Wing strike, Boeing 757-200, G-WJAN

Micro-summary: **Following two approaches, on the third, this Boeing 757-200 clipped the ground and then proceeded to an alternate.**

Event Date: **1998-01-01 at 1932 UTC**

Investigative Body: **Aircraft Accident Investigation Board (AAIB), United Kingdom**

Investigative Body's Web Site: **http://www.aaib.dft.gov/uk/**

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Boeing 757-200, G-WJAN: Main document

Air Accident Report No 3/99

Report by the Dominican Republic Authorities into the accident to Boeing 757-200, G-WJAN at Puerto Plata Airfield, Dominican Republic on 1 January 1998

Contents

Operator:	Airtours International
Aircraft Type and Model:	Boeing 757-200
Nationality:	United Kingdom
Registration:	G-WJAN
Persons on board:	8 crew with 220 passengers
Place of accident:	Puerto Plata Airfield,
	Dominican Republic
	Latitude: N 19° 45·5
	Longitude: W 070° 34·2
	Elevation: 16 feet
Date and Time:	1 January 1998 at 1932 hrs
	All times in this report are UTC

Synopsis

The accident occurred at 1932 hrs on 1 January 1998 at Puerto Plata Airfield, Dominican Republic, and was immediately reported to the Dominican authorities. The accident was investigated in accordance with Annex 13 to the Convention on International Civil Aviation. Accredited Representatives were appointed by the Air Accidents Investigation Branch, UK, (representing the State of Registry and the Operator) and the National Transportation Safety Board, USA, (representing the State of Design and Manufacture).

The accident occurred when the aircraft, which was on a charter passenger flight from Bangor, USA, to Puerto Plata, struck the ground to the right of Runway 26 whilst attempting to land from a low level, visual circuit. The crew had previously attempted two instrument approaches in poor weather neither of which had been successful. Following the ground contact the aircraft diverted to Santo Domingo, Dominican Republic, where it landed without further incident. The passengers, who disembarked at Santo Domingo, sustained no reported injuries. The aircraft suffered major damage to the tail area and was repaired by a team from the manufacturer.

The investigation identified the following causal factors:

(i) A very late go-around, initiated at a speed 14 kt below the target threshold speed, resulted in the underside of the aircraft's tail striking the ground thereby causing considerable damage to the aircraft.

(ii) After an unsuccessful second non-precision instrument approach the commander flew a visual circuit which ultimately required unusual and aggressive manoeuvring of the aircraft, but he was still unable to place the aircraft on the runway.

(iii) The visual circling approach was not discontinued immediately after the commander's spectacles became displaced, which resulted in the aircraft not being stabilised on the runway centre line by 400 ft.

(iv) Numerous deviations from the operator's Standard Operating Procedures (SOPs) by the flight crew precluded the establishment of a stabilised approach, increased the commander's workload and made a successful landing less likely from either of the instrument approaches.

(v) The first officer (FO) did not contribute sufficiently towards the overall management of the flight and failed to challenge any of the commander's flawed decisions as his Crew Resource Management (CRM) training and experience should have equipped him to do.

Three safety recommendations were made during the course of the investigation

Factual information

1.1 History of the flight

The history of the flight was derived using a combination of the pilots' reports and data from the Flight Data Recorder (FDR).

1.1.1 Transit

The aircraft and crew were planned to operate a charter flight from Bangor, Maine, USA, to Puerto Plata in the Dominican Republic. The commander had never before flown an aircraft into this airfield although the first officer had. The flight crew spent the previous night at Bangor and both had sufficient rest prior to the flight. The flight left Bangor at 1500 hrs and the aircraft was serviceable. There were no NOTAMS regarding abnormalities for the landing aids at Puerto Plata or Santo Domingo (the alternate airfield) and the meteorological forecasts for both the destination and the alternate were good.

After about two and a half hours into the flight the cabin supervisor informed the commander that the cabin crew were dealing with a disruptive passenger. After consultation with the cabin supervisor the commander wrote a report for the ground handling agent at Puerto Plata relating to the behaviour of this passenger. By the time that this issue had been dealt with the aircraft was approximately 20 minutes from the Top of Descent point (TOD). The commander then allowed a short flight deck visit by one of the passengers before the crew completed a condensed pre-descent briefing.

A weather update had been obtained prior to TOD and the meteorological conditions at the destination were reported as: surface wind 130°/09 kt, cloud scattered at 1,200 feet with rain, temperature +25°C; there was no report of the prevailing visibility. The commander was the handling pilot for the approach. The fuel at TOD was in excess of 9,000 kg; the associated Vref was 130 kt. At 1807 hrs the crew commenced a stepped descent and were given a direct routing to the Initial Approach Fix (IAF). During the descent it was clear from the indications on the weather radar display that there was significant weather over the airfield. Also, prior to the approach, the commander spoke to the crew of another aircraft that was holding because of the poor weather.

1.1.2 Initial VOR/DME approach

The aircraft was cleared by ATC at Santo Domingo Centre for the VOR/DME approach for Runway 26 at Puerto Plata and the aircraft overflew the IAF at an altitude of 3,000 feet at 210 kt; this IAF was located at 12 DME from the VOR and had a specified crossing altitude of 2,000 feet. The SOPs required that the VOR/DME approach should be flown from the IAF with flaps 20 and the gear down. However, the commander had decided to fly this approach with flaps 5 and the gear down; he intended to configure the aircraft for landing once visual contact had been made with the runway. He did not brief the first officer (FO) on this deviation from the SOP until he called for the selection of flaps 5.

During the right turn onto the inbound track of 263° flaps 1 was selected and the final descent commenced. Once established on the inbound radial, and at a range of 7·25 DME, flaps 5 was selected whilst at 2,300 feet and 210 kt, the gear was selected down at 6·5 DME. The aircraft was still at 2,000 feet at 5·25 DME when the pilot disconnected the autopilot (AP) and commenced the descent to the published Minimum Descent Altitude (MDA) of 660 feet. The aircraft reached the MDA at 1·25 DME and then briefly flew level at this altitude but no visual contact was established with the ground until just prior to commencing the go-around (GA) which was initiated at 0·25 DME by engaging the go-around switches. The published Missed Approach Point (MAP) was at 1·2 DME which was 0·3 nm from the runway threshold. An annotated ground track derived from the FDR using recorded heading and drift angle together with a descent profile for this first missed approach are plotted in Appendix 1 and Appendix 2 respectively.

1.1.3 Missed approach and hold

The missed approach procedure required a right turn to intercept the 360° radial from the Puerto Plata VOR and a climb to 2,000 feet. During this manoeuvre the crew requested a holding position and they were cleared to hold at 25 DME on the 360° radial at 9,000 feet. The minimum fuel for a diversion to Santo Domingo was 3,500 kg but the commander elected to use 5,000 kg as his minimum diversion fuel. Using this figure there was then enough fuel for about 40 minutes holding. The crew actually remained in the holding pattern for 25 minutes during which time they were aware that the other aircraft that had previously been holding had now diverted without commencing an approach at Puerto Plata. Since about 50% of the RT was conducted in Spanish the crew found it difficult to build a coherent picture of what was happening but they understood that two local aircraft had landed successfully. The crew obtained a weather update which reported the visibility as 4 km, the cloud overcast at 800 feet and the surface wind of 090°/15 kt. The weather radar display indicated that the previous significant weather returns had cleared from overhead the airfield. The commander briefed for a further VOR/DME approach for Runway 26 and specifically included in the brief the presence of the tailwind as well as his intention to divert immediately to

Santo Domingo if a GA was required. He updated the cabin crew and passengers on the situation and commenced a second approach at 1911 hrs.

1.1.4 Second VOR/DME approach

The crew were cleared by ATC for a further VOR/DME approach and at 1923 hrs the aircraft overflew the IAF at 2,000 feet whilst turning right onto the inbound track. The commander flew the initial element of this approach at an airspeed of 175 kt with flaps 5 and the gear up. He levelled at 700 feet from where he had visual contact with the coast but not the airfield. Flaps 20 and the gear down were selected at 2·75 DME and simultaneously the AP was de-selected; flaps 30 was selected at 1·75 DME at which point the airspeed was 155 kt. The aircraft then entered a slow descent to a minimum of 350 feet whilst the speed reduced to 132 kt. Both pilots were satisfied with the tracking but neither could yet see the airfield or the runway. The commander then saw the Precision Approach Path Indicators (PAPIs) but they indicated all white and he considered that they were too high on the approach to attempt a landing. The FO saw the PAPIs at the same time as he saw the runway, but this was slightly later than the commander. As they approached the MAP the commander saw that the area to the right of the airfield, over the sea, was clear and so he decided to enter a right-hand visual circuit to land on Runway 26. He informed the FO of his intentions and increased power, but he did not engage the go-around switches. He retained the landing configuration of flaps 30 and gear down and climbed straight ahead to 700 feet before entering a right turn onto the downwind leg. An annotated ground track and a descent profile for the second missed approach are shown in Appendix 3 and Appendix 4 respectively. The FO asked the commander if he was intending to land on Runway 26 or do a tear-drop turn to position for Runway 08. The commander confirmed that the circuit was for Runway 26 since he was confident that this approach was clear and he was unsure about the weather conditions on the approach to Runway 08.

1.1.5 Low level visual circuit

Following the second missed approach the aircraft climbed to 700 feet and commenced a right turn to enter the downwind leg of the circuit. A peak bank angle of 34·5° right wing down was recorded during this turn and the aircraft initially rolled out onto a heading of 097°M and was thus converging with the runway. Whilst on the downwind leg the commander climbed the aircraft up to 800 feet briefly but it went into cloud so he regained 700 feet from where both crew members could clearly see the runway. The aircraft heading was then adjusted left onto 070°M and the FO, in the right seat of the aircraft, was satisfied with the orientation and positioning whilst on the downwind leg. The tower controller passed a surface wind of 090°/10 kt that corresponded with the wind derived by the flight management computer at 700 feet which indicated 100°/13 kt. The commander started his stopwatch abeam the runway threshold and commenced a right turn 25 seconds later from an altitude of 620 feet, he immediately initiated a slight descent. As he entered the turn he had already lost sight of the runway but could see the bay and associated coastline clearly; the FO had good visual contact with the runway and commented that the initial element of the turn looked satisfactory. The commander still had the VOR/DME display selected but was not using it, he had also selected his flight director off. However, the FO selected the runway heading on the mode control panel as the turn was initiated.

The commander reported that about half way round the turn he looked to his right across the flight deck and lowered his head in order to view the runway which he saw was in the expected position. However, as he raised his head, his headset cable caught on the control column, possibly on the map holder, and as he continued to raise his head the left earpiece was pulled from his head and his glasses were dislodged. He was distracted for a period of a few seconds and when he had replaced

his glasses he realised that the angle of bank had reduced to about 15° and that an increased bank angle would be required in order to gain the extended runway centre-line. The FDR data indicated that during the descending turn an initial steady bank angle of 26° was established but, as the aircraft was turning through 120°M, the angle of bank reduced over a period of 11 seconds to 15·1°. Over the next 7 seconds the bank angle varied with values of between 19·3° and 14·7° being recorded, at the end of which the aircraft had descended to 460 feet and was turning through 163°M. The remainder of the right turn, which lasted a further 36 seconds, showed average bank angles of between 22° and 30° but with a peak of 36·5° during the latter stages when the height was 320 feet. The recorded DME at that point was 1·5 nm and the airspeed during the turn had slowly reduced from 140 kt to 130 kt.

1.1.6 Go-around and ground contact

The aircraft was still displaced to the left of the extended centre-line despite the application of these significant bank angles. As the aircraft tracked from left to right onto the extended runway centre-line, below 100 feet, left bank and up to 13·5° of left rudder was applied in an attempt to stabilise on the centre-line but to no avail. As the aircraft crossed the runway threshold both crew members perceived that the inertia was still taking the aircraft to the right. The highest reading of 15·8° left wing down occurred at a height of 45 feet above the ground, the FDR recorded that the thrust levers were retarded and the airspeed decreased to 116 kt. Shortly after the automatic height call out at 50 feet the crew reported that the FO called 'Go-around'. At about this time the bank angle to the left was reduced to 5·6° as the pitch up attitude increased to 10·2° and both thrust levers were fully advanced. One second later, at 1932 hrs, the aircraft struck the ground in scrub land to the right of the runway surface; a normal acceleration value of 1·77g and a lateral acceleration of -0·12g were recorded. At the time of the contact the aircraft was pitched up 10·7° with a roll attitude of 5·6° left wing down and on a heading of 253°M, the indicated airspeed was 115·5 kt and the descent rate was calculated as 360 feet per minute. An annotated ground track for the low level circuit is shown in Appendix 5. A time history plot of pertinent recorded parameters for the period is shown in Appendix 6. The commander thought that the ground contact was the left main gear striking the runway but the FO was not sure which part of the aircraft had made contact.

1.1.7 Diversion to Santo Domingo

During the GA the gear and flaps were retracted, the missed approach procedure was completed and the diversion to Santo Domingo initiated. The transit was flown at FL 200 and there were no problems with the aircraft handling or systems. There were no EICAS warnings and the APU, which had been running since the first approach, continued to function normally. The diversion was uneventful and culminated in a normal visual approach and landing flown by the commander. Subsequent examination of the data recorded on the FDR confirmed that there were no unusual indications or aircraft handling problems during the diversion to Santo Domingo where the aircraft landed at 2000 hrs.

When the engines had been shut down the passengers began to disembark through the forward left door. The cabin crew opened the rear left door and noted the smell of fuel coming from the tail area, this was immediately reported to the flight deck. The commander instructed the FO to shut down the APU which he did using the normal selector. It therefore continued to run during its cool-down period that is nominally set for 60 seconds. The FO contacted the tower and requested fire cover. The commander considered ordering an emergency evacuation but since the slides were now disarmed and about a third of the passengers were already off the aircraft he decided not make such an announcement.

It was only when the flight deck crew left the aircraft and completed a visual inspection of the tail section that they realised the extent of the damage sustained during the ground impact at Puerto Plata.

1.2 Injuries to persons

There were no injuries to the 8 crew or 220 passengers on board.

1.3 Damage to aircraft

The aircraft touched down in scrub land to the right of the runway surface, the left main gear and the tail area received the brunt of the impact. The left main gear struck the ground 5·3 metres beyond the right-hand edge of the runway surface. Vegetation was subsequently removed from the left main gear. Significant damage was readily apparent in the tail area and the APU access doors were badly distorted. The ground impact occurred whilst the engine power was increasing towards the go-around setting. Stones and other debris disturbed by the contact made by the left main gear were propelled by the left engine efflux onto the left horizontal stabiliser which received significant dents and punctures. An inspection by the aircraft manufacturer, conducted at Santo Domingo, determined that the aircraft was not airworthy and a repair team completed the subsequent repairs on the airfield.

1.4 Other damage

Nil

1.5 Personnel information

1.5.1	Commander:	Male, aged 53 years
	Licence:	Airline Transport Pilot's Licence
		valid to 18 April 1998
	Instrument rating:	valid to 10 April 1998
	Base check:	valid to 13 April 1998
	Line check:	valid to 14 March 1998
	Medical certificate:	Class one issued
		valid to 31 January 1998
		Limitations: as or with a co-pilot,
		must wear correcting spectacles
	Flying experience:	

Total Flying:	15,300 hours
On type:	760 hours
Last 90 days:	115 hours
Last 28 days:	35 hours
Last 24 hours:	5 hours (including accident flight)
Previous rest period:	23 hours

1.5.1.1 Operational experience

The commander learned to fly whilst serving in the Royal Air Force. On leaving the air force he joined another operator for whom he flew Comet and Boeing 727 aircraft for 17 years; the majority of this flying was as commander. When he joined his current company in 1991 he had a total of 11,700 hours. He then flew the MD 80 aircraft until 1996 when he converted to the Boeing 757. All of his flying with this company was as commander. He had attended a two day Crew Resource Management (CRM) course in 1995.

1.5.2	First officer:	Male, aged 34 years
	Licence:	Airline Transport Pilot's Licence
		valid to 9 January 2005
	Instrument rating:	valid to 31 August 1998
	Base check:	valid to 1 February 1998
	Line check:	valid to 12 July 1998
	Medical certificate:	Class one issued
		valid to 30 June 1998
	Flying experience:	
	Total Flying:	4,200 hours
	On type:	850 hours
	Last 90 days:	103 hours
	Last 28 days:	38 hours

Last 24 hours:	5 hours (including accident flight)
Previous rest period:	23 hours

1.5.2.1 Operational experience

The FO had gained a Private Pilot's Licence in 1987 and had then worked as a flying instructor in order to extend his flying experience. He gained a Commercial Pilot's Licence, with a frozen ATPL, in 1990. He joined his current company in 1996 at which time he had accrued about 3,000 hours, the majority of which were flying small turbo-prop aircraft. He had operated exclusively as an FO since joining this company. He had attended a CRM course with a previous employer but also attended one in December 1997 which had been arranged by his current company as part of their normal CRM training programme.

1.5.3 Training and testing

All recurrent flying training conducted by this operator for the Boeing 757, including instrument ratings and base checks, was carried out on an approved full flight simulator under the guidance of training captains validated by the UK CAA. CRM training for pilots within the company was conducted by another operator on their behalf. It was noted from the training records that the FO had initially failed the airfield non-precision approach on each of his previous three visits to the simulator and had required extra training in order to attain a satisfactory standard for this procedure. The commander's training records indicated nothing of significance.

1.6 Aircraft information

1.6.1 General information

Manufacturer	Boeing Company
Type	Boeing 757-200
Serial No	28674
Date of construction	March 1997
Certificate of Registration	Issued 20 March 1997 as G-WJAN
Certificate of Airworthiness	Valid until 19 March 2000
Last Scheduled Maintenance	'A' Check on 26 November 1997
	at 3, 474 hours and 1, 150 cycles
Hours/Landings at 1 January 1998	3, 854 hours / 1, 241 landings

1.6.2. Weight and balance

The aircraft mass at take off was 101,775 kg (maximum take off mass 115,667 kg) and the mass at commencement of the first approach was 87,275 kg (maximum landing mass 89,800 kg). The calculated centre of gravity at take off was 25% MAC and at landing it was 24·6% MAC. For the approach and landing phase of flight this represents a normal weight aircraft with the centre of gravity at a mid position.

1.7 Meteorological information

1.7.1 General situation

The synoptic situation at 1300 hrs indicated that a cold front was lying over the island with an associated area of rain showers moving into the area from the east, winds were generally from the south east. The relevant terminal area forecast, valid from 1200 hrs and used by the crew for briefing prior to the flight, indicated a surface wind of 070°/10 kt, visibility greater than 10 km, a few clouds with a base of 2,500 feet, with a temporary change between 1400 and 1900 hrs when the visibility was expected to reduce to 8000 metres in rain.

1.7.2 Actual weather conditions

Upon initial contact with Santo Domingo Centre the crew were passed the following report for the actual meteorological conditions (METAR) at Puerto Plata: surface wind 130°/09 kt, cloud scattered at 1,200 feet with rain, temperature +25°C; there was no report of the prevailing visibility. This report is part of the 1700 hrs METAR for Puerto Plata which had an associated visibility of 6,000 metres in rain. The crew commenced the descent at 1807 hrs during which it became clear to the crew that the actual conditions were not as good as reported since they had indications on their weather radar that there was significant weather over the airfield and another aircraft was already holding whilst awaiting an improvement in the weather. After the first missed approach at 1839 hrs the aircraft entered a holding pattern and subsequently the crew were passed a weather update which reported the visibility as 4,000 metres, the cloud overcast at 800 feet and a surface wind of 090°/15 kt. The weather radar display indicated that the previous significant weather returns had cleared from overhead the airfield and the commander elected to commence a further approach to land. The 1900 hrs METAR recorded a surface wind of 130°/08 kt, visibility of 3,000 metres in light rain, cloud overcast at 1,600 feet. During the subsequent visual circuit the crew entered cloud at 800 feet whilst on the downwind leg.

1.8 Aids to navigation

The Puerto Plata VOR DME beacon had been utilised for both of the instrument approaches to Runway 26 and the associated approach procedure is depicted at Appendix 8. The co-located beacon is sited approximately half way along the runway which is 3,081 metres in length. The IAF, PIVEL, is at 12 DME on the 083° radial and has an associated crossing altitude of 2,000 feet. The VOR and DME were serviceable for both instrument approaches.

1.9 Communications

All communications between the aircraft and the ground stations was conducted using VHF radio which operated satisfactorily throughout.

1.10 Aerodrome Information

1.10.1 Administration

The international airport at Puerto Plata, correctly named "Gregorio Luperon International Airport" is located on the northern coast of the Dominican Republic at the following co-ordinates: N 19° 45·5, W 070° 34·2. The single concrete runway, 08/26, is 3,081 metres long and 46 metres wide and the touchdown elevation for both thresholds is 16 feet. The runway alignment for Runway 26 is 261°M and the magnetic variation is 09û W.

1.10.2 Runways and approaches

Runway 08 has no published instrument procedure and is used for visual approaches only because of the presence of high ground. Runway 26 is served by three alternative instrument procedures: a VOR/DME, a VOR and an NDB; this crew were cleared for the VOR/DME approach. The MAP for the VOR/DME approach for Runway 26 is at 1·2 DME, on the 083° radial, and this is 0·3 nm from the runway threshold, the published MDA for the VOR/DME approach is 660 feet. If the aircraft is in the correct configuration and flying level at the MDA towards the MAP then it is not possible for a B 757 aircraft to complete a safe landing from the MAP. The necessary visual references must be acquired prior to the MAP in order to allow the aircraft to follow a nominal 3û approach path from the MDA to landing. The published MDA for a circling approach to Runway 08 is 800 feet. There is no published MDA for a circling approach to Runway 26 since it is assumed that an aircraft would be able to execute a straight in landing from the instrument approach. However, since the aircraft would be manoeuvring in the same defined area whilst circling for either runway then the MDA of 800 feet could be applied for a circling approach to Runway 26. This runway has no approach lighting system but is equipped with PAPIs which are set to a 3û approach angle, the runway also has green threshold lights and white runway edge lights.

1.11 Flight recorders

1.11.1 General

The Flight Data Recorder (FDR) model 980-4700-035 (serial number 1917) and Cockpit Voice Recorder (CVR) model 980-6020-001 (serial number 1291) were removed from the aircraft and taken to the National Transportation Safety Board (NTSB) in Washington for replay. The replay of both units was conducted by the NTSB in the presence of the Dominican Republic investigator and two investigators from the Air Accidents Investigation Branch UK. Both recorders utilised solid state technology as their recording medium and were replayed without difficulty using the download connector provided on the equipment for that purpose. The CVR, which was of thirty minute recording duration, had been allowed to continue to operate after the aircraft had landed. This, together with the diversion flight from Puerto Plata, ensured that the audio recorded during the accident flight had been over-written. It thus proved to be of no use to the investigation. The FDR maintained a record of the last 51·5 hours of aircraft data including the whole of the incident flight and subsequent landing.

1.11.2 Accident flight

The aircraft departed Bangor, Maine, USA, at 1500 hrs, climbed initially to FL 350 and then to FL 370 where it became established in the cruise with the AP engaged. Top of descent was reached at 1807 hrs. During the descent, at a height of 12,000 feet, the navigation aids were tuned for the VOR DME approach to Puerto Plata; the DME at that stage having recorded values of 38 nm. The frequency selections of the navigation aids were not altered during the subsequent three approaches at Puerto Plata. The aircraft subsequently landed at Santo Domingo at 2000 hrs.

1.12 Wreckage and impact information

The left main gear struck the ground 5·3 metres beyond the right-hand edge of the runway surface. Evidence of the tailstrike on the airfield had been obliterated by subsequent prolonged, moderate rain.

1.13 Medical and pathological information

Nil.

1.14 Fire

There was no pre or post-impact fire.

1.15 Survival aspects

Nil.

1.16 Tests and research

Nil.

1.17 Organisational and management information

1.17.1 History of the operator

This company commenced operations in March 1991 utilising MD-83 aircraft on European charter routes. The fleet eventually increased to eight aircraft operating throughout the year. In 1993 the parent company acquired another tour operator that also had its own airline and this was incorporated into the existing structure, utilising Boeing 757 and Airbus A-320 aircraft. Shortly after this acquisition long haul operations were commenced with the Boeing 757 as a lead-in to operations with two new Boeing 767-300 aircraft. Following a period of sustained growth the fleet now consists of three Boeing 767-300, six Boeing 757-200, ten Airbus A-320 and two Airbus A-321. All 767's and two 757's are used on long haul operations and both types operate regularly into the Dominican Republic.

1.17.2 Crew Resource Management

UK Aeronautical Information Circular (AIC) 143/1993 (Pink) sets out the requirements for holders of a UK Aircraft Operators Certificate (AOC) engaged in public transport flights to train their crews in the practical awareness and application of CRM. All crew employed in the industry were required to have completed an approved CRM course by 1 January 1995. The AIC states the major attributes of CRM training as:

(i) A comprehensive scheme for improving crew performance

(ii) A scheme that addresses the entire crew population

(iii) A scheme that can be extended to all forms of training

(iv) A scheme that concentrates on crew members' attitudes and behaviour, and their impact on safety

(v) An opportunity for individuals to examine their behaviour and make individual decisions on how to improve teamwork, within the aircraft and with outside agencies

(vi) A scheme that uses the crew as a unit of training

Subjects to be incorporated in such a training course include: Standard Operating Procedures, the Flight Deck Social Structure and a detailed examination of the manner in which CRM can be employed in order to make a significant and positive contribution to operations on the flight deck.

The operator currently uses externally provided CRM courses that are attended by all company pilots. Until recently the courses were held 'in house' but due to limitations in classroom space the facilities of another operator are used. The Civil Aviation Authority (CAA) had previously given permission for all recurrent CRM training to be conducted in the simulator as part of the biannual simulator check. The operator now has CAA approval for a CRM course designed to its own requirements, this will be conducted in a new training facility when it is commissioned in 1999.

1.18 Additional information

1.18.1 Standard Operating Procedures

The objective of standard operating procedures (SOPs) is to establish the manner in which the activities of the operating crew will be co-ordinated into a team effort; the overall aim being to ensure that the flight is conducted in a safe and efficient manner. The procedures lay down the sequence of activities, designate which crew member will normally accomplish each item and provide brief explanations where necessary.

The SOPs used by this operator for the Boeing 757 are contained in Volume 1 of the Boeing Operations Manual. They are modified as required to meet their own requirements and these modifications are clearly identified by the use of pink coloured pages. They are prefaced with the following statement:

"The purpose of SOP's is to simplify and standardise normal operations for pilots who may be unfamiliar with each other. There may be unforeseen circumstances where individual SOP's become inappropriate. Any deviation from the following must be agreed, thoroughly briefed and understood by both pilots."

Section 8 of the Boeing 757 Operations Manual refers to the starting of the APU during the approach phase and states:

" The PNF (non flying pilot) may start the APU"

This procedure is therefore allowed but not mandatory.

1.18.2 IFR approach requirements

The operator's Route Manual Volume 1, paragraph 2.5 defines Minimum Descent Altitude (MDA) as follows:

"In relation to the operation of an aircraft at an aerodrome means the altitude in a non precision approach below which descent may not be made without the specified visual reference"

Paragraph 2.15.2 defines the specified visual reference for a non precision approach when established in the landing configuration as:

"*At least seven consecutive lights which may be approach or runway lights or a combination of both. (It is not essential that the aiming point is in view at the MDA).*

OR

The aiming point at touchdown if no approach lighting is available. If the specified visual reference has not been established at minima then an immediate go-around must be accomplished."

Guidance on stabilised approaches is contained in the Volume 1 of the Boeing 757 Operations Manual where it states at Chapter 2, page 02.03.07, paragraph 8.6 that

"On all approaches the aircraft is to be stabilised in the landing configuration with the engines spooled up and checks complete by 700 feet on the radio altimeter (RA).. If the aircraft is not on the centre line and in a stabilised condition by 400 feet above airfield level a go around should be made."

1.18.3 Monitored approaches

The operator has considered the advantages and disadvantages of a monitored approach procedure whereby one pilot flies the aircraft during the approach whilst the other pilot monitors the flying, is responsible for acquiring the required visual references for landing and takes control of the aircraft for that landing. However, after consultation with the training departments of both fleets the operator decided not to adopt this process for IFR approaches.

1.18.4 Non precision approach

The company Operations Manual provides alternate SOPs for a non precision approach which allow for such approaches with or without an associated DME.

If the approach aid allows for DME/height checks or has time/height checks printed on the appropriate published approach chart then the crew will be able to identify clearly whether they are high or low on the projected glideslope and make appropriate corrections to regain the descent path if necessary. In this type of approach the flight crew are attempting to track a virtual vertical profile that approximates a normal 3° glideslope and brings the aircraft to the MDA at the MAP. In this instance the SOP requires that before descent to the MDA the aircraft should be configured for landing with the gear down, flaps 30 and landing checks complete, the subsequent descent is then flown at a normal rate of descent of 700 to 800 feet per minute. The SOP states that "*The entire*

success of the approach depends upon completing all the checks and configuration changes before the decent commences"

When the approach aid does not have an associated DME the SOP requires that the aircraft should approach the initial approach fix at the specified altitude with the gear down and flaps 20. Having pre-selected the MDA in the altitude window the descent is then initiated by setting the vertical speed selector to 1,100 feet per minute and following the descent command to level at the MDA. In this instance the MDA may be maintained to the MAP or to the end of the timing if no MAP is published. The approach may be continued to a landing provided that visual reference can be maintained and a landing can be made in the touchdown area.

The approach chart that was used for the VOR/DME approach for Runway 26 does not have time/height checks nor is it possible to construct easily a descent profile that approximates a normal 3° glideslope and brings the aircraft to the MDA at a suitable distance from the runway threshold in order to continue the descent to land. The pilot would therefore be compelled to use the SOP for a non precision approach which assumes that there is no associated DME. The purpose of the DME on this particular approach is to therefore define the IAF and the MAP.

1.18.5 Visual manoeuvring (Circling)

Visual manoeuvring (circling) is the term used to describe the visual phase of flight after completing an instrument approach, to bring an aircraft into position for landing on a runway which is not suitably located for a straight in approach. The flight procedures for this manoeuvre are contained in volume 1 of the Procedures for Air Navigation Services (PAN OPS) (Fourth edition - 1993).

The PAN OPS document states, at Chapter 4, page 3-26, paragraph 4.5 that:

"When an additional margin is added to the OCA/H (obstacle clearance altitude/ height) for operational considerations in accordance with Annex 6, an MDA/H is specified. Descent below MDA/H should not be made until:

a) visual reference can be established and maintained;

b) the pilot has the landing threshold in sight; and

c) the required obstacle clearance can be maintained and the aircraft is in a position to carry out a landing.

Note: - The procedure does not provide protection from obstacles when the aircraft is below OCA/H."

Furthermore, at Chapter 4, page 3-26 paragraph 4.6 the document states that:

"After initial visual contact, the basic assumption is that the runway environment (i.e. the runway threshold or approach lighting aids or other markings identifiable with the runway) should be kept in sight while at MDA/H for circling."

When discussing the missed approach procedure while circling the document, at Chapter 4, page 3-26 paragraph 4.7 states:

"If visual reference is lost while circling to land from an instrument approach, the missed approach specified for that particular procedure must be followed. It is expected that the pilot will make an initial climbing turn toward the landing runway and overhead the aerodrome where the pilot will establish the aircraft on the missed approach track. ..."

2 Analysis

2.1 Approaches at Puerto Plata

2.1.1 Transit

During the transit the commander became involved in the administrative process involving a disruptive passenger but still allowed a short flight deck visit close to TOD. The crew were then obliged to complete a condensed pre-descent briefing.

The purpose of the pre-descent briefing is to ensure that both crew members have a clear understanding of the proposed plan of action and are in complete agreement as to how this plan will be executed. This aim was not achieved since the FO was unaware of any proposed deviations from the SOP until flaps 5 was selected during the first approach. There was also no evidence of a cohesive plan that would have allowed the aircraft to be flown level at the MDA prior to the MAP.

2.1.2. Initial VOR/DME approach

The SOP required that the VOR/DME approach should be flown from the IAF with the flaps at 20 and the gear down but the commander decided not to follow this SOP. By retaining the flaps 5 setting he was forced to fly the approach at a higher indicated airspeed of 170 kt, instead of 150 kt which would have been the minimum speed with flaps 20. This increased speed allowed him less time to assess the visual segment of the approach thus making a GA more likely in the prevailing conditions. The time available for a visual assessment was further reduced by the known tailwind. Moreover, in the event that the commander had decided to land he would have had to select flaps 25 or flaps 30 in order to do so. This change in configuration from flaps 5 to a landing flap setting produces significant variations in pitching moments across the wing of the Boeing 757 which would have increased the pilot's workload during the difficult transition from a non-precision to a visual approach. Finally the crew did not initiate a GA at the published MAP of 1.2 DME but delayed this action until 0·25 DME. These deviations from the SOPs made a successful landing from the initial approach less likely in the prevailing weather conditions.

2.1.3 Second VOR/DME approach

When the aircraft was cleared for a further VOR/DME approach the commander, once again, failed to configure the aircraft in accordance with the SOPs. In so doing he increased his workload by making late configuration changes as he approached the MAP thus making a successful landing less likely.

Having levelled initially at the MDA the aircraft then entered a shallow descent, which was not corrected by the crew, to a minimum of 350 feet although neither crew member could see the airfield or the runway. This is at variance with the Route Manual which prohibits descent below the MDA without the specified visual reference; the specified visual reference in this instance being the aiming point at touchdown since no approach lighting was available

On approaching the MAP the commander saw that the area to the right of the airfield, which was over the sea, was clear so he decided to enter a right-hand visual circuit to attempt a visual approach to land on Runway 26. This was despite his briefed intention to divert immediately to the alternate airfield in the event of an unsuccessful approach and placed him in a wholly unbriefed scenario.

2.1.4 Low level visual circuit

In electing to fly a right-hand, low level, visual circuit from the left seat the commander placed himself in a difficult and unfamiliar situation. This is evidenced by the poor accuracy of flying during the manoeuvre. Furthermore, lack of familiarity with this manoeuvre is apparent in his decision to enter the final turn after only 25 seconds beyond the point abeam the threshold and to immediately commence a slight descent from an altitude of 620 feet. These two actions made it difficult for him to ensure that the aircraft was stabilised on the *centre line* by 400 feet as required by the Boeing 757 Operations Manual.

The commander commenced the downwind leg at 700 ft. When established on the downwind leg he climbed the aircraft up to 800 feet, the published MDA for the circling manoeuvre, but entered cloud. PANOPS requires that the missed approach must be followed once visual contact is lost. However, instead of executing the missed approach the commander descended the aircraft to 700 ft and ultimately 620 ft by the end of the downwind leg. Although he believed that he was over the sea at this stage, by descending below the published MDA of 800 ft he could no longer be sure of protection from obstacles especially since he was relying on guidance from the FO for positioning during this manoeuvre.

During the final right turn the commander initially lost sight of the runway. About half way around the turn, and in an attempt to gain an early sighting of the runway, the pilot leant forward to increase his viewing angle across the cockpit. In doing so his spectacles became dislodged and the bank angle reduced to about 15°. In an attempt to recover the extended centre line the aircraft was manoeuvred aggressively with a peak bank angle of 36·5° being achieved at 320 feet. Further manoeuvring using both left bank and rudder was then accomplished, below 100 feet, in an attempt to stabilise on the centre line, at 45 feet the aircraft was still 15·8° left wing down. Despite these control inputs the inertia of the aircraft was still taking it to the right as the aircraft crossed the runway threshold and the speed reduced to 115·5 kt. It is apparent that neither crew member was aware of the consequences of attempting to manoeuvre aggressively such a large aircraft and the effect of inertia in relation to the resultant ground track. It is partly for this reason that the Boeing 757 Operations Manual requires that if the aircraft is not on the *centre line* and in a stabilised condition by 400 feet then a go-around should be made.

2.2 Crew co-ordination

Throughout the approaches at Puerto Plata the commander deviated persistently from the SOPs and company regulations often without any prior consultation with the FO. Moreover, there were instances where the operation of the aircraft was unusual or where individual parameters far exceeded those experienced in normal operations. However, the FO confirmed that he only questioned the commander's actions or intentions on one occasion when he asked which runway he was positioning for as he entered the visual approach. These high workload situations are exactly the areas where sudden incapacitation of the flying pilot would endanger the safety of the aircraft and it is therefore imperative that whenever any such deviations are observed the non flying pilot must draw attention to them and satisfy himself that the other pilot is not suffering from a subtle,

incipient or sudden incapacity. The FO made no such contribution during these approaches but seemed content to rely on his own assessment of the commander as being someone in whom he had complete confidence both in terms of judgement and ability. It seems probable that it was the automatic height call out at 50 feet that provided the impetus for the FO to make a purposeful and independent intervention when he called "Go-around".

Neither the commander nor the FO demonstrated the most basic principles of CRM during these approaches. The commander had attended a two day CRM course in 1995 and his subsequent recurrent CRM training had been conducted in the simulator as allowed by the CAA. The FO had attended an approved CRM course just two weeks prior to the accident but had apparently not yet assimilated much of that training. The operator now has CAA approval for a CRM course designed to its own requirements. This training will be conducted in a new training facility when it is commissioned in 1999.

2.3 Human factors

There are no obvious extraneous factors to account for the crew's performance. Although some disruption of circadian rhythm was inherent in the operation the crew was reasonably well rested before the flight. Towards the end of the flight the commander had to write a report on a disruptive passenger. This was completed before the descent towards Puerto Plata was commenced, and then the commander had elected to allow a flight deck visit. This suggests that the flight crew were relaxed rather than under pressure.

The aircraft was damaged as a result of difficulties that the commander experienced in manoeuvring the aircraft whilst attempting to land from the visual circuit. The relative novelty of the procedure, and the particular demands inherent in performing a right-hand circuit from the left seat account for some of the inaccuracy in handling. Also, the FO's call for a go-around was too late to prevent ground contact. These facts flow directly from the adoption of a low level circuit procedure which imposed heavy demands on the crew in terms of making unusual visual judgements requiring an acute appreciation of the aircraft's inertia. All of these difficulties would have been avoided if SOPs had been adhered to.

The commander's motivation in deviating from SOPs probably derived from professional pride in his ability, and concern to provide as good a service as possible for the company and its customers. The commander understands the relative importance of commercial and safety considerations, and has previously diverted aircraft when the situation demanded it. On the basis of one interview and a personality test, the commander does not appear exceptionally prone to reckless behaviour. It seems likely, therefore, that he relished the challenge of completing this flight as planned in difficult conditions, and, allowed himself to be deceived into pursuing that challenge in a gradually increasingly risky manner. The insidious acceptance of increasing risk in pursuit of a goal is best averted by means of clear planning, considering all the relevant options, and decisive adherence to the plan by all crew members. The commander's failure in this respect calls into question the effectiveness of his CRM training.

The FO raised only one query about the commander's decisions - which runway did he intend to use for landing. The FO appears to have been confident in the commander's ability and judgement as a pilot. Nevertheless his CRM training should have prepared him to challenge non standard procedures. It may be that the initial violations, on the first approach, (non standard flap setting and the prosecution of the approach to 0·25 DME) did not seem particularly alarming, especially as the pre descent brief had been somewhat condensed. Acceptance of these deviations then prepared the

ground for further violations on subsequent approaches. There is a clear conflict between the roles of the FO as a junior, learning from the commander's experience and judgement, and as monitor and conscience, ensuring proper adherence to procedures. It is this type of issue that CRM training is designed to address, and, in this case, the FO's training appears to have failed and again calls into doubt his CRM training.

2.4 Adherence to standard operating procedures

The operator's SOPs for the B 757, as amended by the pink pages, are produced in the Boeing Operations Manual. They state that "*there may be unforeseen circumstances where individual SOP's become inappropriate. Any deviation ....must be agreed, thoroughly briefed and understood by both pilots*.". The circumstances at Puerto Plata did not justify deviating from the SOPs and no such deviation was briefed. SOPs should form the bedrock for the manner in which an aircraft is operated and it is not clear why these pilots chose to take advantage of the caveat allowing deviation from them.

One of the causes of this accident was the manner in which a number of the SOPs were disregarded by this crew. Whilst this may have been a unique event for the crew it would be appropriate for the management to adopt proactive measures to monitor compliance with SOPs by their crews. The operator had already investigated such a system which reviews, on a routine basis, disidentified FDR records in order to assess adherence to the SOPs. It is recommended that the operator should ensure that such a programme is introduced as soon as possible.

2.5 Approach procedures

This flight crew were faced with an unfamiliar instrument approach, in poor weather conditions, to an airfield that was new to the commander. In prosecuting the approach the commander flew the aircraft himself, without the aid of the autopilot and autothrottle and also made all of the executive decisions. In these circumstances the other member of the flight crew, the FO, was virtually redundant. In a cockpit designed for operation by two people the pilots must work as a team whilst utilising effectively the technology provided by the aircraft. A number of procedural mechanisms are available which attempt to address this issue by formally defining the task sharing. This also has the benefit of encouraging adherence to SOPs since this is the only way to ensure that both pilots know how the approach will be prosecuted. This operator encourages the use of the autoflight systems during complex approach procedures in order to minimise the workload on the operating pilot, however, in this instance the pilot dispensed with these systems as the workload increased. It may be that the current procedures allow too much latitude to the flight crew and thus provide an opportunity to corrupt the concepts of teamwork and the effective use of technology. In view of this accident the operator should review, in general terms, the operating procedures to ensure that they are providing the most effective guidance to pilots in order to ensure safe and efficient approach procedures.

2.6 Meteorology

The meteorological forecast that the crew used for their pre flight briefing indicated that the generally fine weather conditions at Puerto Plata would deteriorate temporarily to 8,000 metres in rain by the estimated time of their arrival at 1840 hrs. This deterioration was accurately reflected in the METAR issued at 1700 hrs but the primary cue to this deterioration, the reduction in visibility to 6,000 metres, was not passed to the crew when they requested the destination weather prior to top of descent, nor did they request the visibility once they realised that it had been omitted.

However, the crew were aware that the weather was not good since another aircraft was already holding, awaiting an improvement in the weather, and indications on the weather radar showed strong weather returns from the area directly over the airfield. Subsequent meteorological reports to the crew provided reasonably accurate descriptions of the rapidly changing situation as the heavy rain showers moved away.

2.7 Airfield facilities

Runway 26 is the only runway at Puerto Plata which allows for an instrument approach in poor weather and yet the only lighting provided on this runway is for the PAPIs, the threshold and the runway edges. During the latter stages of both instrument approaches the pilots were unable to locate the runway until they saw the PAPIs from a position from which they were unable to execute a safe landing. Some form of approach lighting would allow for easier visual acquisition of the runway and thus enhance safety in inclement weather. It is therefore recommended that the airfield authority provide an effective form of approach lighting for Runway 26 at Puerto Plata.

2.8 Actions by the crew after landing

After the landing at Santo Domingo the cabin crew informed the flight crew that they suspected a fuel leak from the APU, the commander instructed the FO to shut it down. The FO used the normal selector to do so and the APU consequently entered a 60 second cool down period prior to shutting down. Alternatively he could have pulled the APU fire switch which would have shut down the APU immediately.

It is unlikely that the commander understood the severity of the damage to the aircraft and the APU when he was informed of the suspected fuel leak at the rear of the aircraft. However, it may have been wise to request more information rather than just dismiss the idea of calling for an emergency evacuation. It was estimated that only one third of his 220 passengers had disembarked at this time and the remaining passengers had no reason, at this stage, to expedite their exit from the aircraft. A brief discussion with the cabin supervisor may have produced a more urgent disembarkation.

2.9 Summary of the engineering investigation

The fuselage underside was scraped and crushed from aft of the rear pressure bulkhead (Frame 1720) to the rear of the APU bay doors, the damage being biased towards the left side. The leading edges of the APU bay doors were crushed rearwards and upwards into the bay and the APU fuel supply line had been ruptured at the firewall that had been crushed and torn. Fuselage distortion during the impact left some wrinkling of the skin panels on the left side aft of the wing root fairing but no permanent twisting of the fuselage was detected.

The left stabilator was dented and punctured on its leading edge and underside by debris, probably stones, thrown up from the left main landing gear's contact with the ground.

2.10 Summary

The crew were suitably qualified and experienced for the flight and the aircraft was serviceable. During the descent to Puerto Plata the commander was aware that the weather was poor but it was entirely reasonable for him to commence the VOR/DME instrument approach. The crew were unable to locate the runway and followed the missed approach procedure into a holding pattern. After 25 minutes the commander commenced a second VOR/DME approach which was also

unsuccessful. He then applied power and entered a visual circuit at 700 feet. During the final turn of this circuit the commander became distracted as his spectacles were dislodged and despite aggressive manoeuvring, at low level, he was unable to fly the aircraft onto the runway. The aircraft struck the ground in scrub land to the right of the runway surface, the left main gear and the tail of the aircraft took the force of the impact. The flight crew had already initiated the go-around and they diverted to Santo Domingo where the aircraft landed safely. During the transit the crew had no indications of any problems whilst handling the aircraft or with its systems. There were no reported injuries to any personnel. A repair team from the aircraft manufacturer declared the damage to be so severe that the aircraft was not airworthy and the necessary repairs were completed at Santo Domingo.

Throughout both instrument approaches and the subsequent visual circuit the commander deviated on a number of occasions from the company SOPs and regulations. The FO made little contribution to the successful management of the flight but was content to rely totally on the commander's judgement and ability. Neither the commander nor the FO demonstrated the most basic principles of CRM during these approaches. Three safety recommendations have been made as a result of this accident.

3 Conclusions

(a) Findings

Both crew members were correctly licensed and qualified for the planned flight. They both held a valid medical certificate and were adequately rested.

The aircraft had valid Certificates of Airworthiness and Maintenance.

The aircraft was serviceable and had been maintained in accordance with the required maintenance schedule.

The navigation aids required for the planned approach were serviceable.

The commander, who was to be the pilot flying the approach, did not conduct an effective top of descent briefing.

There was no evidence of a cohesive plan that would have allowed the aircraft to be flown level at the MDA prior to the MAP during the first approach.

Significant deviation from the SOPs made a successful landing from the initial approach most unlikely in the prevailing weather conditions.

The aircraft was allowed to continue in level flight at MDA for 1 nm beyond the MAP before the commander initiated the go-around procedure.

During the second VOR/DME approach the commander failed to configure the aircraft in accordance with the SOPs thus making a successful landing unlikely.

During the second approach the aircraft descended below the MDA without the specified visual reference being available to the crew.

The commander did not stabilise the aircraft on the approach by 700 feet above the ground on any of the approaches.

Neither crew member was aware of the consequences of attempting to manoeuvre aggressively such a large aircraft and the effect of inertia in relation to the resultant ground track.

The FO made no useful contribution during any of the approaches but seemed content to rely on his own assessment of the commander as being someone in whom he had complete confidence both in terms of judgement and ability.

The commander had attended a two day CRM course in 1995. His subsequent recurrent training had been completed in the flight simulator as allowed by the CAA.

The FO had attended an approved CRM course just two weeks prior to the accident but had apparently not yet assimilated much of that training.

Neither the commander nor the FO demonstrated the basic principles of CRM during these approaches.

(b) Causes

The following causal factors were identified:

(i) A very late go-around, initiated at a speed 14 kt below the target threshold speed, resulted in the underside of the aircraft's tail striking the ground thereby causing considerable damage to the aircraft.

(ii) After an unsuccessful second non-precision instrument approach the commander flew a visual circuit which ultimately required unusual and aggressive manoeuvring of the aircraft, but he was still unable to place the aircraft on the runway.

(iii) The visual circling approach was not discontinued immediately after the commander's spectacles became displaced, which resulted in the aircraft not being stabilised on the runway *centre line* by 400 ft.

(iv) Numerous deviations from the operator's Standard Operating Procedures (SOPs) by the flight crew precluded the establishment of a stabilised approach, increased the commander's workload and made a successful landing less likely from either of the instrument approaches.

(v) The first officer (FO) did not contribute sufficiently towards the overall management of the flight and failed to challenge any of the commander's flawed decisions as his Crew Resource Management (CRM) training and experience should have equipped him to do.

Safety recommendations

During the course of the investigation the following safety recommendations were made:

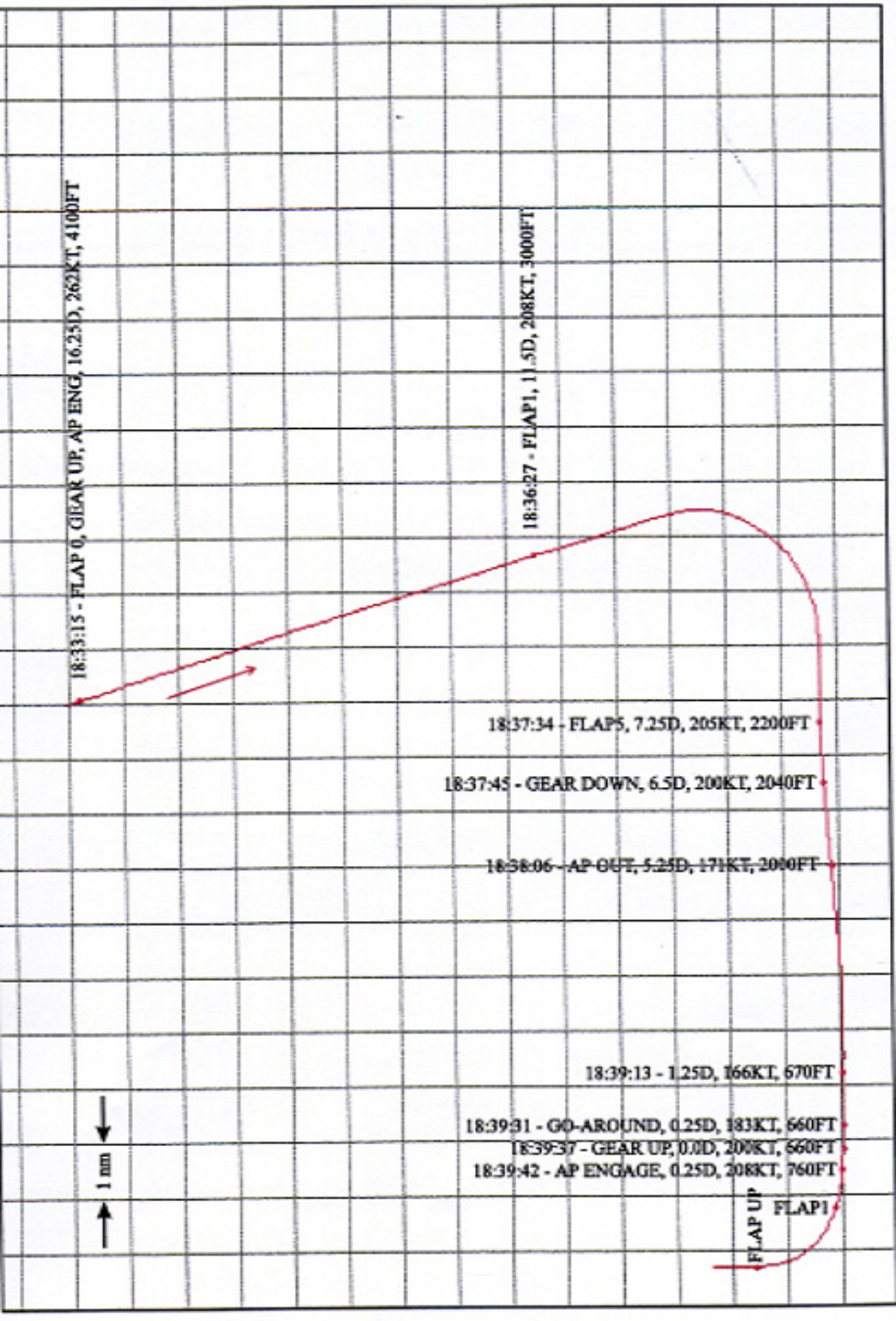
4.1 It is recommended that the operator should ensure that a programme to review, on a routine basis, disidentified FDR records in order to assess adherence to SOPs by its crews, is introduced as soon as possible.

4.2 The operator should review, in general terms, the operating procedures to ensure that they are providing the most effective guidance to pilots in order to ensure safe and efficient approach procedures.

4.3 The airfield authority should provide an effective form of approach lighting for Runway 26 at Puerto Plata.

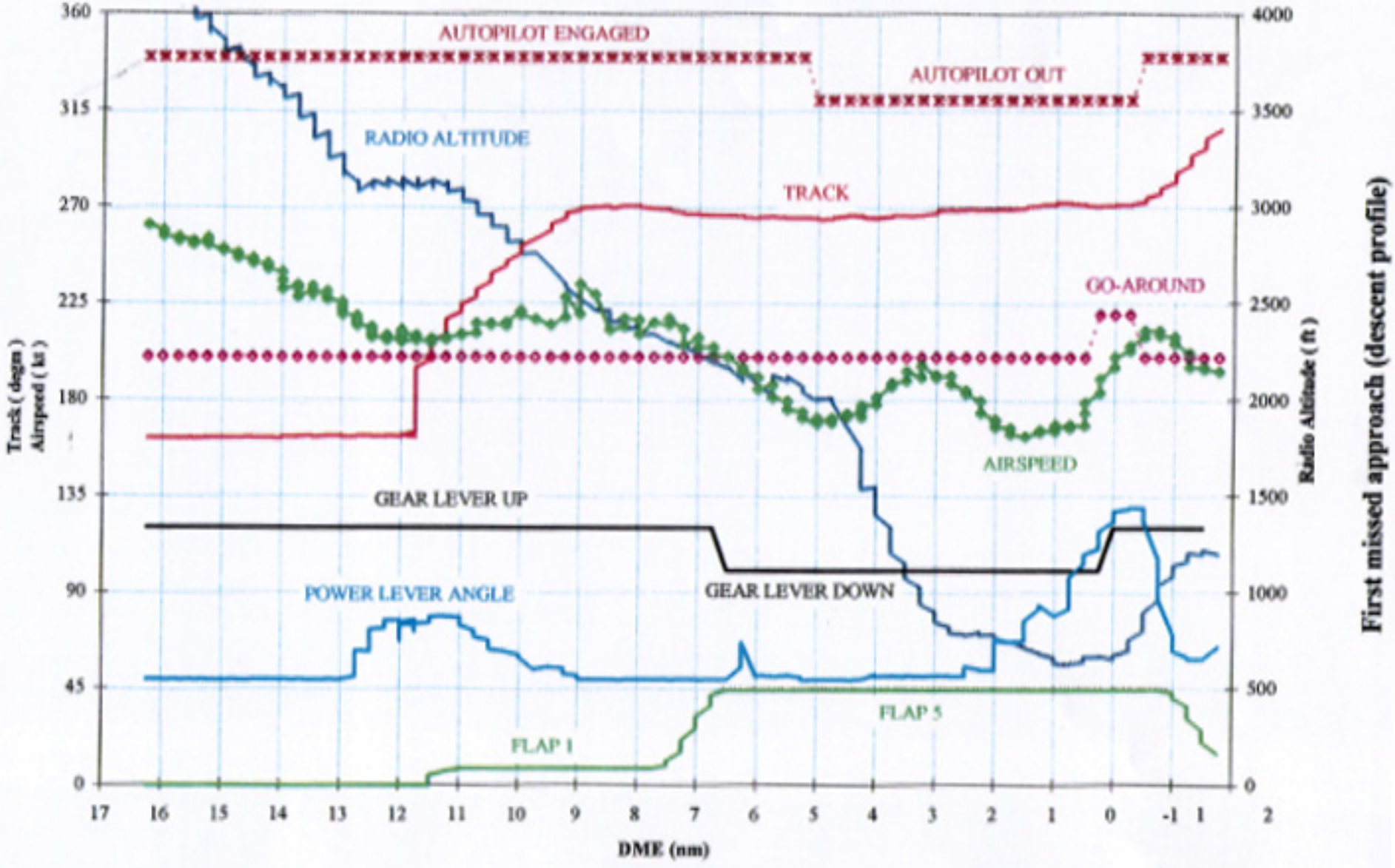
Return to Inspector's Investigations (Formal Reports) IndexReturn to Air Accidents Investigation Branch IndexReturn to DETR Aviation IndexReturn to Home PageWeb Site Terms

APPENDIX 1



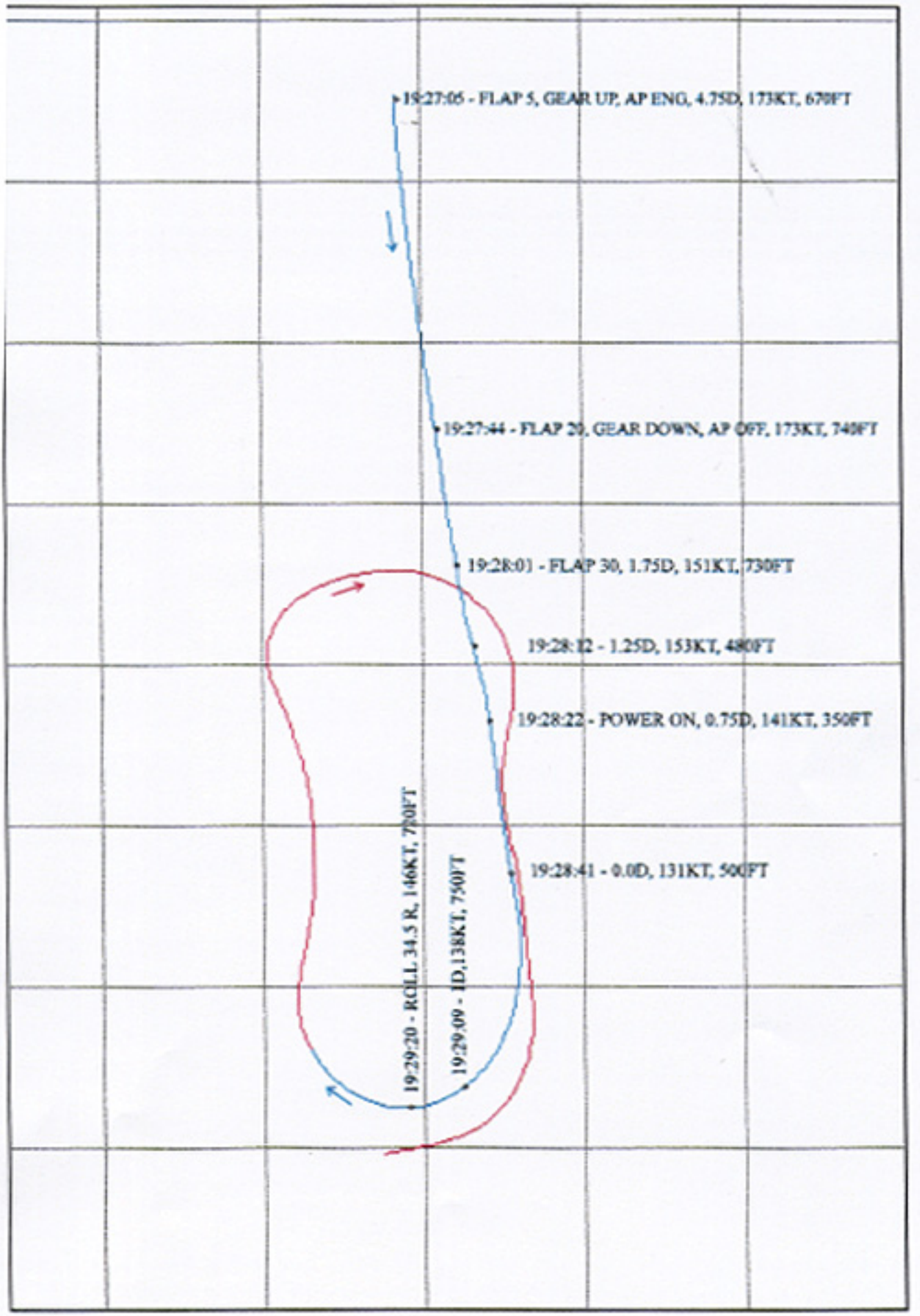
First missed approach (ground track)

APPENDIX 2



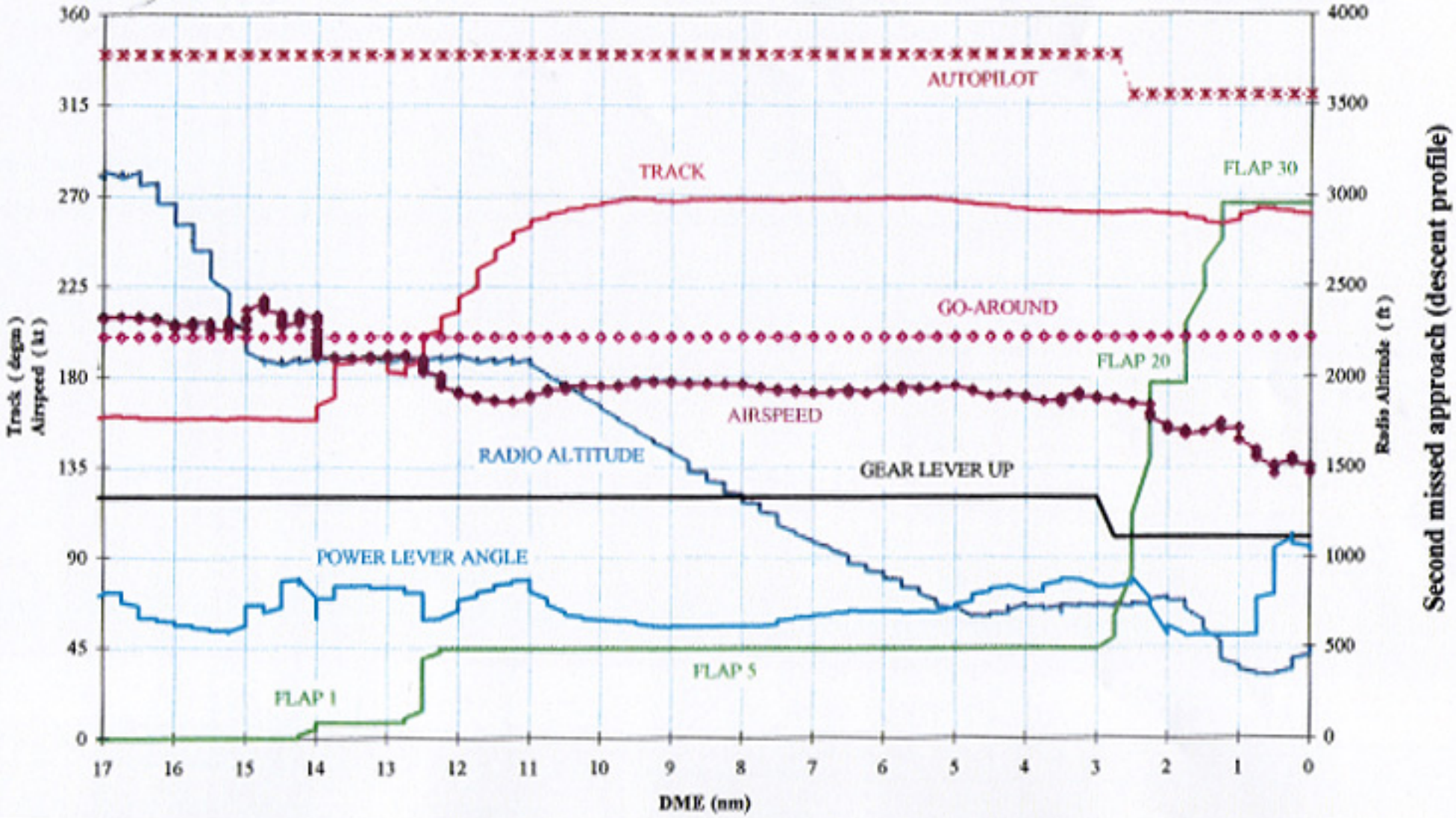
First missed approach (descent profile)

APPENDIX 3



Second missed approach (ground track)

APPENDIX 4


Second missed approach (descent profile)
Track (degm)
Airspeed (kt)
Radio Altitude (ft)
DME (nm)
AUTOPILOT
TRACK
FLAP 30
GO-AROUND
FLAP 20
AIRSPEED
RADIO ALTITUDE
GEAR LEVER UP
POWER LEVER ANGLE
FLAP 5
FLAP 1
360
315
270
225
180
135
90
45
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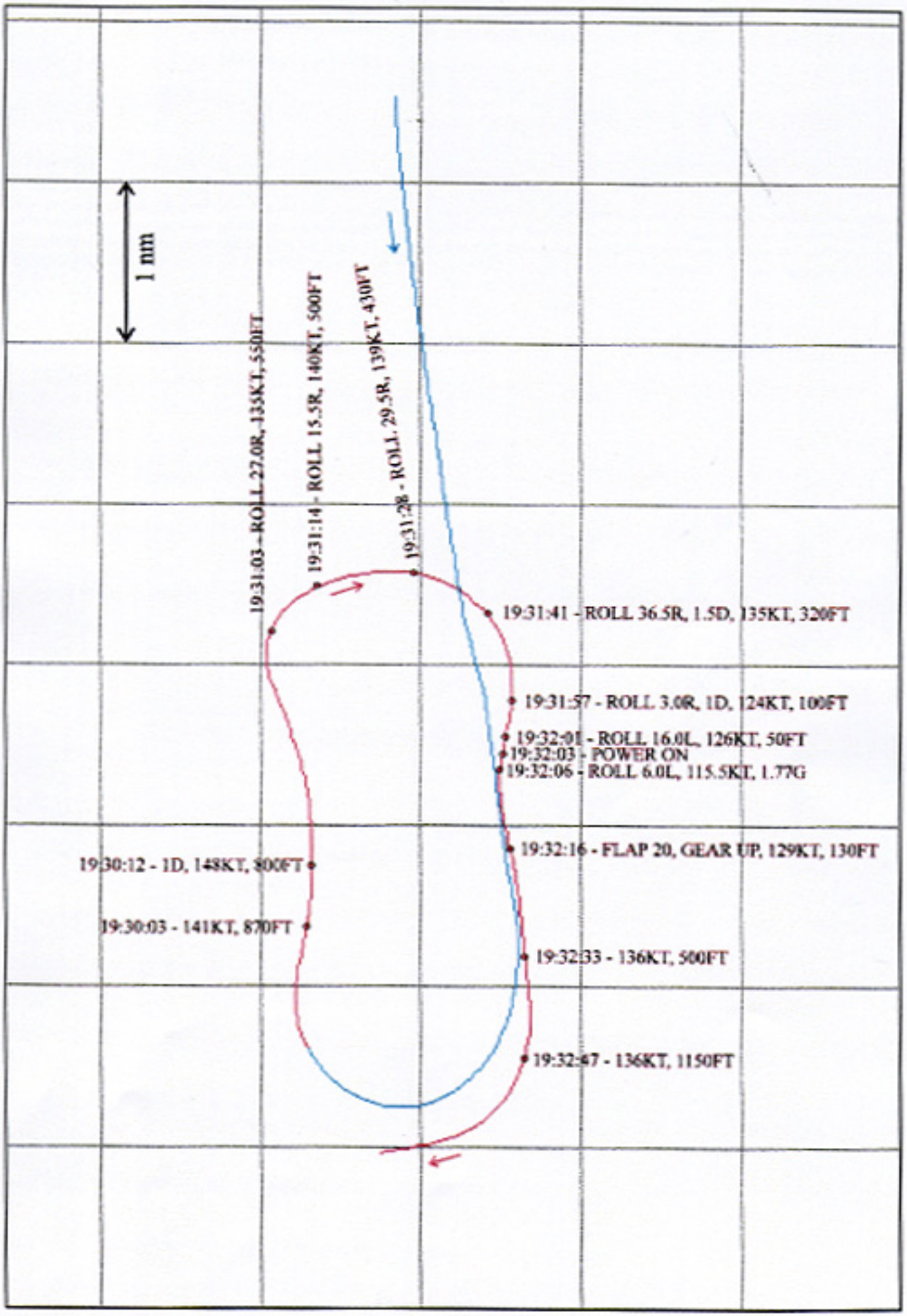
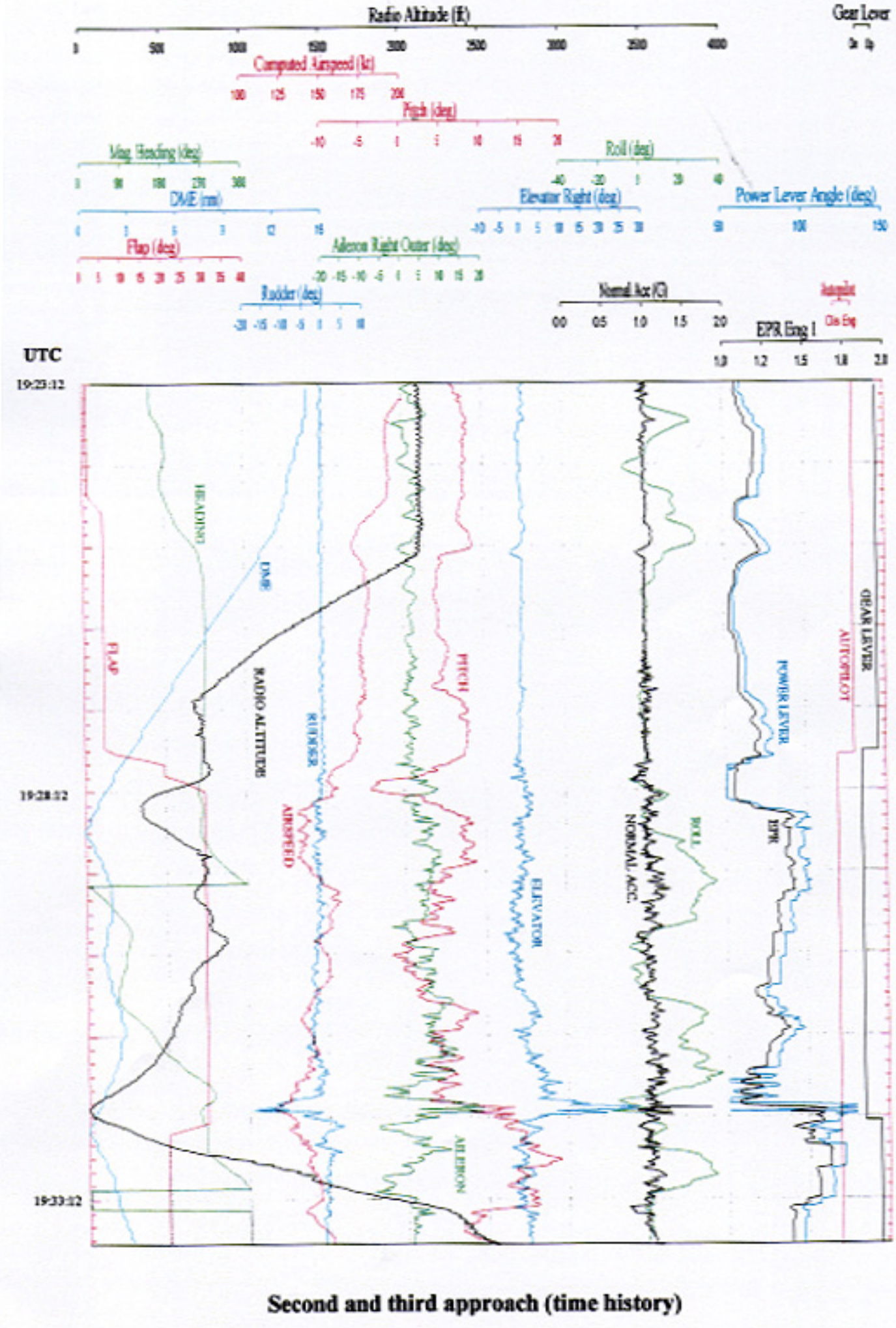
APPENDIX 5



Low level visual circuit (ground track)

APPENDIX 6



Second and third approach (time history)

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APPENDIX 8

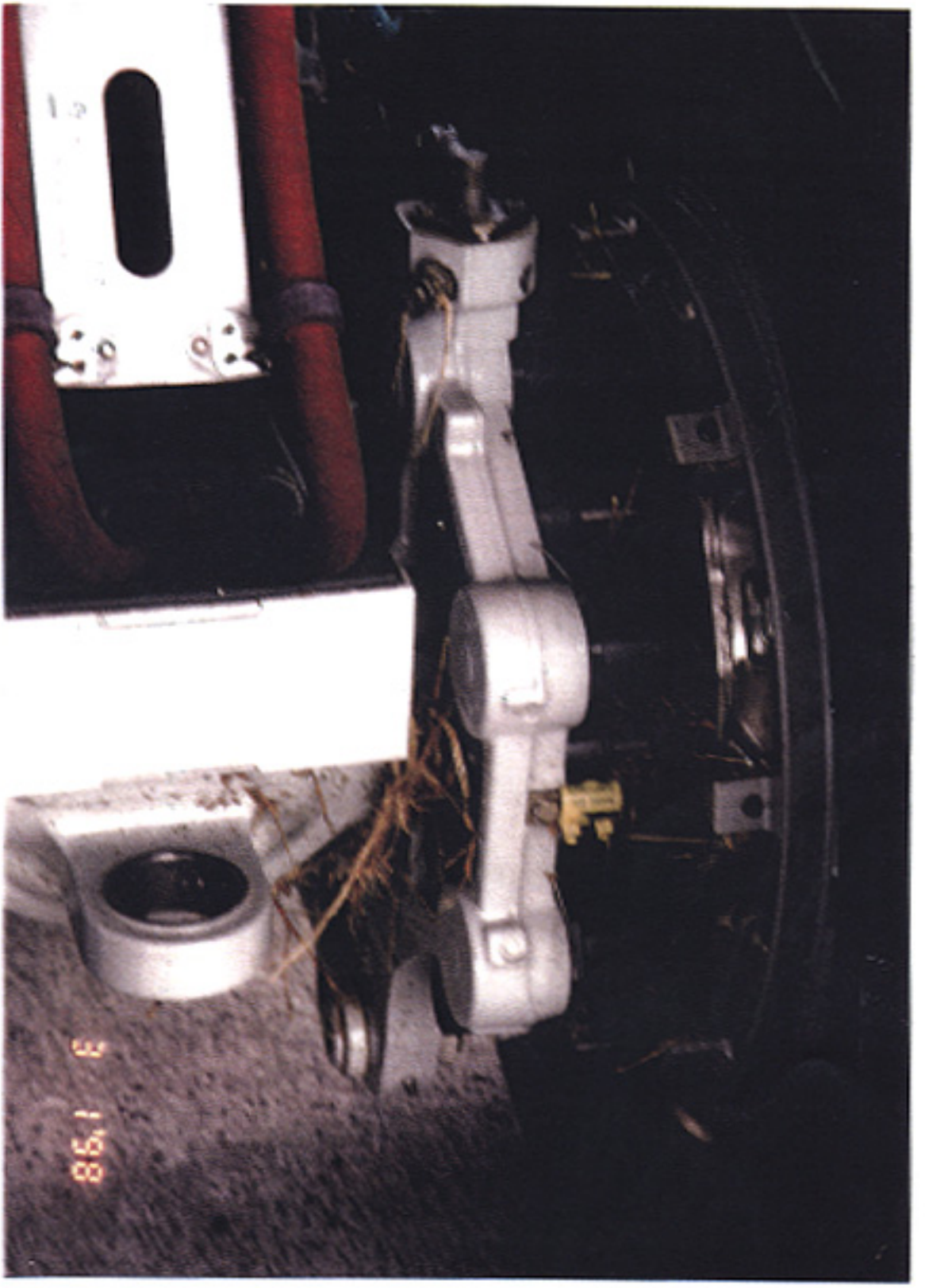

Figure 1 View of left main gear

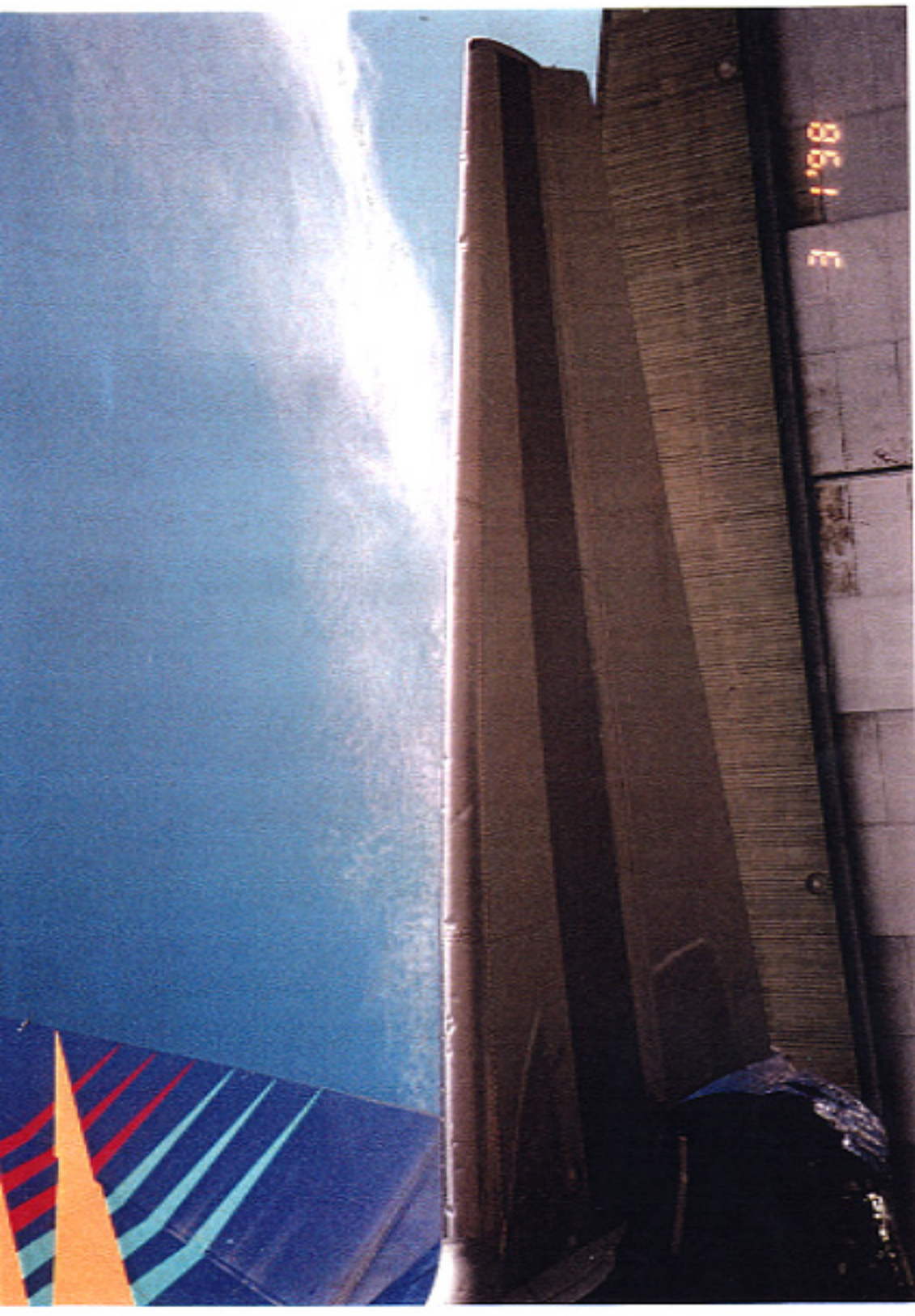

Figure 2 View of left horizontal stabiliser

Figure 3 View of damage to rear fuselage