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REPORT
ACCIDENT

Hard landing, inappropriate stopover maintenance procedure, take-off with a substantially damaged aeroplane

Aircraft	Airbus A330-211 registered F-GZCB
Date and time	13 April 2011 at 18 h 25[(1)]
Operator	Air France
Place	Caracas-Maiquetía Simón Bolívar Airport (Venezuela)
Type of flight	Scheduled international public transport of passengers
Persons on board	Captain (PF), copilot (PNF), copilot (relief), 10 cabin crew, 202 passengers
Consequences and damage	Aeroplane substantially damaged

(1) Unless otherwise indicated, the times given in this report are expressed in universal coordinated time (UTC). Four hours and thirty minutes should be subtracted to obtain the local time in Caracas.

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.

1 - HISTORY OF FLIGHT

The following elements come from data recorded on the QAR and interviews. The cockpit voice recorder (CVR) was no longer available.

1.1 Paris - Caracas Flight

On 13 April 2011, at 8 h 55, the crew took off from Paris Charles de Gaulle airport bound for Caracas (Venezuela).

The presence of several storm cells, rain and tailwind on the flight path was mentioned during the arrival briefing carried out fifteen minutes before descent. ATIS data was not available.

The captain was PF. He was cleared for an ILS approach ILS to runway 10. The approach air traffic control service regulated the traffic with radar. The approach was carried out outside the clouds visible on the on-board radar.

The start of the approach was carried out with autopilot and A/THR engaged.

The aeroplane was lined up on the localizer 10 NM from the threshold and intercepted the glide path at 6 NM.

The crew selected a speed of 136 kt, which corresponded to the Vapp approach speed.

A few moments later, autopilot and A/THR were disengaged and the slat and flap selector was positioned on "FULL".

On first radio contact with the control tower, the controller replied "Roger, wind zero six zero ten knots, report on short final, windshear on final one mile".

(2)AAL: Above Aerodrome Level.

(3)MCC: Maintenance Coordination Centre.

Descending through 1,000 ft AAL(2), the crew saw the runway. The vertical speed was about - 950 ft/min. Pitch attitude was - 0.4° and bank angle was 3° to the right. The displayed speed (CAS) was 153 kt (Vapp + 17 kt), gradually decreasing until reaching the approach speed.

Shortly before descending through 500 ft AAL, deviations were called out by the PNF and corrected by the PF. Specifically, when the bank angle reached 9° to the left, the captain's sidestick was moved to the right stop. Similarly, at a height of 200 ft, the PF thought they were above the glide path. The PNF called out a speed deviation, the CAS changed quickly from 138 kt to 153 kt (Vapp+17 kt). The PF corrected and targeted a touchdown on the aiming point.

He made two pitch-down inputs and the thrust levers were gradually pushed back (until the landing). The pitch attitude became slightly negative and the vertical speed increased.

At a height of 50 ft, the PF applied a sustained pitch-up input and the pitch attitude increased. The CAS was 136 kt and decreasing. At about 35 ft, a GPWS "Sink Rate" warning was triggered.

The aeroplane landed at 18 h 55 min 25 with a pitch attitude of 5°. The normal acceleration recorded was then 2.74 g and the computed vertical speed was about - 1,200 ft/min.

There was no windshear warning.

1.2 Operations during the Stopover

The captain noted the hard landing in the aircraft's technical log (ATL).

The Air France stopover technical team implemented a technical data sheet specific to hard landings, contained in the on-board documentation. This team stated that during these operations no R15 report (Load Report automatically generated and sent to the MCC(3) in the event of a hard landing) corresponded to this landing.

The summary of the data received meant that the mechanics decided that no in-depth checking was necessary; the return to service approval was signed.

1.3 Caracas - Paris Flight

The relief crew took command of the aeroplane. The walk-around inspection, carried out by the PNF, accompanied by a stopover technician, did not lead to any specific observations.

At about 23 h 00, the crew took off for Paris Charles de Gaulle. At the beginning of the initial climb, the crew was unable to retract the landing gear. Several warnings linked to the cabin air conditioning were triggered and displayed on the ECAM. The captain decided to return to land back at Caracas. After using up the excess fuel, the crew landed at a weight close to that of the certified maximum.

On the apron, considerable damage was observed on the right landing gear and on the fuselage.

2 - ADDITIONAL INFORMATION

2.1 The Aeroplane's Flight Path

2.1.1 Flight path deviations

The operator's procedures require the PNF to call out any deviations to the PF on final particularly when:

- The speed exceeds the target speed by 10 kt, or
- The pitch attitude is less than 0°, or
- The bank angle exceeds 7°, or
- Vertical speed exceeds 1,000 ft/min in descent
- The deviation in LOC is ¼ point or more, or
- That of the GLIDE is 1 point or more.

The appropriate response by the PF is:

- To read back the PNF's deviation call-outs;
- To take suitable corrective actions in order to bring the parameters back to within the range of values that comply with the defined stabilisation conditions;
- To assess if the conditions for stabilisation will be sufficiently restored before landing, and initiate a go-around if necessary.

They also ensured that in the event of clear destabilisation below the stabilisation ceiling, that is to say 500 ft in VMC, a go-around or a missed landing should be performed (GENOPS 02.04.05).

On short final, below the stabilisation ceiling, several deviations destabilising the approach were recorded. In particular:

- At a radio altimeter height of 350 ft, the vertical speed was above 1,000 ft/min for two seconds;
- At a radio altimeter height of 310 ft, the speed exceeded the Vapp by more than 10 kt for four seconds;
- At a radio altimeter height of 300 ft, the slope exceeded 7° for 2 seconds;
- At a radio altimeter height of 175 ft, the glide deviation was more than one point for less than two seconds.

According to the crew interviews, these deviations were called out by the PNF in accordance with airline procedures. The FDR data showed that they had been corrected by the PF, each time correctly.

The SINK RATE warning was triggered while the aeroplane was at a radio altitude height of 35 ft and stopped after compression of the main landing gear.

The crew did not perform a go-around or a missed landing procedure.

2.1.2 The influence of the wind

The manufacturer modelled winds that indicated that the aeroplane had encountered considerable deviations in the wind's vertical, lateral and longitudinal components.

The average wind was a tail wind during the greater part of the approach. It changed direction about fifteen seconds before the wheels touched down, changing successively from a tailwind to a headwind (7 kt) then back to a tailwind (10 kt).

At the same time, the aeroplane was subject to the impact of a cross wind, changing from a left cross wind (10 kt) to a right cross wind (10 kt) in ten seconds and downdraughts (7 kt) and up-draughts (6 kt).

2.1.3 Protections and warnings

During final, the Windshear warning was not triggered because the criteria taken into account to generate it had not been met.

Windshear detection is based on the estimation of a defined severity factor like the wind's contribution to the variation in the total energy of the aeroplane in flight. It should be noted that this warning is inhibited below 50 ft.

The information on the vertical acceleration suffered on landing appears systematically on the PFD but does not remain displayed. Pilots are therefore unable to confirm it without referring to the R15 report.

2.1.4 Use of A/THR

The PF did not use A/THR for the final approach.

Since the beginning of 2012, Air France stated that awareness-raising actions for instructors and crew on the use of A/THR were in progress to remind them that it must be favoured when more crew availability was required.

2.2 Maintenance Operations in Caracas

Reception of the aeroplane from Paris was carried out by a handling company as the Air France station technical team was busy preparing another aeroplane. The captain had no direct contact with the technical team.

The captain noted a hard landing in the ATL: "HARD LANDING ON ARRIVAL". He met the station manager who had in addition heard some of the passengers' remarks on the hard landing and informed him that there was an inspection of the aeroplane to perform.

Shortly afterwards, one of the airline's two technicians performed an external inspection of the aeroplane in very heavy rain and in poor light. He then received verbal information from the station manager relating to the hard landing indicated by the captain. He then read the note in the ATL.

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The technician applied the technical data sheet (31-032) dealing with hard landings, contained in the on-board documentation. He looked in particular in the ACMS[4] for an R15 report. He found two dated 16 and 21 March 2011, but none for 13 April.

This report is automatically generated when criteria based on the acceleration and vertical speed parameters are met[5]

The technician then contacted the MCC (at CDG) to check if such a report had been received. The MCC stated that they had received no R15 report relating to this flight.

At the station technician's request the MCC checked the operation of the DMU[6] by looking for other reports issued during the flight and stated that the messages had been received, the last one being an R02 report dated 13 April at 12 h 10.

The PFR[7] contains no failure message relating to a landing gear problem. In compliance with the technical data sheet used, given the absence of an R15 report and the reported smooth running of the DMU, no inspection was required. The technician mentioned this in the ATL.

He then completed inspection of the aeroplane and took advantage of an improvement in the meteorological conditions to again carry out an inspection limited to the landing gear.

No anomaly was detected at the level of the shock absorbers. He left the parking area. The second technician arrived on site without meeting his colleague and carried out an external inspection without reporting any anomaly. Both technicians finished the inspection of the aeroplane together and the APRS was signed.

[4] ACMS : Aircraft Condition Monitoring System.

[5] These criteria were encountered in the case of the aeroplane's first landing in Caracas.

[6] DMU : Data Management Unit.

[7] PFR : Post Flight Report : maintenance messages generated at the end of the flight.

2.3 Technical Documentation

The AMM 05-51-11 PB 601 describes the maintenance actions to be carried out in the event of hard landing mentioned by the crew. The analytic approach shows how to use the information provided by the R15 report. However, the absence of the R15 report is not provided for. This may result in an erroneous reading and therefore an absence of inspection before the re-entry into service of the aeroplane. In addition, the A330's AMM, contrary to that of the A320, does not present any Inspection Flow Charts that summarise the maintenance actions to be carried out when a hard landing is reported. The existing overview (05-51-11 PB601, p 37 "load report 15 flow chart") was only applicable to the implementation of the R15.

The AMM was not used by the Caracas technical team.

Two Air France technical data sheets, referring to the AMM, describing the maintenance actions to carry out after a hard landing: one (n° 31-032 in June 2008), integrated into the on-board documentation, was used by the Caracas maintenance team and the other (n° 05-0001 February 2011) was in place at the MCC. They include an explanatory overview of the processes to apply (flowchart). The logic described does not correspond however to the chapter dedicated to the AMM:

- The aeroplane's technical data sheet requires, in the absence of the R15 report, the DMU to be checked. If smooth operation is noted, then no inspection is required.
- The MCC technical data sheet requires checking the presence of a "Normal Landing" report in the ACMS. If it is present, there is no inspection to carry out. If it is absent, it is necessary to take out the maintenance recorder (QAR or DAR) and to read it out as soon as it reaches base;

The "Normal Landing" report generating function was not installed on this aeroplane.

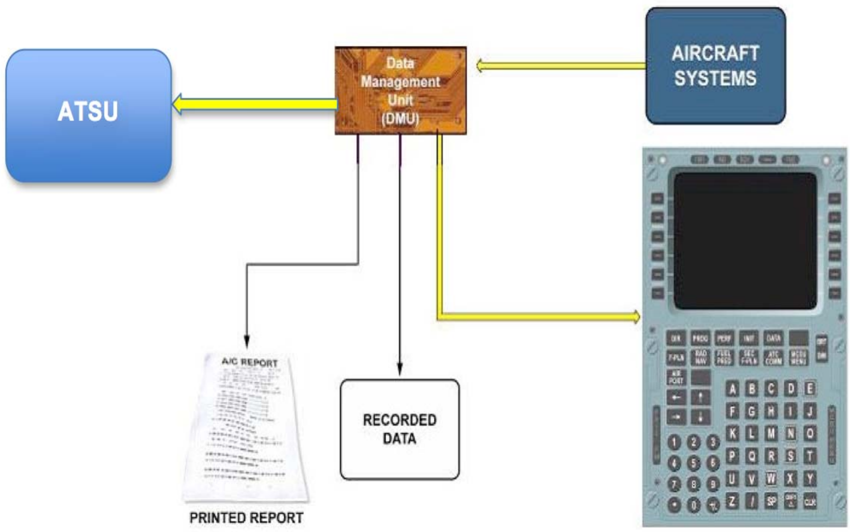
2.4 Examination of the DMU

The DMU is part of the flight data management system (ACMS). One of its functions is to record data from the aeroplane systems and to generate reports according to criteria defined by the manufacturer and the operator. The reports are mainly recorded on a non-volatile memory device in the DMU. They can be consulted via the ACMS menu on the MCDU[8]. In the airline configuration, these maintenance messages are also sent to a ground station, via the ACARS system[9] integrated into the ATSU[10]. ACARS messages are transmitted as a priority by VHF or, if this is unavailable, by satellite. During the outbound Paris - Caracas flight, ACARS messages were received by the MCC, from the start to the end of the flight. The last report (R02 - Cruise performance) generated during this flight, issued and received was dated 13 April at 12 h 10 min 28.

[8]Master Control Display Unit.

[9]Aircraft Communication Addressing and Reporting System.

[10] Air Traffic Service Unit.



On 13 April, no R15 report relating to the hard landing had been received by the MCC. The last R15 found via the MCDU was dated 21 March 2011. An R15, generated by the DMU on 13 April, at 18 h 55 min 26 had been sent on 14 April at 21 h 14 min 02, or the day after the Paris - Caracas flight, at the beginning of the breakdown action. It is likely that the R15 associated with the last flight was not available at the time of the technicians' operations.

Two malfunctions occurred during these flights:

- The DMU did not issue a R15 report immediately after the hard landing, yet the conditions to generate it were met;
- No R15 report associated with the last flight was available on the page of the ACMS menu of the MCDU.

The DMU was examined at the manufacturer's and the equipment supplier.

The first malfunction was a problem that is recognised and documented by the equipment supplier and the manufacturer. This phenomenon, called DMU Lock Up(11), may lead to the following effects:

(11)No information indicates a DMU Lock Up on the ECAM.

- loss of ACMS menu on the MCDU;
- loss of the report generating function (including R15);
- loss of communication between the DMU and the MCDU;
- loss of communication between the DMU and the ATSU that prevents any report generated by the DMU being sent via the ATSU and ACARS;
- loss of data recorded in the DAR.

Further examinations did not make it possible to identify the causes of the second malfunction.

2.5 Examination of the landing gear fixed piston

The landing gear was examined in two stages. The first examination carried out in an approved workshop enabled the absence of hydraulic fluid to be noted as well as internal fractures on the body of the fixed unit (Upper Piston). Further examinations, including in particular the characterisation of the fractures, were carried out at the manufacturer's. The examinations showed that the fractures were the result of abnormally high stress.

The incipient failure did not show any pre-weakening. Its characteristic fracture surfaces indicated that it was sudden. However the presence of an end mark was noted about twenty centimetres from the source of the fracture, indicating the development and propagation of the crack in two stages.

This mark corresponded to the end of the cracking during the immobilisation of the aeroplane on the tarmac, on arrival of the flight from Paris.

The final fracture was a result of deterioration of the landing gear which may have occurred either during taxiing to take-off on the return flight or during landing of the same flight.

The violent impact of the landing gear during the hard landing caused an excessive local increase in the damping hydraulic pressure in the lower part of the mechanism leading to constraints greater than the materials' resistance. There was excessive compression of the static piston, subsequently limiting its movement. This damage prevented the full operation of the landing gear retraction sequence.

In the situation described above, it appeared that the damping fluids and pressure were still contained in the damper at the time of the external inspection. Despite the internal damage to the right landing gear, the lower section of the chrome piston was visible. The position and attitude of the aeroplane on the tarmac therefore appeared normal.

No previous landing gear operation failure had been noted.

2.6 Crew experience

- The captain (PF) had a total of 12,921 flying hours, including 1,122 on type. He had landed six times at Caracas.
- The copilot (PNF) had a total of 6,319 flying hours, including 922 on type. He had landed six times at Caracas.
- The reserve pilot a total of 5,944 flying hours, including 1,186 on type. He had landed three times at Caracas.

3 - LESSONS LEARNED AND CONCLUSION

3.1 Decision to Continue the Approach

During the landing at Caracas, the aeroplane was subjected to a number of variations in wind direction and strength. In these conditions, in manual flight and without the A/THR engaged, the PF was confronted with a considerable work load. The trajectory deviations called out by the PNF generated trajectory corrections by the PF. These corrections were considered adequate by the crew and they decided to continue the landing.

The approach was no longer stabilised below 500 ft despite reducing the deviations called out. Just before landing, changes in wind direction, combined with the PF's pitch-down input, caused an increase in the vertical speed. The absence of thrust adjustment led to a reduction in speed (CAS).

3.2 Inspection of Damage

On arrival of the first flight, the internal damage to the landing gear was not visible from the outside. The level of chrome apparent at the bottom of the damper mobile piston was not enough to attract the technical team's attention or the crew's. It is likely that the destruction of the damper continued during the return flight: during taxiing on an uneven surface, or on rotation on take-off at a heavy weight, or landing close to the maximum weight authorised, or even a combination of these.

In the reported visibility conditions (poor light, heavy rain), the damage to the airframe was difficult to detect. However, application of the procedures set out in the AMM in the event of a hard landing, guaranteeing the aeroplane's airworthiness, would have made it possible to note the damage and to undertake in-depth checks. The latter were not carried out by the technical team, misled by an inappropriate technical data sheet in the on-board documentation.

The absence of analysis of the parameters recorded on the QAR and/or DFDR led to an erroneous final diagnosis then to the re-entry into service of a substantially damaged aeroplane.

A technical data sheet cannot be used as a support for carrying out maintenance tasks: it is an assistance document which should not replace the AMM. It must be considered as a non-permanent document and a checking process must ensure a review of these notes.

Technical data sheets are not subject to specific audits and are not part of the regulatory documents managed by the airline's continuing airworthiness system and monitored by OSAC. They may however be sample checked during monitoring audits carried out by the OSAC, the French organisation for civil aviation safety (as during maintenance activity audits, for example).

Following this accident, the airline revoked the aforementioned two technical data sheets.

The AMM does not explicitly allow for the absence of the R15 report, and this could lead to erroneous understanding of maintenance actions to be carried out.

3.3 Absence of Issue of R15 Report

An internal problem in the DMU led to the loss of communication between the equipment and the aeroplane's information transmission system. This malfunction, already identified by the equipment supplier, blocked dispatch of the R15 report. The data were not displayed on the page dedicated to the MCDU. The technical team on the stopover did not have access to the stored data. The investigation was not able to identify the causes preventing the display of the report on the dedicated MCDU page and its dispatch by ACARS.

3.4 Causes

The hard landing was due to the continuation of the landing although the trajectory deviations should have led to a go-around. The work load generated by piloting without A/THR assistance, in degraded meteorological conditions was a contributing factor.

This hard landing caused the implosion, undetectable on the ground during the stopover, of the right landing gear damper fixed piston. This made landing gear retraction impossible during the return flight.

The use of the operator's inadequate technical data sheets in effect on the day of the event and the absence of R15 report issue meant that the damage caused by the hard landing was not detected. This led to the departure of a commercial flight with a substantially damaged aeroplane.

4 - SAFETY RECOMMENDATIONS

Note: In accordance with Article 17.3 of European Regulation (EU) 996/2010 of the European Parliament and Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation shall in no case create a presumption of blame or liability for an accident, a serious incident or an incident. The addressee of a safety recommendation shall inform the safety investigation authority which issued the recommendation of the actions taken or under consideration, under the conditions described in Article 18 of the aforementioned Regulation.

Maintenance procedures in the event of a hard landing

The investigation showed that the operator used inappropriate technical data sheets, replacing the manufacturer's AMM. Following this accident, the operator revoked these two technical data sheets.

In addition, the AMM chapter dedicated to hard landings does not explicitly take into account the absence of an R15 report. This may lead the reader to a biased diagnosis and an unsuitable maintenance action. Unlike the A320 AMM, for example, (figure 602/ TASK 05-51-11-991-016), there is no Inspection Flow Chart to help technicians. This may lead to the departure of a commercial flight with a substantially damaged aeroplane.

Consequently, the BEA recommends that:

- **Airbus ensure that the chapters in the AMM relating to hard landings of aeroplanes equipped with the "Hard landing" report generation function take into consideration the absence of R15 reports, specifically by integrating flow charts useful to establishing a diagnosis. [Recommandation FRAN-2013-062]**