Air Accident Investigation Unit Ireland

SERIOUS INCIDENT REPORT
Boeing 737-8AS, EI-DAI, Dublin Airport, Ireland 19 November 2009

Department of Transport Tourism and Sport
An Roinn Iompair Turasóireachta Agus Spóirt

AAIU Report No: 2011-007
State File No: IRL00909109
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In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Air Accidents, on 20 November 2009, appointed Mr. Paul Farrell as the Investigator-in-Charge to carry out a Field Investigation into this Serious Incident and prepare a Final Report. The sole purpose of this Investigation is the prevention of aviation Accidents and Incidents. It is not the purpose of the Investigation to apportion blame or liability.

Aircraft Type and Registration:	Boeing 737-8AS, EI-DAI
No. and Type of Engines:	2 x CFM 56-7B26
Aircraft Serial Number:	33547
Year of Manufacture:	2003
Date and Time (UTC):	19 November 2009 @ 12.45 hrs
Location:	Runway (RWY) 16 at Dublin Airport, Co. Dublin, Ireland (EIDW)
Type of Flight:	Scheduled passenger
Persons on Board:	Crew - 6 Passengers - 127
Injuries:	Crew - Nil Passengers - Nil
Nature of Damage:	Minor
Commander's Licence:	Airline Transport Pilot Licence (Aeroplane), issued by the Irish Aviation Authority (IAA)
Commander's Details:	Male, aged 44 years
Commander's Flying Experience:	9,480 hours, of which 4,730 were on type
Notification Source:	Operator
Information Source:	Air safety report submitted by the aircraft Commander. AAIU Field Investigation

SYNOPSIS

Conditions were blustery and during touchdown the aircraft rolled to the left and pitched nose down. The left engine nacelle scraped the runway surface. Damage was minor. There were no injuries and the crew did not realise that the nacelle had contacted the runway.

1. FACTUAL INFORMATION

1.1 History of the Flight

The aircraft was operating a scheduled flight from Rome's Ciampino airport (LIRA) to EIDW. The Commander informed the Investigation that weather at Dublin was forecast to be blustery during the day. The First Officer was the Pilot Flying and the Commander was the Pilot Monitoring.

On the leg to Dublin a full briefing was carried out including flap selection, runway length with regard to flap setting, the landing chart and windshear. At Dublin the aircraft joined the approach traffic sequence for landing. There was a strong wind from the southwest, which the Commander estimated as 70 kts at 3,000 ft. The Commander rechecked the limits after the control tower provided a wind report and concluded that it was within limits. Although conditions were blustery the Commander reported that the approach was normal given the conditions and the aircraft was configured ahead of normal and flown with plus 15 kts added due to wind[1]. At approx 300 ft the aircraft was slightly left of the localiser. The Commander called this out and the First Officer corrected it promptly. The Commander said that the approach was normal until approx 25 feet when the left wing dropped due to the wind. The Commander assisted the First Officer with a control input. According to the Commander's report the aircraft was now steady on profile and a flare was initiated; the aircraft did not seem to descend and at this point the Commander closed the thrust levers. Simultaneously, the left wing dropped again as the aircraft descended to the runway. The Commander said that the aircraft landed quite benignly albeit with the left wing low. The Commander reported that at no stage did he or First Officer suspect ground contact.

1.2 Subsequent Events

Subsequently, a different crew operated the aircraft on the next two sectors to and from Poland. On arrival back in Dublin this commander (for these Polish sectors) learned that a member of the public had reported the earlier nacelle scrape. He reported, *"No damage was visible from normal eye level and the crew of the inbound flight didn't report anything unusual"*. The event was reported to the AAIU on 20 November 2010, an Investigation was initiated and the aircraft was inspected. An area of 300 mm x 400 mm on the bottom of the left engine nacelle was found to exhibit evidence of ground contact, with some related, less significant damage aft of the main area of damage (see **Photo No. 1**). **Photo No. 2** shows the location of the damaged nacelle cowling on the aircraft.

1 **Landing Reference Speed** (VREF) for this configuration (gross weight 124,500 pounds approx.) was 136 kts. The selected airspeed data on final approach indicated that the crew was targeting 152 knots computed airspeed (VREF + 16).

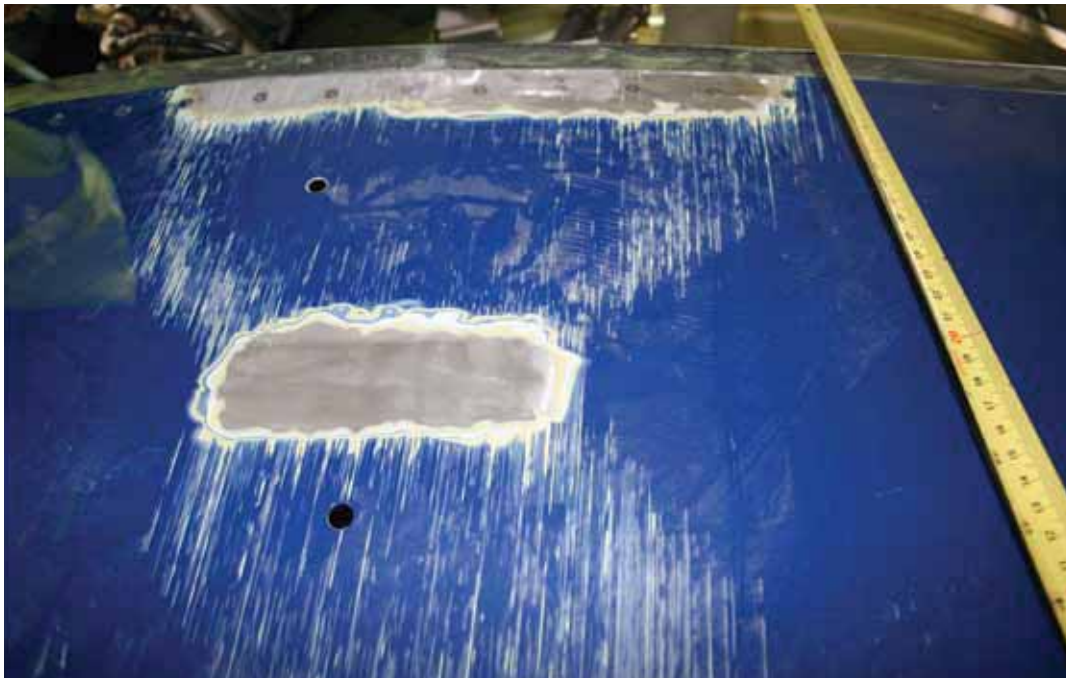


Photo No. 1: Engine nacelle damage

Photo No. 2: Location of nacelle on the aircraft

1.3 Recorded Data

The Operator only became aware of this event after the aircraft had operated two additional sectors and consequently it was not possible to retrieve the Cockpit Voice Recordings for the actual event.

The Flight Data Recorder (FDR) data was recovered and analysed. The data indicates that at 90 ft Radio Altitude (RA) the aircraft's roll attitude was 9 degrees to the right. Seven seconds later, at 30 ft RA, the aircraft's roll attitude was 10 degrees to the left. Two seconds later at 16 ft RA the aircraft's roll attitude was 6 degrees to the right. Finally, two seconds later, at touchdown, the aircraft's roll attitude was 12 degrees to the left. The aircraft landed on the left main gear first followed by the nose gear and the right main gear.

The data also shows that the autopilot was disconnected at about 400 ft RA. Significant use of the control wheel and rudder pedal inputs were in evidence after autopilot disconnection, increasing in magnitude closer to the point of touchdown. The data shows that at 150 ft the aircraft deviated one dot below the glideslope. The data also shows that no warning or caution for wind shear or pre-wind shear was recorded.

Just prior to landing there were significant rudder inputs and in the two seconds before the left gear contacts the ground the aircraft nose drops from 3.6 degrees nose-up to 1.7 degrees nose-down. The Ground Contact Angles – Normal Landing Chart, **Figure No. 1** (see **Section 1.7**), indicates that the pitch and roll at the point of touchdown were inside the ground contact limits as published by the aircraft manufacturer. While ground contact should not have been expected the chart shows that the risk of engine nacelle ground contact increases as aircraft pitch decreases. **Appendix A** shows a selection of recorded parameters from 300 ft (RA) to landing.

1.4 Meteorological Information

The actual weather reports (METARS) for EIDW issued before and after the event are as follows :
EIDW 191300Z 20026G36KT 180V240 9999 -RA FEW016 BKN021 BKN045 14/12 Q0992 WS RWY16 NOSIG

EIDW 191230Z 20025G41KT 9999 -RA FEW017 BKN023 BKN038 14/12 Q0992 NOSIG

It is noted that the later METAR reports that wind shear had been observed at EIDW.

Met Éireann provided the Investigation with a detailed report on the prevailing weather conditions at the time of the event. This report shows, inter alia, that the maximum gust recorded by the anemometer system at EIDW was 40 kts at approximately 12.45 hrs UTC (the time of the event).

The Operator's Operations Manual prescribes the method for calculation of cross winds as follows, *"To calculate the crosswind component to assess* ***crosswind limitation*** *use* ***ALL the steady wind plus half the gust value (..)*** *(not half the gust component)"*. Applying this algorithm to the METAR winds gives maximum cross winds of 20.5 kts at 12.30 hrs and 18 kts at 13.00 hrs. Given that the METARS indicate light rain the runway surface would have been wet. The Operator's Operations Manual stipulates a Crosswind Limitation of, *"Wet – 30 kts"*.

1.5 Guidance for Approach Stabilisation

The B737 Flight Crew Training Manual (FCTM) uses the Flight Safety Foundation's (FSF) published criteria for flying a stabilised approach. In relation to glide slope the guidance states, *"ILS approaches should be flown within one dot of the glide slope"*. The guidance also provides that, *"As the airplane crosses the runway threshold it should be: … on a stabilized flight path using normal manoeuvring"*. In relation to un-stabilised approaches the guidance states, *"An approach that becomes un-stabilised below 1,000 feet AFE in IMC or below 500 feet AFE in VMC requires an immediate go-around"*[2].

1.6 Landing Technique

The FCTM prescribes three techniques for crosswind landings; De-crab During Flare, Touchdown in Crab and Sideslip (Wing Low). Of these techniques only Sideslip (Wing Low) caters for the possibility of one main wheel touching down before the other wheels. The technique specifies that, *"Touchdown is accomplished with the upwind wheels touching just before the downwind wheels"*.

The technique description also contains a warning that, *"Overcontrolling must be avoided because overbanking could cause the engine nacelle or outboard wing flap to contact the runway"*. In this particular event, the downwind wheels touched down first, followed by the nose and the upwind wheels.

The Operator's B737 Flight Crew Operations Manual states that *"in crosswind landings the de-crab during flare and touch down with crab techniques are normally used"*. The data indicates that the crew had followed the De-crab During Flare technique.

1.7 Pitch and Roll Limit Conditions

The FCTM contains a Ground Contact Angles – Normal Landing Chart[3] that sets out the envelope of body roll and pitch attitudes for landing at which the aircraft structure contacts the ground, given certain assumptions. The maximum roll and pitch attitude data for the aircraft during the touchdown sequence, were 12 degrees roll left and 2 degrees pitch down. These values were plotted on the chart and the result is shown at **Figure No. 1**.

As can be seen from **Figure No. 1**, the data was marginally within the published structural ground contact envelope. However, it must be noted that the chart is predicated on certain assumptions e.g. a rigid wing, strut and tire compression for a static aircraft on-ground at maximum taxi weight (MTW), level ground surface, etc. Structural wing flexing due to dynamic landing and environmental loads, runway crown, as well as tyre pressure and landing gear strut pressure, mean that the ground contact envelope encountered during actual aircraft operations may be smaller than the envelope presented in the FCTM. In addition, data sample rates (for pitch and roll) during a highly dynamic landing may mask the absolute positions that were actually achieved.

2 **AFE:** Above Field Elevation

3 The chart presented in the FCTM, and reproduced here, represents one half of a symmetrical chart with the axis of symmetry at the zero degrees roll angle position. Thus, for a given pitch angle, plotting roll of –12 degrees or +12 degrees gives the same quantitative indication of ground contact possibility.

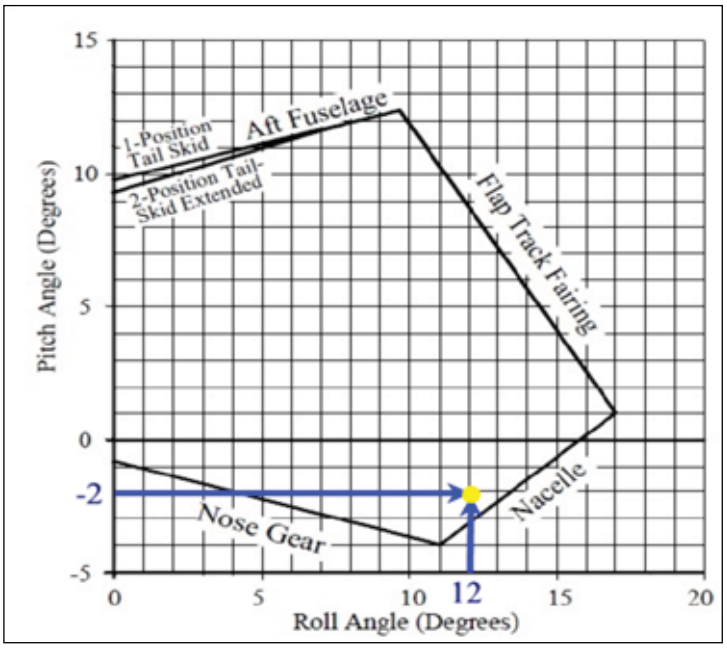


Figure No. 1: Pitch and roll limit chart for ground contact.

1.8 Walk-around Inspection

The Operator's procedures require that, before each flight, a pilot carries out a *"TRANSIT/ PREFLIGHT"* inspection and the Commander certifies this in the aircraft technical log. This check was carried out and certified in the aircraft technical log for each of the two legs that the incident aircraft subsequently flew. The first item on the inspection checklist states:-

"WALK AROUND AIRCRAFT, VISUALLY INSPECTING FROM GROUND WITH NO PANELS REMOVED, CHECK FOR DAMAGE TO INCLUDE CHECKING FOR EVIDENCE OF BIRDSTRIKE DAMAGE TO THE FUSELAGE AND ENGINES, DEFECTS, OBVIOUS SIGNS OF WEAR AND PANELS ARE SECURE AND LEAKS (WITH PARTICULAR ATTENTION TO LEAKS FROM THE TOILET SERVICE PANELS). CHECK ENGINE INTAKES AS VISIBLE FOR OBVIOUS DAMAGE."

The Investigation notes that the bottom surface of the engine nacelle is approximately 600 mm above the ground. Inspection can be accomplished from either side but does require the pilot either to squat low/kneel or to use an inspection mirror.

1.9 Crew Records

The training records and licence details for the event crew and the crew that subsequently operated the aircraft were provided by the Operator and the Investigation found no anomalies.

2. ANALYSIS

2.1 The Approach

The approach was carried out in blustery conditions, but within the Operator's crosswind limitations. The aircraft slightly exceeded one dot below the glideslope at 150 ft RA. This does not necessarily mean that the approach was unstabilised. However, it is noted that at 30 ft, the aircraft's roll attitude was 10 degrees to the left and two seconds later at 16 ft the aircraft's roll attitude was 6 degrees to the right; this indicates a roll rate of 8 degrees per second within 20 ft approximately of the runway surface. Similarly, the rolling of the aircraft from 6 degrees right at 16 ft to 12 degrees left at landing indicates a roll rate of 9 degrees per second, down to the runway surface. Also, from the 30ft/10 degrees left roll position the data shows significant, continuously changing, rudder pedal inputs and rudder movement. Considering the nature of this manoeuvring close to the ground, in accordance with the Operator's published stabilised approach guidance, the option to go-around should have been chosen.

2.2 Landing Gear Ground Contact Sequence

The aircraft landed first on the left main gear, followed by the nose gear and then the right main gear. This touch down sequence does not correspond with any of the FCTM prescribed crosswind landing techniques. Failure to land on the two main gears before touching down on the nose gear increases the side loading on the nose gear and may result in damage. A factor that contributed to this incorrect landing sequence was dropping the aircraft's nose from 3.6 degrees nose up to 1.7 degrees nose down in the 2 seconds before the left main gear contacted the ground.

2.3 Unreported and Undetected Nacelle Damage

The Crew did not notice the nacelle scrape and consequently it was not reported/recorded in the Technical Log. The damage to the engine nacelle was not detected during either of the pre-flight inspections conducted before the next two sectors. The bottom surface of the engine nacelle is approximately 600 mm above the ground. Although inspection can be accomplished from either side it requires the pilot either to squat low/kneel or to use an inspection mirror. However, the Investigation notes that the pre-flight inspection checklist does not specifically require checking of the bottom of the engine nacelle. As the engine nacelle is quite low to the ground it would be prudent to inspect it closely on a walk around inspection, especially after the aircraft has been operated in gusty or turbulent conditions.

2.4 Ground Contact Angles – Normal Landing Chart

The FCTM Ground Contact Angles – Normal Landing Chart is predicated on certain assumptions e.g. a rigid wing. Structural wing flexing due to dynamic landing and environmental loads, as well as tyre pressure and landing gear strut pressure, mean that the ground contact envelope encountered during actual aircraft operations may be smaller than the ideal presented in the FCTM. The FCTM does not make it clear that the pitch and roll combinations within the published envelope of the Ground Contact Angles – Normal Landing Chart can result in aircraft structure contacting the ground due to dynamic landing loads.

3. CONCLUSIONS

(a) Findings

1. The approach was made in blustery conditions, but within the Operator's crosswind limitations.
2. The aircraft landed on the left main gear first followed by the nose gear and the right main gear.
3. The aircraft nose dropped from 3.6 degrees nose up to 1.7 degrees nose down in the 2 seconds before the left main gear contacted the ground.
4. The Investigation considers that, due to the nature of the aircraft manoeuvring close to the ground, a go-around should have been conducted.
5. The crew was not aware that the left engine nacelle had contacted the runway and did not record it in the technical log.
6. The crew who operated the two subsequent legs was unaware that the engine nacelle had contacted the ground and the nacelle damage resulting from the ground contact was not detected during two subsequent pre-flight inspections.
7. The pre-flight inspection checklist did not specifically require checking of the bottom of engine nacelles for evidence of ground contact.
8. The bottom of the engine nacelle is 600 mm above the ground and susceptible to ground contact damage during a one-wing-low, nose low landing.
9. The FCTM Ground Contact Angles – Normal Landing Chart does not make it clear that pitch and roll combinations within the published envelope can result in aircraft structure contacting the ground due to dynamic landing loads on structural wing flexing, strut and tyre compression, and runway crown.

(b) Probable Cause

Rolling of the aircraft to 12 degrees left with inappropriate aircraft pitch attitude, at the moment of touch down.

(c) Contributory Factor

Continuing an approach which required significant manoeuvring and control inputs close to the ground.

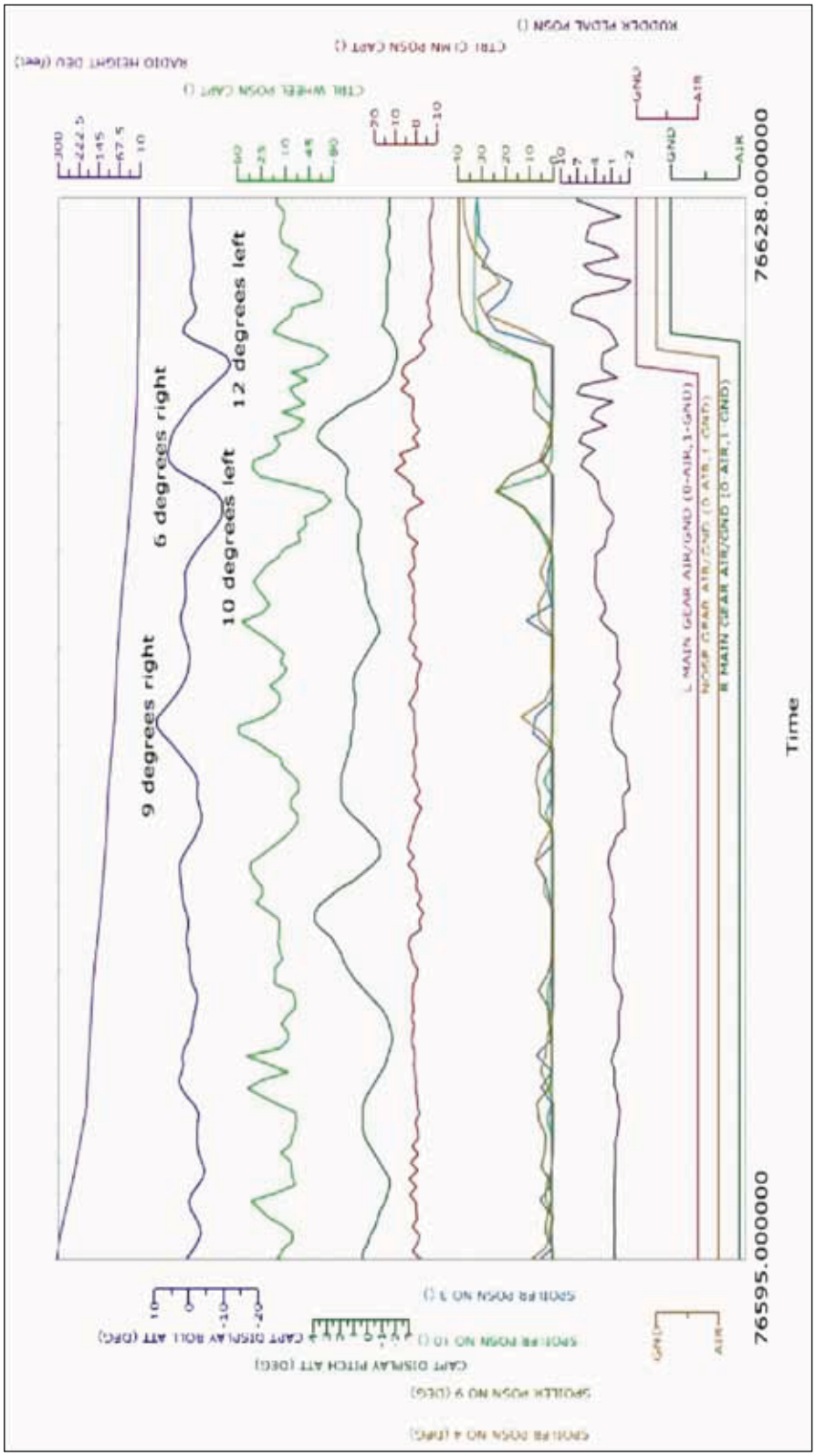
4. SAFETY RECOMMENDATIONS

It is recommended that:

1. The Boeing Aircraft Company should amend the Transit/Pre-flight inspection checklist to specifically require checking of the lower surfaces of engine nacelles for evidence of ground contact. **(IRLD2011005)**
2. The Boeing Aircraft Company should revise the FCTM to advise operators that pitch and roll combinations within the published envelope on the Ground Contact Angles – Normal Landing Chart, can still result in aircraft structure contacting the ground due to the effects of dynamic landing loads on the assumptions used. **(IRLD2011006)**
3. Ryanair Ltd. should conduct a safety awareness programme to communicate to flight crew the threat of engine nacelle ground contact when landing in difficult wind conditions. **(IRLD2011007)**

APPENDIX A

Plot of selected parameters



- END -

In accordance with Annex 13 to the International Civil Aviation Organisation Convention, Council Directive 94/56/EC, and Statutory Instrument No. 205 of 1997, AIR NAVIGATION (NOTIFICATION AND INVESTIGATION OF ACCIDENTS AND INCIDENTS) REGULATION, 1997, the sole purpose of these investigations is to prevent aviation accidents and serious incidents. It is not the purpose of any such accident investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

NOTE: S.I. 205 of 1997 is superseded by S.I. 460 of 2009 as of the 9 December 2009. Investigations undertaken after 9 December 2009 are subject to the provisions of S.I. 460 of 2009

Produced by the Air Accident Investigation Unit

AAIU Reports are available on the internet www.aaiu.ie

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