondary radar. The antenna was located on the southern side of the airfield and the processed output was monitored on 16 inch displays in the Gatwick approach control room.

The radar display would normally be selected to the 30 nm radius range scale while being used to control aircraft on the intermediate approach. When used to provide a surveillance radar approach facility it would normally be selected to the 15 nm radius range scale in order to provide more accurate centreline guidance.

The recorded data which was used to plot the aircraft's flight path has an accuracy in azimuth of $^1/_{16}$ nm and 1 aerial counting pulse (about 0.09°).

There was no evidence to suggest that the system was subject to any significant unserviceability at the time of the incident.

1.8.2 Instrument landing system

The ILS localiser on Runway 26L was transmitted on a frequency of 110.9 Megahertz (MHz) and coded 'I-WW'. The locator NDB, positioned at 4.1 nm DME, was on frequency 338 Kilohertz and coded 'GE'.

The radiation from a localiser antenna produces a composite field pattern which is amplitude modulated by a 90 Hertz (Hz) and a 150 Hz tone. For an aircraft approaching the runway, the 150 Hz tone predominates on the right and the 90 Hz tone on the left. The difference in depth of modulation (DDM) is defined as the difference in percentage modulation of the larger and smaller of these two tones at any point; it is normal to divide the result by 100 and represent it as a decimal. The DDM will be zero when percentage modulation of both tones is equal; this is the course line and is the locus of points nearest to the runway centreline in any horizontal plane. The course sector is defined as a sector in a horizontal plane which contains the course line and is limited by the loci of points

nearest to the course line at which the DDM is 0.155. When an aircraft on the approach is displaced to the limit of the course sector, the course deviation bar on the HSI would be deflected 2 dots in the appropriate direction. The course sector angle of the localiser on Runway 26 was 4°.

As the aircraft successfully followed the localiser on its third approach and no other aircraft reported problems with the ILS, the Airport Authority did not consider it necessary to carry out an immediate flight check. The annual flight inspection was carried out over the period 10 to 15 March and the flight inspection report was satisfactory.

1.9 Communications

Communications between the aircraft and Gatwick ATC during the three approaches were with Gatwick Approach on frequency 125.875 MHz, Gatwick Radar on frequency 118.6 MHz, and Gatwick Tower on frequency 124.225 MHz.

All radiotelephony communications were satisfactory and were recorded.

1.10 Aerodrome information

The aerodrome chart for London Gatwick Airport is reproduced at Appendix B and shows the radar track of the aircraft during the final stage of the second approach. The south terminal is at the eastern end of the airfield and its elevation was 316 feet amsl. The runway in use was 26L.

1.10.1 Runway characteristics

Runway 26L was orientated 262°M and had a declared landing distance available of 2,831 metres; the elevation of the displaced landing threshold was 195 feet amsl.

1.10.2 Runway lighting

The approach was lit by 914 metres of high intensity centreline lights with five cross-bars; there was supplementary lighting on the inner 300 metres. Two flashing white strobe lights, one either side of the centreline, operated 400 metres prior to the threshold; these were of variable intensity and were visible in the approach sector only.

The runway threshold was lit by high intensity green lights and wing bars.

The runway edge was lit by flush, high intensity bi-directional lights; those from the runway end to the displaced landing threshold showed red. The centreline was lit by high intensity colour coded lights at 15 metre spacing.

Precision approach position indicators were available and were set for a 3° approach.

All lighting associated with Runway 26L and the approach to it was checked after the incident and was found to be serviceable.

1.10.3 Low visibility procedures

Aeroplanes and vehicles in the vicinity of a runway may affect the localiser and glidepath signal. In consequence there is a requirement to protect the appropriate sensitive areas when the localiser is being used during automatic landings. To achieve this level of protection for Category II/III operations the appropriate low visibility procedures were instituted. These were in force when Continental 04 made its first approach and remained in force until 1040 hrs.

There was no evidence to suggest that there had been a breach of these procedures.

1.11 Flight recorders

1.11.1 Replay of flight recorders

The flight data recorder fitted was a Sundstrand Universal Flight Data Recorder (UFDR); the unit was removed at Newark by the National Transportation Safety Board (NTSB) and a copy tape supplied to the AAIB, from which a satisfactory replay was made.

The data recorded on the UFDR was correlated with the radar recording; it was not possible to check directly the radar positions and heights as no recording is made on the UFDR of the localiser or glideslope indications. The only recording of altitude on the UFDR is from the aircraft pressure source, and radio height, which would have provided more precise height information close to the ground, was not recorded. Operation of the autopilot or the various modes selected was not recorded by the UFDR. The requirements of FAR Part 121 for aircraft manufactured after 11 October 1991 do require recording of glideslope, localiser, radio height and autopilot operation amongst others, but there was no requirement for retrofit.

The cockpit voice recorder was not replayed as recording of the approaches into Gatwick would have been overwritten during the return flight to Newark.

1.11.2 Interpretation of data

Appendix A shows the radar track for each approach, the runway at Gatwick and the extended centreline. The first and second approaches followed a track to the north of the extended centreline, the final approach tracked the centreline exactly.

Relevant parameters from the UFDR have been plotted for each approach. Some of the engine parameters, including engine pressure ratio (EPR) on No 4 engine, were unserviceable, and therefore have not been plotted on the figures. The recorded values of pressure altitude are based on a pressure setting of 1013 mb, these have been corrected for the pressure on the day to give height above mean sea level.

1.11.2.1 First approach

Appendix C shows selected parameters from the UFDR. Figure C-1 shows the first approach beginning at around 1020 hrs, as the aircraft turned onto a northerly heading descending at around 800 ft/min through 5,500 feet amsl, with flap 5° selected. Flap 20° was selected at 1022 hrs, with the aircraft turning onto a heading of 300°M, and descending through 3,500 feet amsl. The calibrated airspeed (CAS) was between 160 and 170 kt. Rate of descent increased slightly to 1,800 ft/min just before power was increased and the aircraft levelled at around 2,100 feet amsl at 1024 hrs airspeed between 155 and 165 kt.

The aircraft turned left towards runway heading, passing through 270°M. It can be seen from the heading that the aircraft was not stabilised onto the runway heading, with roll inputs required of up to +20° right wing down (RWD) and up to -10° left wing down (LWD). The actual heading of the runway is 262°M; the heading of the aircraft varied between 270° and 248°M. Appendix A shows the ground track of the aircraft which initially passed through the extended centreline as the aircraft turned onto runway heading, and the approach which was displaced to the right of the extended centreline.

At 1025 hrs the aircraft then began to descend on the glideslope, from around 2,100 feet amsl with a rate of descent of 1,300 ft/min and airspeed around 160 kt CAS. The heading decreased from 270°M to around 250°M. Flap 30° was selected at an altitude of 1,210 feet amsl, just as the power was increased for the go-around. Flaps were selected to 5°, 30 seconds later, as the aircraft climbed away on a heading of 270°M.

1.11.2.2 Second approach

Figure C-2 shows the second approach with flap 20° selected at around 2,900 feet amsl. At around 1034 hrs, the aircraft turned from the downwind position to a heading initially of 300°M, and descended to about 2,400 feet amsl before turning left onto 263°M, and beginning to descend at 1,200 ft/min, with the airspeed 160 kt CAS. Flap 25° was selected at 1,600 feet amsl, 177 kt CAS, 78 seconds before the go-around was initiated, and flap 30° selected 20 seconds later at 1,265 feet amsl, and an airspeed of 168 kt CAS.

The heading was more stable than on the previous approach, with an average of 260°M, which was the radar heading passed by the controller to the aircraft. Appendix A shows that again the aircraft track was displaced to the right of the extended centreline.

At 1038:30 hrs at a height of 567 feet amsl, the aircraft turned left to a heading of 256°M towards the runway, with a roll attitude of -10° LWD, and then +7° RWD, and -10° LWD. This manoeuvre occurred as the commander became visual with the ground and brought the aircraft back towards the runway, as shown in Appendix A.

There was an increase in pitch attitude, and an increase in engine EPR at 492 feet amsl as the aircraft began to go-around. About 10 seconds later the lowest altitude of 432 feet amsl (212 feet above airfield elevation) was reached. The airspeed dropped to 134 kt CAS, and the aircraft climbed away initially on a heading of 252°M, gradually turning right to 270°M.

1.11.2.3 Third approach and landing

Figure C-3 shows the final manual approach and landing, beginning at 1044 hrs on the downwind leg. The aircraft turned onto the runway heading at 1047:40 hrs level at around 2,000 to 2,100 feet amsl then descended on the glideslope at a rate of 850 ft/min, and a airspeed of 150 kt CAS, with Flap 30. The heading on the approach was 260°M. Appendix A shows the track of the aircraft, which followed the extended centreline. The landing appeared normal; reverse thrust was used after touchdown.

1.12 Examination of aircraft

1.12.1 Automatic flight control system technical log history

The incident was not notified to the AAIB until the aircraft had already departed. AAIB personnel did not examine the aircraft or any of the components, however, the following information was derived from the aircraft technical log.

The No 1 navigation receiver was changed on 1 February 1993 and the system was subjected to a 'ramp-down' check as a result of which the 'A' channel was given CHECK CAT II 1600 status. The following day a flight check was carried out and the 'A' channel was regraded to CAT II 1600.

On 4 February 1993, the 'C' FD computer was reported to be inoperative; a ground test found no fault.

On 7 February 1993, after the incident, the commander made an entry in the technical log to the effect that, on the first approach the aircraft did not track the localiser and on the second it did not capture the localiser. He noted that the third

approach, which was flown manually, was satisfactory. The recorded action was that the No 1 navigation receiver was changed and consequently the 'A' channel of the automatic flight control system was downgraded to CHECK CAT II 1600.

On 8 February, a flight check was made using the 'B' channel; the system failed the check because of an over-correction to the left at 150 feet agl. No fault was found when the system was subsequently tested on the ground. The following day, 9 February 1993, a 'ramp-down' check was carried out and both systems were graded CHECK CAT II 1200. A flight check was carried out on 14 February 1993; it was satisfactory, however, the central air data computer was replaced and consequently both systems reverted to CHECK CAT II 1200 status.

On 15 February 1993, a further flight check was carried out; the aircraft established to the left of the localiser and was ½ dot above the glideslope at 100 feet agl. No fault was found when the system was subsequently tested on the ground. The CHECK CAT II 1200 status was retained on both systems and a satisfactory flight check was carried out on 18 February 1993; both systems were regraded to CAT II 1200. On the following day the FD and AP NAV flight mode annunciators on the commander's FMA remained amber during an approach in the LAND mode and consequently both systems were downgraded to CHECK CAT II 1200.

On 20 February 1993, the No 1 and 2 roll computers were replaced and consequently both systems reverted to CHECK CAT II 1600. Although not recorded in the technical log, other documentation indicated that the No 2 compass coupler was also changed at this time. On 21 February 1993 a successful flight check was carried out on the 'B' channel; the 'A' channel was upgraded to CAT II 1600 following a flight check on 22 February 1993.

A 'ramp-down' check was carried out on 25 February 1993 and both systems were given CHECK CAT II 1200 status. A failure of the No 1 navigation receiver glideslope channel precluded a satisfactory check. No fault was found when the system was subsequently tested on the ground and, following a further 'ramp-down' check the status remained at CHECK CAT II 1200.

The No 2 navigation receiver was changed on 26 February 1993 and a flight check later that day confirmed both systems as CAT II 1200. It appeared that this particular sequence of failed approaches ended at this point.

1.13 Medical and pathological information

Not relevant.

1.14 Fire

Not relevant.

1.15 Survival aspects

Not relevant.

1.16 Tests and research

1.16.1 Component testing

The No 1 navigation receiver which was removed on 7 February, as a consequence of the incident, was tested at the airline's avionics repair facility at Denver, USA. It was subjected to detailed examination with a full and prolonged test of the localiser function. No defect was found.

Two roll computers were removed from the aircraft on 20 February 1993. It was not possible to say which computer was in which system at the time of the incident, as the operator's diagnostic process had changed their position in the aircraft and no reliable record had been kept. Both computers were subjected to the standard Honeywell test procedure at their Northwest Support Centre, Renton, USA.

Roll computer serial No 0080480 passed all ten Built-in Test Equipment (BITE) checks on a manual fixture. It also passed all ten initial BITE checks on the Automatic Test Equipment (ATE), however, it subsequently failed nine other checks at ambient and elevated temperatures. The localiser/VOR sensor module A4A11 was then replaced and the roll computer subsequently functioned correctly.

Roll computer serial No 1060799 failed position BITE 1 check on the manual fixture. It also failed this check at ambient temperature on the ATE; at elevated temperature it failed three other checks. The gyroscope was replaced in consequence of the BITE 1, capacitor A9C1 was replaced because of leakage and module A6A10 was replaced in consequence of other check failures. The roll computer then initially passed all checks but became subject to an intermittent failure at BITE 2.

The compass coupler was tested at the Honeywell Central Support Centre, Wichita, USA and was subsequently opened and examined. The unit was heated to 160°F and retested. No failures occurred.

1.16.2 Effect of component defects on performance

As the design authority for the SPZ 1 automatic flight control system, Honeywell Air Transport Systems Division, Phoenix, USA were asked to evaluate the effect that the defects identified would have had on the operation of the system. After

further tests on the defective module and subsequent analysis, their provisional conclusions were as follows:

a. The only defect which could have produced the anomaly like that experienced on the incident flight was that in roll computer 0080480, module A4A11. As the 'A' channel autopilot was selected on the first two approaches, it was assumed that this roll computer was associated with the 'A' channel.

b. The defect identified would cause the minimum beam detector to be tripped before localiser capture. It is possible that this prematurely generated the localiser on-course logic.

c. The localiser on-course logic enables the course and beam error integral paths and causes bank angle and rate limits to be reduced. This may have been the reason why the aircraft failed to capture the localiser.

d. The course and beam error integral paths normally establish a heading to maintain zero beam error. The course error component has a 33 second washout after the localiser on-course logic enables it; if this happened prematurely a large output may have been sensed which would have cancelled out part of the beam error and caused the aircraft to establish on a parallel inbound track, in this case, to the right of the localiser centreline.

e. In the LAND mode further consequences of the defect would have become evident at or below 1,500 feet, however, there was no evidence to suggest that this mode was still selected at 1,500 feet on the first approach and it was not relevant to the second approach which was flown in the ILS mode.

1.16.3 Flight test of the defective components

There was no SPZ 1 systems bench test facility in existence and therefore the confirmation of the theoretical effects of the defects identified could only be obtained by flight test. It was planned to install the defective module in an otherwise serviceable roll computer and to ground test this to confirm that it behaved in the same way as roll computer 0080480 when first removed from the aircraft. It was then to be installed in a Boeing 747 aircraft with a similar overall flight control system modification state to N33021, of which it is believed that there are relatively few in service. However, the module which experienced the fault is common to other installations, of different modification standards, in a much larger number of aircraft.

In conjunction with Honeywell and Boeing, a flight test programme was devised. Unfortunately the FAA division responsible for maintenance standards in the

airline ruled that the installation in an aircraft of a component, the performance of which was suspect, was contrary to Federal Aviation Regulations. Following discussions between the National Transportation Safety Board (NTSB) and the FAA, the FAA agreed to issue an experimental flight permit, however, this work was outside the time-scale of this report.

1.17 Additional information

1.17.1 Procedures for Air Navigation Services - Aircraft Operations (PANS-OPS)

Volume 1 of the ICAO PANS-OPS describes operational procedures recommended for the guidance of flight operations personnel, including flight crew. It aims to show that published procedures should be strictly adhered to in order that an acceptable level of safety may be achieved and maintained. The following recommended procedures are relevant to this incident:

> "3.5. Final approach segment - precision approach - ILS
>
> 3.5.4.1 The final approach segment begins at the final approach point (FAP). This is a point in space on the centreline of the localizer where the intermediate approach altitude/height intersects the nominal glidepath.
>
> 3.5.4.2 Generally glidepath interception occurs at heights from 300 m (984 ft) to 900 m (2,955 ft) above runway elevation. On a 3° glidepath interception occurs between 6 km (3 nm) and 19 km (10 nm) from the threshold.
>
> 3.5.4.3 The width of the ILS final approach area is much narrower than those of non-precision approaches. Descent on the glidepath must never be initiated until the aircraft is within the tracking tolerance of the localizer. The ILS obstacle clearance assumes that the pilot does not normally deviate from the centreline more than half a scale deflection after being established on track. Thereafter the aircraft should adhere to the on-course, on-glidepath position since a more than half course sector deflection or more than half course fly-up deflection combined with other allowable system tolerances could place the aircraft in the vicinity of the edge or bottom of the protected airspace where loss of protection from obstacles can occur."

Volume 2 of the ICAO PANS-OPS describes the essential areas and obstacle clearance requirements for the achievement of safe, regular instrument flight operations. Part III, Chapter 21 describes the procedure construction and obstacle clearance criteria related the ILS approach and defines the protected airspace described in the preceding paragraph. The methods are complex and are

intended for the guidance of procedural specialists; as the construction of these areas is not in contention, no detail of the methods is contained in this report.

1.17.2 Jeppesen Airway Manual

Continental Airlines' flight crews were required to adhere to the procedures published in the Jeppesen Airway Manual; this manual was available on the flight deck. The Air Traffic Control section of the manual contains a sub-section headed 'FLIGHT PROCEDURES'. This sub-section describes operational procedures and reproduces whole or part paragraphs from PANS-OPS; paragraphs 3.5.4.1, 3.5.4.2 and 3.5.4.3 above are reproduced in full.

1.17.3 Continental Airlines Boeing 747-200 Flight Manual Procedures

Section 4 of the Flight Manual contained the normal operating procedures. The section which covered precision approach procedures defined the monitored approach as:

> "A monitored approach is a procedure that allows the captain additional time to acquire and assess visual landing cues prior to reaching decision height. Normally the approach should be automatic-coupled with the first officer operating the autopilot, controlling the airspeed (manually or with autothrottles), and supervised or monitored by the captain. Monitored approach procedures and call-outs are the same as Cat II, except that Cat I criteria apply if the approach is flown in Cat I weather conditions."

The only performance limits quoted in the Flight Manual for Category II approaches were those which had to be complied with below 500 feet. These included:

Localizer within ½ dot right or left on raw data.

Raw data must match with computed data.

If these limits were not met a missed approach was mandatory.

1.17.4 Approach monitoring aids

The CAA is currently carrying out a programme of research and development of an approach monitoring aid which uses information from existing airfield radar systems to alert controllers if an aircraft is outside the approach sector. The optimum type of display and alert is being studied as is the controller's response to an alert and what advice or instruction he/she should give to the aircraft.

1.18 New investigation techniques

None.

2 Analysis

2.1 Introduction

The weather was suitable for CAT I approaches during the period when the aircraft was making all three approaches to Runway 26L at Gatwick and the incident occurred on the second ILS approach. The aircraft did not satisfactorily capture the localiser and was displaced well to the right of the centreline throughout this approach. It passed close to the south terminal building and a missed approach was initiated.

This analysis examines why the AFCS did not satisfactorily capture the localiser on either of the first two approaches and why both the aircraft commander and the No 2 radar director subsequently failed to appreciate the extent by which the flight path was displaced to the right of the localiser centreline. It also considers various associated operational and technical aspects.

2.2 Technical aspects

The AFCS suffered a series of faults during the month of February 1993. The sequence seemed to have been broken by the removal of both roll computers and the compass coupler on 20 February 1993 and the replacement of the No 2 navigation receiver on 26 February 1993 following which a satisfactory CAT II 1200 upgrade was achieved.

No explanation could be found for the removal of the No 1 navigation receiver after the incident flight. The action seems illogical as the manually flown third approach was satisfactory. The evidence suggests that, on all three approaches, the ILS information displayed on the flight deck was valid and the flight director indications were in the correct sense.

The balance of evidence suggests that there was a fault in a module of the 'A' channel roll computer which caused the aircraft to fly through the localiser and establish on an inbound track right of the centreline. It was also evident that this fault did not result in a failure warning indication to the crew. It is likely that roll computer serial No 0080480 was the one which was removed from the 'A' channel and that the defect in module A4A11 was the one which caused the erroneous capture. In conjunction with Honeywell and Boeing, a flight test programme was devised to confirm the behaviour of this module in a representative aircraft. Following discussions between the NTSB and the FAA, the FAA agreed to issue an experimental flight permit for the flight test, however, this work was outside the time-scale of this report.

There are believed to be a relatively small number of aircraft in service fitted with a Honeywell SPZ 1 AFCS of similar overall modification standard to that installed in N33021. However, the module which experienced the fault is common to other installations, of different modification standards, in a much larger number of aircraft.

It is therefore recommended that the Federal Aviation Administration determine more fully the effect of the failure experienced by the module in the roll computer serial No 0080480 on the behaviour of the aircraft; whether a failure warning indication should be provided for such a case; and the relevance of such a failure to other types fitted with this or similar roll computers.

2.3 The first approach

On the first approach to Runway 26L, with the AFCS engaged, the aircraft flew through the localiser centreline and established on an inbound track about 3,000 feet to the right, at 9½ nm from touchdown. It appeared to track towards the centreline, however, it began to deviate again as it approached the FAP. The crew were occupied with their attempt to identify the problem and, despite the fact that the aircraft was about 2,500 feet to the right of the centreline at the FAP, the approach was continued and descent on the glideslope was initiated. The decision to carry out the missed approach procedure, albeit made at a later point than ideal, was considered to have been prudent.

The combination of configuring the aircraft for the descent and attempting to fly it manually back onto the centreline may have overloaded the first officer. The FDR trace showed evidence of over controlling, particularly in roll. A certain amount of confusion appears to have existed and the commander, albeit at a later point than ideal, quite rightly ordered the first officer to carry out the missed approach procedure.

2.4 The second approach

The commander suspected that there was a fault in the AFCS and so, on the second approach, he decided to use only the 'A' autopilot. He reasoned that it was probably the more reliable because it had the higher grade according to the Category II status system; he also thought that the accuracy of the 'A' channel may have been affected by the less accurate 'B' autopilot. The 'A' autopilot, however, was the first engaged in the approach sequence and it alone would have controlled the aircraft during the localiser capture portion of the first approach. It would therefore have been more logical to suspect this autopilot or its associated components and to have used the 'B' autopilot for the second approach.

The aircraft again flew through the localiser centreline and established on an inbound track about 2,500 feet to the right, at 7¾ nm from touchdown. While the crew were trying to resolve the situation, the radar director told them they were "...JUST SLIGHTLY NORTH, COMING BACK ON THE CENTRELINE." A confliction now existed; the information given by the radar director implied that the aircraft was only slightly north of the centreline whereas the flight instruments indicated a gross displacement. The commander chose the option which best fitted his expectation and the, in fact correct, information being presented on the flight deck was rejected.

All three crew members reported independently that both HSI course deviation bars were displaced about 1⅔ to 1¾ dots to the left and were oscillating slightly; both ADI roll command bars demanded a left roll correction to maintain the desired localiser course. None recalled precisely at which stage this was or for how long it persisted nor did any recall seeing on-course indications at any time during the approach; the deflections were in the correct sense and would have been equivalent to a localiser deviation of about 1,400 feet at 8 nm from touchdown. This situation could only have existed shortly before the aircraft established on the displaced inbound track. There was no evidence to suggest that the information displayed on the flight instruments was other than correct and, indeed, its accuracy was confirmed by the fact that the commander was able to carry out a successful third approach by reference to it.

Oscillation of the course deviation bar could indicate that there was some form of interference with the localiser beam. This would normally be of short duration and would clear as soon as the object causing the interference moved out of the line of the beam. Low visibility procedures were introduced to alleviate this by restricting the area in which aircraft manoeuvre while Category II/III operations were taking place. These were in force when Continental 04 made its first two approaches and there was no evidence to suggest that there had been a breach of the procedures.

At the FAP, the aircraft was about 2,500 feet right of the centreline, a situation which would have shown full scale deflection on the localiser display, yet the approach was continued and the glideslope descent was initiated.

The commander stated that he had visual contact with the ground at about 1,000 feet amsl and he estimated that the flight visibility was 1½ to 2 nm. He was aware that the aircraft was to the right of the centreline but decided to continue the approach with the intention of carrying out a missed approach at 700 feet amsl if he had not got the required visual references. The only approach minimum that this figure approximates to is the minimum descent altitude of 695 feet, for a localiser only approach to Runway 26L.

At 1¾ nm from touchdown the commander saw first the approach lights and then the runway. He immediately banked the aircraft left towards the touchdown point. The manoeuvre carried out to regain the centreline was relatively gentle, however, the manoeuvres necessary to achieve a landing would have been performed at a much lower level; the consequent decision to carry out a missed approach was considered to have been prudent.

2.5 The third approach

The ODM's instruction that the aircraft should divert to another airport with better weather was considered by the crew to have been an unnecessary distraction, however, they had not at the time appreciated how close the aircraft had passed to the terminal building. The ODM's action was, in the circumstances, considered to have been reasonable.

The commander calculated that there was enough fuel left, in addition to the required reserves, to carry out another approach and he decided that this time he would not use the AFCS. His decision to conduct a third approach, using basic navigation information, was therefore reasonable.

The aircraft was positioned, by the radar director, for the localiser intercept in a similar manner to the previous approach. This time the commander established the aircraft on the centreline; this was confirmed by the radar director. An accurate ILS approach was flown with reference to the aircraft navigation system with no further radar assistance.

2.6 The ATCO

The ATCO occupying the No 2 radar director position was an experienced controller both in the position and at London Gatwick Airport. The handover on return from his break had been normal and he was aware of the problems Continental 04 had experienced on the first approach. When he took over the position the radar was working normally and the aircraft was on the intermediate approach.

When the aircraft had turned onto the final approach track, he assessed that its radar return was slightly to the north of the centreline; he immediately informed the crew. The first officer's reply that they suspected a "FALSE SIGNAL" because the "LOCALISER" indicated a "SHARP LEFT TURN" led the radar director to believe that there was still a problem with the aircraft flight control system and did not cause him to question his assessment that the aircraft was only slightly north of the centreline.

The radar director could not explain why he initially told the aircraft to turn right onto 265°, however, the instruction was preceded by "...JUST SLIGHTLY NORTH,

COMING BACK ON THE CENTRELINE...". It is possible that he had anticipated the aircraft's interception of the centreline and had passed a heading which would have maintained the inbound track of 262° in the prevailing northerly wind. Subsequent headings were more compatible with his perception that the aircraft was still slightly to the north of the centreline. He remained convinced of this and his conviction was probably reinforced by the way the crew readily accepted his advice and asked him to continue to give headings.

The radar director had allowed a situation to develop where he was giving centreline guidance in the final approach sector. This would only occur on a Surveillance Radar Approach (SRA), when it was his normal practice to select the radar display to the 15 nm radius range scale. He neither offered nor considered he was giving an SRA and he made the conscious decision to remain on the 30 nm radius range. However, it is possible that he had subconsciously interpreted the displacement of the edge of the radar return from the radar video map centreline as if the radius range scale had, in fact, been selected to 15 nm, his normal practice for centreline guidance in the final approach sector. His consequent perception would have been that the aircraft was much closer to the centreline than it actually was.

No satisfactory explanation could be found for the radar director's subsequent offer of "AN EMERGENCY SRA" down to one nautical mile and an altitude of 500 feet or "HEADING GUIDANCE ON THE CENTRELINE" with "DESCENT ON THE GLIDEPATH" for the third approach. Neither of these were recognised procedures and the offer should not have been made.

There was no evidence to suggest that the radar director deliberately violated rules or procedures; his only motivation was to help the crew to achieve a successful approach in poor weather.

2.7 The flight crew

The USA based flight crew had been on duty for about 11 hours at the time of the incident, a usual period for this type of operation; they were experienced in long haul operations and were not aware of having a higher level of fatigue than normal. However, the aircraft started the approach sequence shortly after 1009 hrs which would have been 0409 hrs local time at the departure airfield, Houston. Although many eastbound transatlantic flights adhere to this sort of schedule, it is an accepted fact that the performance of flight crews can be degraded during what, to their USA orientated 'biological clocks', would be the early hours of the morning.

The evidence given by each member of the flight crew was consistent, however, there was a large part of both the first and second approaches for which they could supply little detailed information.

A problem existed on the first approach which had led to the failure of the AFCS to capture and track the localiser. When it happened again on the second approach the crew appear to have become convinced that, not only was there a fault in the AFCS, but also that the information being presented on the flight deck was in error. This conviction was reinforced by the actions of the radar director and it is probable that a situation developed where, implicitly, the latter had offered, and the commander had accepted, a non-approved approach for which there were neither published procedures nor minima.

The commander did not recall consciously flying the headings given by the radar director; he thought that he had calculated and flown headings to achieve a gradual centreline intercept. However, the radar director was asked to continue to pass headings; the FDR indicated that the aircraft closely followed those headings. Throughout the approach the aircraft's displacement from the centreline was such that the localiser would have shown full scale deflection. In these circumstances, it is difficult to see how the commander assessed the aircraft's displacement from the centreline without reference to the guidance given by the radar director.

There was no evidence to suggest that the commander deliberately violated rules or procedures, however, the decision to continue both the first and second approaches past the FAP, when the aircraft was outside the localiser course sector, was ill-advised and contrary to company and internationally recognised procedures.

2.8 Approach monitoring aid

The research and development by the CAA of an approach monitoring aid with its associated operating procedures is welcomed. There is no doubt that it could make a valuable contribution to the safety of aircraft on the approach to an airfield. Such a system may have prevented this incident developing, however, as the programme is still underway, it is felt that it would be inappropriate to make any formal recommendation related to it at this juncture.

3 Conclusions

(a) Findings

(i) The crew were properly licensed, rested and medically fit to conduct the flight.

(ii) The aircraft was correctly loaded and its documentation was in order.

(iii) The weather conditions at Gatwick were suitable for a Category 1 ILS approach.

(iv) Both the ILS and radar equipment at London Gatwick Airport were serviceable at the time of the incident and the information they provided was accurate.

(v) A fault in module A4A11 of the 'A' channel roll computer caused the aircraft to fly through the localiser and to establish on an inbound track right of the centreline on the first two approaches.

(vi) Apart from the fault in the 'A' channel roll computer the aircraft automatic flight control and navigation systems had no faults relevant to the incident.

(vii) Descent on the glideslope was initiated on both the first and second approaches when the aircraft was outside the localiser course sector.

(viii) The first approach was inaccurately flown by the first officer and was terminated at about 3 nm from touchdown.

(ix) On the second approach, the radar director incorrectly assessed the aircraft's displacement from the centreline and passed heading guidance based on this erroneous assessment.

(x) On the second approach, the procedure used by the radar director was non-standard; it should neither have been given by the No 2 radar director nor accepted by the aircraft commander.

(xi) On the second approach, the flight crew used the azimuth guidance given by the radar director and the ILS glidepath information to continue the approach beyond the FAP.

(xii) The aircraft was outside the localiser course sector throughout the second approach which was terminated when a missed approach was initiated; power was applied at about 500 feet amsl. Considering the manoeuvres which would have been required to achieve a landing, the commander's decision to go-around was prudent.

(xiii) The lowest recorded altitude the aircraft reached was 432 feet at ½ nm from touchdown; it was displaced about 900 feet to the right of the centreline. The published elevation of the highest point on the south terminal building was 316 feet; this point was about 500 feet to the right of the aircraft's track.

(b) Causes

The following causal factors were identified:

(i) Failure of the AFCS to capture and establish the aircraft on the localiser.

(ii) Failure of the aircraft crew to appreciate that the navigational information being presented to them on the flight deck was correct.

(iii) Failure of the commander to appreciate the extent of the aircraft's displacement from the centreline, on the second approach, and to take prompt and effective action to regain the correct approach path.

(iv) Failure of the No 2 radar director to appreciate the extent of the aircraft's displacement from the centreline which caused him to pass misleading information to the aircraft commander.

(v) The commander's acceptance of the azimuth guidance given by the radar director and the ILS glidepath information as adequate reference to continue the approach beyond the FAP.

4 Safety Recommendations

The following recommendation was made during the course of the investigation:

4.1 It is recommended that the Federal Aviation Administration determine the effect of the failure experienced by the module in the roll computer serial No 0080480 on the behaviour of the aircraft; whether a failure warning indication should be provided for such a case; and the relevance of such a failure to other types fitted with this or similar roll computers [Recommendation 94-9].

M M CHARLES

Inspector of Accidents

April 1994