CIAIAC

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Report IN-013/2011

Incident occurred on 20 April 2011, involving an Airbus A-320-211 aircraft, registration number EC-GRH, operated by Vueling, at Seville Airport (Seville-Spain)

GOBIERNO DE ESPAÑA

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COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

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Foreword

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident object of the investigation, and its probable causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) n.º 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1, 4 and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

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Abbreviations

00°	Degree
AC	Alternating Current
ACARS	Aircraft Communication adressing and reporting system
ACC	Area Control Centre
AEMET	National Meteorological Agency («Agencia Estatal de Meteorología»)
AESA	National Air Safety Agency («Agencia Estatal de Seguridad Aérea»)
AFFF	Aqueous Film Forming Foam
AGL	Above ground level
AMM	Aicraft Maintenance Manual
APP	Approach control office
APU	Auxiliary Power Unit
ATC	Air Traffic Control
ATEC	Automatic Test Equipment Complex
ATHR	Autothrust
A/P	Auto Pilot
A/T	Auto Thrust
ATPL (A)	Airline transport pilot licence
BCN	IATA Code for Barcelona airport (Spain)
BEA	French accident investigation authority («Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile»)
BITE	Built-In Test Equipment
BSCU	Brake and Steering Control Unit
CAA	Civil Aviation Authority
CAS	Calibrated airspeed
CECOA	Airport Operations Control Center
CFDIU	Centralized Fault Display Interface Unit
CIAIAC	Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (Spanish AIB)
CMM	Component Maintenance Manual
CPL (A)	Commercial pilot's licence
CRM	Crew Resource Management
CSD	Constant speed drive
CVR	Cockpit Voice Recorder
DAR	Data Access Recorder
DC	Direct Current
DC	Distribution Circuit
DGAC	Directorate General of Civil Aviation («Dirección General de Aviación Civil»)
DME	Distance Measurement equipment
DOW	Dedweight
ECAM	Electronic Centralized Aircraft Monitoring
EPGS	Electrical Power Generation System
ESPM	Electrical Standard Practices Manual
FCOM	Flight Crew Operating Manual
FD	Flight Director
FIR	Flight Information Region
FL	Flight level
FLOW	Flow control center
ft	Foot
GCU	Generator Control Unit
GEN	Generator
GND/LCL	Ground/Local
GS	Ground speed
h	Hour(s)
HCU	Hydraulic Control Unit
hPa	Hectopascal(s)
ICAO	International Civil Aviation Organization
IDG	Integrated Drive Generator

Abbreviations

ILS	Instruments Landing System
JAR-FCL	Joint Aviation Regulations – Flight Crew Licenses
kg	Kilogram(s)
km	Kilometre(s)
kt	Knot(s)
LAW	Estimated landing weight
LDG	Landing
LECSAPN	Seville control Centre-north approach sector
LEZL	IACO code for Seville airport (Spain)
LGCIU	Landing Gear Control and Interface Unit
LGCL	Landing Gear Control Lever
LH	Left Hand
LT	Local Time
LVDT	Linear Variable Differential Transducer
L/G	Landing Gear
m	Metre(s)
m/s	Metres per seconds
MEL	Minimum equipment list
METAR	Normal aerodrome weather report
MHz	Megahertz
MLG	Main Landing Gear
MLW	Maximum landing weight
mm	Millimetre(s)
MTOW	Maximum take-off weight
N/A	Not applicable
NLG	Nose Landing Gear
NTSB	National Transportation Safety Board
NWS	Nose Landing Gear Steering
OEB	Operating Engineering Bulletins
P/N	Part Number
PF	Pilot Flying
PFD	Primary Flight Display
PFR	Post Flight Report
PNF	Pilot Not Flying
PWR	Power
QNH	Adjustment of pressure scale such that during take-off and landing the altimeter indicates the height above sea level of the airport.
QRH	Quick Reference Handbook
RAT	Ram Air Turbine
RH	Right Hand
RVDT	Rotary Variable Differential Transducer
RWY	Runway
S/N	Serial Number
SEI	Seville airport Firefighting and Rescue service
SSFDR	Solid State Flight Data Recorder
SVQ	IATA code for Seville airport (Spain)
TCU	Terminal Control Unit
TLB	Technical Log Book
TOW	Take-off weight
TR	Transformer – Rectifier
TSM	Trouble Shooting Manual
TWR	Aerodrome Control Tower
UIR	Upper Information Region
UTC	Coordinated Universal Time
V	Volt(s)

Synopsis

Owner and operator:	VUELING
Aircraft:	Airbus A-320-211, registration EC-GRH
Date and time of accident:	Wednesday, 4 April 2011; at 20:50 hours[1]
Place of accident:	Seville Airport (Seville – Spain)
Persons onboard:	157; 7 crew members and 150 passengers. No injuries reported
Type of flight:	Commercial Air Transport – Scheduled – Domestic – Passenger
Flight phase:	Landing
Date of approval:	27 May 2015

Summary of accident

On Wednesday April 20th 2011, the Airbus A-320 aircraft registered under the number EC-GRH, operated by the company Vueling, took off at 19:02 h from Barcelona Airport on a scheduled flight identified as VY2220, with Seville Airport being the destination. On board there were 150 passengers, 4 cabin crew and 3 technical crew (one captain and two co-pilots, one of them undergoing practical training).

With the aircraft stabilised at flight level 350, an amber warning (Master Caution) was displayed in the cockpit at 19:29 h, accompanied by an ILS1 FAULT[2] message on the ECAM (Electronic Centralised Aircraft Monitor). At the same time, the captain's primary flight display (PFD1) went completely blank. Seconds later, and without any corrective action having been taken, this warning cleared, the PFD1 was recovered and a new message appeared WHEEL NWS FAULT[3].

At 20:19 h, during the phase of final approach and during lowering of the landing gear, a new warning appeared: L/G SHOCK ABSORBER FAULT[4]. At this moment, the auto pilot (A/P), auto thrust (A/T) and flight director (FD) were lost, the navigation equipment remaining operable.

[1] Unless otherwise indicated, all time references in this report are in local time (HL). UTC time may be determined by subtracting two hours from the local time.
[2] CM1 ILS equipment failure.
[3] Failure of nose wheel steering system.
[4] Failure of landing gear shock absorber.

The emergency procedure corresponding to the WHEEL N. W. STEER FAULT[5] warning includes a note establishing that if the L/G SHOCK ABSORBER FAULT warning also appears, there is a possibility that the nose landing gear wheels will be left rotated 90° with respect to the longitudinal axis of the aircraft. This situation was confirmed from the control tower when the crew performed a low pass for this purpose.

The aircraft was authorised to carry out a direct ILS approach to runway 27 at 20:45 hours, and three minutes later was authorised to land, with a 10 kt wind at 240°. During the landing, the aircraft remained on the centreline and decelerated correctly, coming to a halt on the runway at the junction with quick exit E3, with the right-hand wheel of the nose landing gear burst. Following conformation that there was no fire, the passengers disembarked in accordance with the normal procedure.

The investigation has determined that the incident occurred as a result of the aircraft's nose landing gear wheels rotating irreversibly to the physical limit of 95° with respect to its longitudinal axis, with the aircraft in the air and the nose landing gear extended. The investigation has underlined the fact that three independent faults were present at the same time, although it was not possible to reach any conclusions regarding their origin.

As a result of investigation of the incident, a safety recommendation has been issued, addressed to the manufacturer of the aircraft.

[5] A318/A319/A320/A321 Vueling FCOM, Abnormal and Emergency, Landing Gear, section 3.02.32, page 9.

1. FACTUAL INFORMATION

1.1. History of the flight

On Wednesday April 20th 2011, the Airbus A-320 aircraft registered under the number EC-GRH, operated by the company Vueling, took off at 19:02 h from Barcelona Airport on a scheduled flight identified as VY2220, with Seville Airport being the destination. On board there were 150 passengers, 4 cabin crew and 3 technical crew (one captain and two co-pilots, one of them undergoing practical training).

During this phase of the flight, the captain was the pilot at the controls (PF) and was acting also as instructor of the co-pilot who was undergoing training, the latter sitting in the right-hand seat and acting as pilot not flying (PNF). The unrestricted co-pilot was acting as supervisor of the co-pilot who was undergoing training.

With the aircraft stabilised at flight level 350, and having crossed the UIR Madrid line, an amber warning (Master Caution) was displayed in the cockpit at 19:29 h, accompanied by an ILS1 FAULT[6] message on the ECAM (Electronic Centralised Aircraft Monitor). At the same time, the captain's primary flight display (PFD1) went completely blank.

The crew pointed out that two or three seconds later, and without any corrective action having been taken, this warning cleared and the PFD1 was recovered, although a new message WHEEL NWS FAULT[7] appeared.

At this moment, the captain decided to have the unrestricted co-pilot occupy the right-hand seat, taking over from the co-pilot who was undergoing training.

They carried out the briefing for approach to runway 27, considering the possibility of the aircraft's not being able taxi because of the nose wheel steering fault, thereby preventing them from clearing the runway. According to the 20:00 h (18:00 UTC) METAR, the weather at Seville Airport included winds at 220° with an intensity of 11 kt.

At 20:08 h, the aircraft contacted the Seville approach control centre for the first time and declared an urgency (PAN-PAN PAN-PAN PAN-PAN), informing of the possibility of the runway being left blocked. As from that moment, Seville Airport declared a Local Alert, placing the operation of other incoming and outgoing traffic on hold.

At 20:19 h, during the phase of final approach, and on lowering the landing gear, a new warning message appeared: L/G SHOCK ABSORBER FAULT[8], coinciding with the

[6] CM1 ILS equipment failure.
[7] Failure of nose wheel steering system.
[8] Failure of landing gear shock absorber.

Figure 1. Aircraft in the air

display of the three green lights corresponding to the three struts of the landing gear locked in the down position. At this moment, the auto pilot (A/P), auto thrust (A/T) and flight director (FD) were lost, the navigation equipment remaining operable. The captain took over control of the aircraft in manual mode, without managing to recover these automatisms.

The section on abnormal and emergency procedures corresponding to the landing gear of the operator's Flight Crew Operating Manual (FCOM) establishes the procedure to be adhered to when the WHEEL N. W. STEER FAULT[9] warning appears. This procedure includes a note that establishes that if the L/G SHOCK ABSORBER FAULT also appears, there is a possibility that the nose wheels will be left rotated 90° relative to the longitudinal axis of the aircraft. For this reason, at 20:21 h the crew made a low pass in order for the control tower to confirm the position of the landing gear. The controller confirmed that the nose wheels were turned to the right.

The crew requested permission to fly a circuit towards the south in order to avoid flying over the city of Seville and some storm clouds that were seen to the north, this manoeuvre being authorised.

At 20:29 hours and once again in contact with the Seville approach control centre, the aircraft declared an emergency (MAYDAY MAYDAY MAYDAY), requesting the possibility of using foam on the runway to mitigate possible damage. At 20:35 hours they were informed that this was not possible since the airport did not have a foam suitable for this type of emergency.

At 20:40 hours, after having carried out the corresponding briefings and having prepared the crew and passengers, the aircraft initiated the manoeuvre to take up its

Figure 2. Aircraft stopped on the ground

[9] A318/A319/A320/A321 Vueling FCOM, Abnormal and Emergency, Landing Gear, section 3.02.32, page 9.

position on the final ILS leg and perform the touchdown, being authorised by the control people to line up for a direct ILS approach to runway 27 at 20:45 h.

At 20:48 h, the aircraft contacted the Seville control tower, which authorised it to land, with 10 kt winds at 240°.

The crew reported that the landing had been normal, without vibrations and with just a little more noise than normal. When the aircraft came to a halt, they shut down the engines. They then spoke to the control tower and the fire-fighters, confirming that there was no fire. Consequently, the decision was taken to have the passengers disembark using the normal procedure, this being performed between 20:55 and 21:14 h, local time.

At 22:10 h the aircraft was towed off the runway, at 22:15 h the runway was declared operable and at 22:18 h the emergency was declared to be over. The closure of the airport affected a total 29 flights. Of these, 11 were incoming flights, which were detoured to the airports of Jerez and Málaga, and 18 were departures, with 5 cancellations and 13 delays.

1.2. Injuries to persons

Injuries	Crew	Passangers	Total in the aircraft	Others
Fatal				
Serious				
Minor				Not applicable
None	7	150	157	Not applicable
TOTAL	**7**	**150**	**157**	

1.3. Damage to aircraft

As a result of the incident, the right-hand wheel of the nose landing gear burst.

1.4. Other damage

There was no other damage.

1.5. Personnel information

The pilot in command of the aircraft, of French nationality and 47 years of age, held an Airline Transport Pilot's Licence (ATPL (A)), JAR-FCL, issued by the French Directorate

General for Civil Aviation (DGAC), valid until 17/09/2015, with A320 type qualification, valid until 31/12/2011. He also had a valid class 1 medical certificate, in force to 30/09/2011. The pilot had a total 10,400 flight hours, 4,100 on this aircraft type. In the last 30 days he had accumulated 97:15 hours of flight, 09:37 in the last 48 h.

The co-pilot of the aircraft, of Spanish nationality and 33 years of age, held an Airline Transport Pilot's Licence (ATPL (A)), JAR-FCL, issued by the Spanish National Air Safety Agency (AESA), valid until 24/02/2016, with A320 type qualification, valid until 19/04/2012. He also had a class 1 medical certificate valid until 17/06/2011. His experience amounted to a total 5,700 flight hours, 3,100 on this aircraft type. In the last 30 days he had accumulated 62:16 hours of flight, 10:06 in the last 48 h.

The co-pilot who was undergoing training, of Spanish nationality and 42 years of age, held a Commercial Pilot's Licence (CPL (A)), JAR-FCL, issued by the Spanish National Air Safety Agency (AESA), valid until 25/09/2012, with A320 type qualification, valid until 31/01/2012. He also had a class1 medical certificate valid until 10/08/2011. His experience amounted to a total 870 flight hours, 90 on this aircraft type. In the last 30 days he had accumulated 63:12 hours of flight, 12:59 in the last 48 h.

The four members of the cabin crew held the necessary licences, qualifications and medical certificates, valid and in force as of the date of the incident.

Likewise, all the crew members had attended the training courses approved by the operator in accordance with the applicable standards.

The air traffic controllers who were on shift and intervened in the flight affected by this incident held the necessary licences, qualifications and medical certificates, valid and in force as of the date of the incident.

1.6. Aircraft information

1.6.1. *Cell*

The Airbus A-320-211 aircraft with registration number EC-GRH, was manufactured by AIRBUS S.A.S. in 1990 under serial number 146, and was equipped with two CFM International model CFM–56–5A1 engines. On the date of the incident it was being operated by Vueling Airlines, S.A.

The aircraft possessed registration certificate number 4252, issued on 16/09/2009, a normal airworthiness certificate number 4183, large aircraft category, issued on 03/11/2005, and an airworthiness revision certificate valid until 06/08/2011.

Listed below are the latest revisions of each type performed on the aircraft and its components in the five years previous to the incident, in accordance with the contents of its approved maintenance schedule:

Revision	Date	Hours	Cycles
A3	11/01/2011	45,379	34,718
A2	29/09/2010	44,729	34,201
A1	04/08/2010	44,195	33,786
A4	31/05/2010	43,609	33,326
C2	02/02/2010	42,994	32,803
C1	31/05/2008	38,957	29,600
D3	28/09/2006	33,712	25,948

Likewise, the weights and centering data listed below were included on the load sheet for this flight:

<table>
<tr><td>Take-off weight in the operation (TOW)</td><td>64,101 kg</td><td>Maximum Authorised</td><td>MTOW</td><td>73,350 kg</td></tr>
<tr><td>Estimated landing weight in the operation (LAW)</td><td>60,201 kg</td><td>Maximum Authorised</td><td>MLW</td><td>64,500 kg</td></tr>
<tr><td>Deadweight (DOW)</td><td>43,234 kg</td><td colspan="3"></td></tr>
<tr><td rowspan="2">Centre of gravity in the operation</td><td>At take-off</td><td>MACTOW</td><td colspan="2">35.82% MAC</td></tr>
<tr><td>Estimated at landing</td><td>MACLAW</td><td colspan="2">37.85% MAC</td></tr>
</table>

1.6.2. *Description of nose landing gear*

The landing gear of the aircraft is made up of three struts, each with a shock absorber, two wheels and a set of closing doors. Two of these are located under the wings, on either side of the fuselage, and fold away into the latter, constituting the main landing gear (MLG). The third strut is located in the lower part of the forward fuselage and is retracted forwards, centred from front to back; this constitutes the nose landing gear (NLG). Under normal operating conditions, with the shock absorber extended, the wheels of the nose landing gear are kept aligned from front to back by means of a mechanical centering device, regardless of whether the gear is extended or retracted.

Both the landing gear extension system and the system for steering of the nose landing gear are governed and controlled by means of electrical components, and are actuated by hydraulic components. The gear bay closing doors are actuated by means of hydraulic and mechanical components.

1.6.2.1. Drive system

The normal system for extension and retraction of the landing gear is governed and controlled by means of electrical components, and actuated by hydraulic components.

The electrical system is equipped with a landing gear control lever (LGCL), two landing gear control and interface units (LGCIU), an electrohydraulic gear selection valve, an electrohydraulic gear bay door selection valve, 32 proximity sensors with their corresponding reference elements (*targets*) and a set of status indicating lights. The electrical control system has two sub-systems, each controlled by a different LGCIU with associated sensors, such that at any given moment one of the units will be in control mode and the other in monitoring mode, each using the information provided by its respective associated proximity sensors. In the event of failure of one of the units or associated proximity sensors, the other unit will be in control mode at all times.

The hydromechanical components include three gear actuation cylinders, three gear bay door actuation cylinders, three folded gear locking devices, three closed door locking devices, three door bypass valves (to allow for opening on the ground), one nose landing gear down lock release actuator and two main landing gear lock actuation cylinders.

When the LGCL is actuated, the LGCIU sends a signal to the set of electrohydraulic valves; the proximity sensors send signals to the LGCIU and the correct actuation sequence of the landing gear is ensured.

In the event of failure of the extension system, the landing gear may be extended from the cockpit by means of a mechanical free-fall actuator; in this case, a cut-off valve prevents hydraulic pressure from reaching the landing gear actuation circuit.

In the event of failure of the mechanical centering device for the wheels of the nose landing gear, with the latter retracted and locked in the up position, there is sufficient free space around the wheels in the landing gear bay for the wheels to turn some 20° in any direction up to contact with the upper part of the bay; this does not prevent the nose landing gear from dropping freely if required.

1.6.2.2. Steering system

The nose landing gear steering system is controlled by the brake and steering control unit (BSCU) and is actuated by the hydraulic control unit (HCU) and a steering actuator.

When the nose landing gear is extended and the door selector valve is commanded to close, the hydraulic block is pressurised. When, furthermore, the main landing gear is compressed, the two chambers of the steering actuator receive hydraulic pressure and the wheels of the nose landing gear are sent to the 0° position. In this position, the nose wheels will rotate depending on the BSCU reference speed and on the actuations from the cockpit on their steering elements. Thus, by acting on the pedals, the wheels may be turned a maximum 6°, while actuation of the manual actuators (tiller) allows for turning by up to 74°.

Furthermore, the mechanical centering system of the nose landing gear is designed to keep the wheels centred in flight, with the gear extended and without the steering control available. In the event of an unexpected turning command, with hydraulic pressure in the steering actuator, the loads applied by the latter on the rotating components is sufficient to overcome the mechanical centering system and make the wheels turn, the latter then being able to reach the physical turning limit (95° to either side, corresponding to the limit angles for towing of the aircraft on the ground).

1.6.3. *Braking and steering control unit (BSCU)*

The brake and steering control unit (BSCU) receives position signals from the sensors installed on the nose landing gear and from a sensor that monitors the position of the steering control module servovalve. When the landing gear is lowered and the BSCU receives a signal indicating that the nose landing gear is down and locked, it begins to monitor the angular position of the nose landing gear wheels, beginning with a series of five steering tests. On completion of a test on the braking system and on the availability of pressure in the steering servovalve, the BSCU initiates the steering test. On completion of the first four test sequences, the BSCU applies a 10° rotation command for 5 seconds, which produces an alternative movement of up to 1°.

Once gear down has been selected, and one second after the nose landing gear is down and locked, the BSCU determines the position of its wheels; if it detects that the wheels are displaced from the mechanical centering position, it will attempt to centre them by sending an appropriate signal to the servovalve. If the BSCU does not receive information confirming that the servovalve has moved as commanded, it will continue to monitor the position of this valve for 0.5 seconds and, if still no response is obtained, will cut off the hydraulic pressure, thereby leaving steering of the nose landing gear unavailable. Failure of nose wheel centering will initiate a WHEEL NWS FAULT warning on the ECAM.

One issue that should be underlined at this juncture is that the BSCU receives the signal corresponding to landing gear down directly from an output from the LGCL, while other items of equipment receive it from different outputs. For this reason it is possible for different items of equipment to have different signals coming from one same component. Thus, the flight data recorder receives this signal once it has been processed by the two LGCIU’s, which in turn receive it from different BSCU outputs.

1.6.4. *Description of the electrical system of the aircraft*

The electrical system of the aircraft is fed by two alternating current generators (GEN 1 and 2), each installed in the nacelles of the engines and driven by the latter via a constant speed drive (CSD) module. Each generator and constant speed drive module assembly constitutes an integrated drive generator (GEN + CSD = IDG). A third alternating current generator, moved by the auxiliary power unit (APU), may replace either of the main units or both. In addition, there is a connection for electricity to be received from an external power generator (EXT PWR) and an emergency generator (EMER GEN), driven by the hydraulic circuit of a ram air turbine (RAT).

The power produced by each main generator feeds an alternating current distribution circuit (AC BUS 1 and 2), and N.º 1 also feeds an essential services circuit (AC ESS BUS). The system allows any circuit to be fed by the sources available at each moment in time, ensuring that the two generators cannot be connected in parallel to one same circuit.

Each of the main alternating current circuits includes a Transformer – Rectifier (TR1 and 2) that produces direct current for the feed of the corresponding distribution circuits (DC BUS 1 and 2); N.º 1 also feeds an essential services circuit (DC ESS BUS) and the battery feed circuit (DC BAT BUS).

It should be pointed out that with generator N.º 1 in operation, the cockpit automatism and indicating elements corresponding to the left-hand pilot’s station (captain) and channel No 1 of the BSCU receive alternating current feed from phase C of alternating current circuit N.º 1 (AC BUS 1).

1.6.4.1. Connection of generators to the distribution circuits

Each generator is connected to the alternating current distribution circuits of the aircraft by means of a bundle of cables running from the generator to a connector that is incorporated in the the junction box located on the corresponding engine support (pylon).

The plug installed at the end of the cable bundle has female terminals that connect to the male terminals of the receptacle.

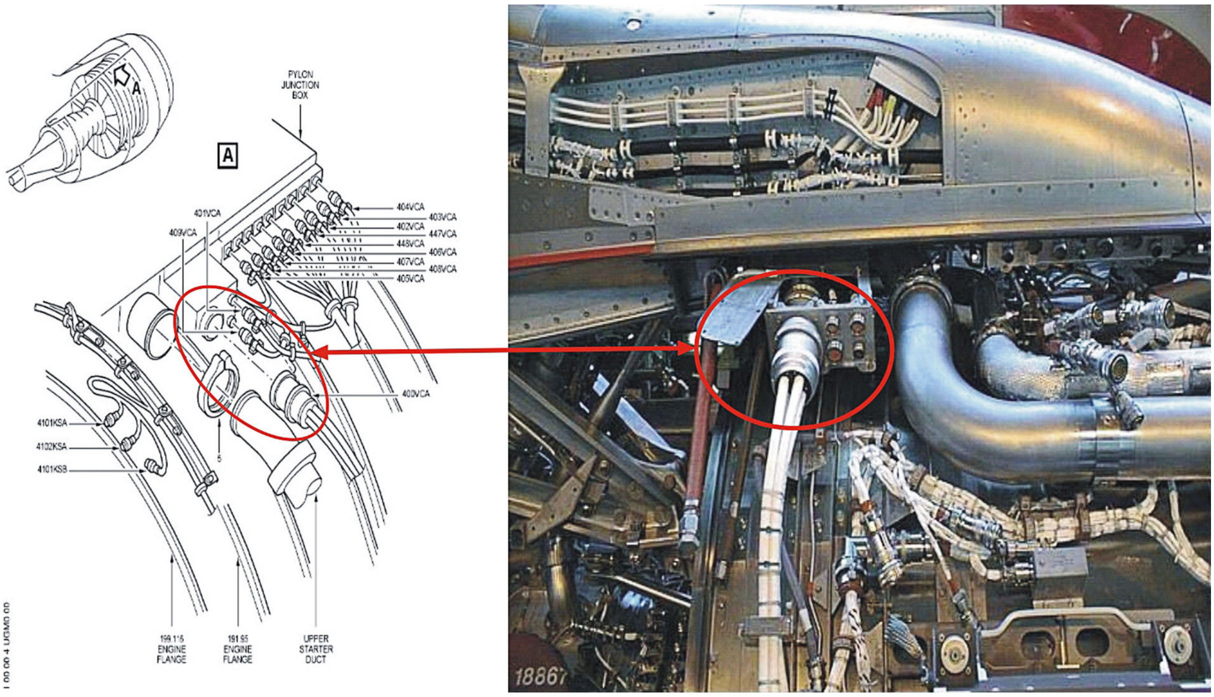

Figura 3. Connection of generator to aircraft circuits

1.6.4.2. Protection against electrical current fluctuations

In accordance with its design requirements, each generator control unit (GCU) monitors the voltage supplied by the corresponding generator and emits a fault signal causing it to be disconnected if the voltage measured is out of range, connecting the affected bus to the available generator.

The aircraft involved in this incident was equipped with with a classical electrical power generation system (EPGS), in which the low voltage protection was activated if the voltage on any of the phases was below 100 V for a period of 4.5 seconds. The fact that this did not occur in this case indicates that the voltage drops on phase C of generator N.° 1 of the aircraft lasted less than 4.5 seconds. Furthermore, this is consistent with the data obtained from the flight data recorder.

Furthermore, the PFR's corresponding to flights in which there were current fluctuations include the maintenance message *POWER SUPPLY INTERRUPT*, corresponding to current interruptions lasting longer than 200 m and subsequent recovery of power.

1.7. Meteorological information

1.7.1. *General information*

According to the information supplied by the National Meteorological Agency (AEMET), the general situation in the south of the Iberian Peninsula was one of an area of low pressure, 1,006 hPa, located to the west of the peninsula, with an associated cold front entering from the west, and another low pressure area, 1,004 hPa, located in the north of Morocco and Algiers.

1.7.2. *Information on aerodrome*

At Seville Airport, the METAR reports for April 20th 2011, between 17:00 and 22:00 hours, were as follows:

17:00: METAR LEZL 201500Z 21010KT 160V240 9999 SCT040 SCT049 22/13 Q1007 NOSIG=
17:30: METAR LEZL 201530Z 22012KT 9999 SCT040TCU SCT049 23/13 Q1006 NOSIG=
18:00: METAR LEZL 201600Z 22011KT 9999 SCT040TCU SCT049 22/12 Q1006 NOSIG=
18:30: METAR LEZL 201630Z 22010KT 9999 FEW040TCU SCT049 22/12 Q1006 NOSIG=
19:00: METAR LEZL 201700Z 24011KT 9999 FEW040 SCT049 21/13 Q1006 NOSIG=
19:30: METAR LEZL 201730Z 23013KT 9999 SCT045 21/13 Q1006 NOSIG=
20:00: METAR LEZL 201800Z 22011KT 9999 SCT049 20/13 Q1006 NOSIG=
20:30: METAR LEZL 201830Z 23009KT 9999 SCT049 20/13 Q1006 NOSIG=
21:00: METAR LEZL 201900Z 24008KT 9999 SCT049 20/13 Q1006 NOSIG=
21:30: METAR LEZL 201930Z 23005KT 9999 SCT049 19/13 Q1007 NOSIG=
22:00: METAR LEZL 202000Z 22008KT 9999 SCT049 19/13 Q1007 NOSIG=

From these reports it may be gathered that the meteorological situation during the interval considered was as follows:

- Average wind in 10 minutes: Between 210° and 230°, i.e. south-westerly.
- Average wind speed in 10 minutes: Between 5 kt (21:30 h) and 13 kt (19:30 h).
- Visibility: 10 km or more.
- Cloud cover: Sky partially covered (3 or 4 octas) with the cloud base between 4,000 ft (1,219 m) and 4,900 ft (1,494 m). From 17:30 to 18:30 h, TCU convective cloud (vertically developed cumulus congestus). There were also Cu (cumulus), Sc (stratocumulus) and Ac (altocumulus) type clouds.
- Temperature: Between 19° and 23 °C / Dew point temperature: Between 12° and 13 °C.
- QNH: Between 1,006 and 1,007 hPa.
- There was no warning of observed lightning or any storms expected.

1.8. Aids to navigation

All the navigation aids along the route followed by the aircraft and for ILS approach to runway 27 of Seville Airport were operable on the day of the incident and operated correctly when required by the crew of the aircraft.

For the ILS approach to runway 27, the crew used the corresponding JEPPESEN chart, with ILS-DME radio aid support with call sign **ISV**.

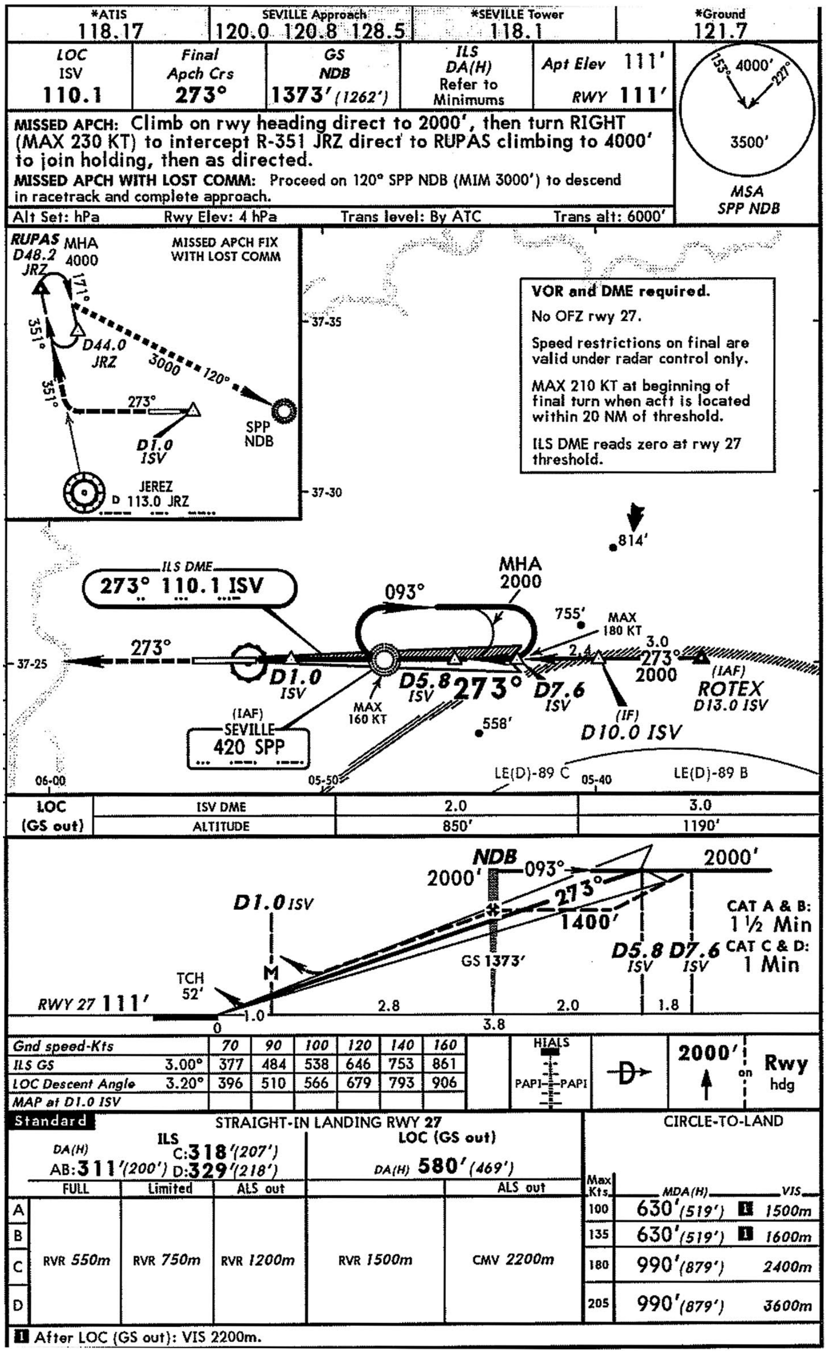

Figure 4. JEPPESEN chart for ILS approach to runway 27 at Seville

1.9. Communications

1.9.1. *Ground-air communications*

As from the moment in which the first warning occurred in the cockpit, the aircraft maintained the communications listed below with the control centres:

- Seville Control Centre-North Approach Sector (LECSAPN), at a frequency of 120.8 MHz, between 20:07:25 and 20:19:31 hours and between 20:28:52 and 20:46:36 h.
- Seville Airport Control Tower (TWR), at a frequency of 118.1 MHz, between 20:19:41 and 20:27:31 h and between 20:48:23 and 20:59:15 h.

The most relevant communications between these two centres and the aircraft are transcribed below.

Time	Station	Contents/observations
20:07:25	**VLG2220**	**Contact with APP** Declaration of urgency: PAN-PAN, PAN-PAN, PAN-PAN.
20:07:36	VLG2220	Problem with the steering control of the aircraft and probable need for assistance on the ground.
20:12:18	LECSAPN	Authorisation for ILS approach to RWY27, QNH 1006, descent at your discretion and permission to shorten if wished.
20:19:23	VLG2220	Established on localiser.
20:19:26	**LECSAPN**	**Flight transferred to TWR**
20:19:41	**VLG2220**	**Contact with TWR** 5 NM out and set for RWY27
20:20:18	TWR	Authorisation for landing on RWY27, with wind 240/10.
20:20:43	VLG2220	Authorisation requested to fly low over the field for confirmation of the position of the nose landing gear.
20:21:11	TWR	Authorised, with wind 220/10.
20:21:17	VLG2220	Reports manoeuvre aborted and intention to fly a visual traffic circuit to the left.
20:22:39	TWR	Reports landing gear apparently down and locked, with nose landing gear turned to the right.
20:22:51	VLG2220	Suspicions confirmed. Requests route to the south of the field to fly a couple of waiting circuits and attempt to solve the problem. Can maintain 2,000 ft.
20:23:14	TWR	Authorised at will, with QNH 1006.
20:26:35	VLG2220	Asks whether course can be maintained for the time being instead of flying waiting circuits.
20:26:44	TWR	Will consult with APP.
20:27:26	**TWR**	**Transfers flight back to LECSAPN**
20:28:52	**VLG2220**	**Contacts LECSAPN once more** They are to the south of the city, leaving course 090. They need a few minutes more to perform a new approach.

Time	Station	Contents/observations
20:29:20	VLG2220	Declaration of emergency: MAYDAY, MAYDAY, MAYDAY. The landing gear is not correctly locked and they require the presence of the fire brigade beside the runway. Asks whether the airport has foam in case they have problems during landing.
20:30:15	VLG2220	There are 150 passengers and 7 crew on board. They have a little more than 3,000 kg of fuel on board and are not carrying any hazardous goods.
20:34:38	VLG2220	Confirms visual contact with the ground. They need another three or four minutes before initiating the approach.
20:36:06	LECSAPN	Reports that the airport does not have foam.
20:36:12	VLG2220	The landing gear is not in the correct position. They may have steering problems during the landing; there may be sparks and the landing gear might even break. They need the fire brigade next to the runway and will attempt to stop on it.
20:36:47	VLG2220	Asks whether the fire-fighters are ready.
20:37:00	LECSAPN	They are ready.
20:37:55	VLG2220	They need thirty seconds more for preparations in the cabin, possibly a little more. They will report when ready.
20:39:16	LECSAPN	Asks for an estimate of landing time.
20:39:22	VLG2220	Estimates five more minutes.
20:40:33	VLG2220	They are prepared to intercept the localiser, proceed 26 miles on final and attempt the approach.
20:40:43	LECSAPN	Authorised to fly as requested.
20:45:43	LECSAPN	Authorised to proceed directly to ILS approach to RWY27.
20:46:29	**LECSAPN**	**Transfers the flight back to TWR**
20:48:23	**VLG2220**	**Contacts TWR once again** They are 3 NM out and set for RWY27.
20:48:29	TWR	Authorised to land, with wind 240/10.
20:48:36	VLG2220	Confirms authorisation and repeats that they will remain on the runway due to the lack of nose wheel steering.
20:50:52	**COMMENT**	**AIRCRAFT STOPPED ON RUNWAY (SSFDR)**
20:51:13	TWR	Reports that there are no flames.
20:51:15	VLG2220	Requests confirmation.
20:51:18	TWR	Confirms absence of flames from the nose landing gear.

Time	Station	Contents/observations
20:51:19	VLG2220	Requests that fire-fighters check for the absence of fire.
20:53:05	VLG2220	Reports that if the fire-fighters confirm the absence of fire, they will disembark using stairs and buses.
20:53:20	TWR	Will coordinate with Coordination Office and report back.
20:58:37	TWR	Reports that the fire-fighters are saying that there is a blown tyre but no fire. They can see the buses and stairs in front of the aircraft ready for evacuation.
20:58:53	VLG2220	Confirms that disembarking will be performed as previously announced, with stairs and buses, and regrets having occupied the runway in that way.
20:59:15	TWR	Signs off with a greeting.

1.9.2. *Ground-ground communications*

As regards the ground stations, the following centres communicated with one another by telephone and hot lines:

- Seville Airport Control Tower (TWR).
- Airport Operations Control Centre (CECOA).
- Flow Control Centre (FLOW).
- Seville Airport Fire-Fighting and Rescue Service (SEI).
- Seville Control Centre – North Approach Sector, or Supervisor (LECSAPN).

Described below are the most relevant communications between these centres, maintained from the corresponding positions of the Seville Airport Control Tower:

Local Sector (LCL) – Control tower console N.° 1

Communications were maintained between the TWR, CECOA and LECSAPN centres. The three centres kept one another informed and coordinated the necessary actions in relation to the event between 20:15:43 and 20:52:48 h.

Ground Sector (GND) – Control tower console N.° 2

Communications were maintained between the TWR, LECSAPN, CECOA and SEI centres. The four centres kept one another informed and coordinated the necessary actions in relation to the event between 20:08:00 and 20:56:56 h.

It should be pointed out that the first call, at 20:08:00 h, was from the Seville ACC supervisor to the TWR to request that all take-offs be suspended and to report on the reasons for this.

Stand-by position - Control tower console N.º 3

Communications were maintained between the TWR, LECSAPN and FLOW centres. The three centres kept one another informed and coordinated the actions required to detour the flights bound for Seville airport and keep on the ground those that were to take off from it between 20:23:13 and 20:28:03 h.

1.10. Aerodrome information

Seville airport, with ICAO denomination **LEZL** and IATA denomination **SVQ**, is located 10 km to the north-west of the city of Seville, the elevation of its reference point being 34 m (111 ft). It has an asphalt runway denominated 09/27, with a magnetic orientation of 093º/273º and dimensions of 3,360 × 45 m. At its two ends it is equipped with visual and radioelectric aids for ICAO category I precision approaches (CAT I).

As regards the fire-fighting and rescue services, the published fire category is 7; i.e., the operational response time target to the ends of runway 09/27 is less than 3 minutes, and the rescue equipment available is in keeping with the published fire category.

It should be pointed out that Seville airport did not have available foam suitable to cover the runways in the event of an emergency landing. ICAO Appendix 14 ("Aerodromes") and the "Technical Standards for the design and operation of aerodromes for public use" in force in Spain do not contemplate the rendering of such a service.

1.11. Flight recorders

The aircraft was equipped with a solid-state flight data recorder (SSFDR) and a cockpit voice recorder (CVR), located in the rear part of the fuselage. Both recorders were recovered in good condition and without apparent damage and were sent to the recorders laboratory (STAR) of the company Iberia, which carried out maintenance on the aircraft, for delivery to the CIAIAC.

In addition to the flight recorders, the aircraft was equipped with a data access recorder (DAR), with magnetic tape, which recorded the data necessary for the operator's analysis programmes. The tape installed, which had been mounted on April 9th 2011, was recovered. This tape was sent for reading to the Iberia recorders laboratory, which reported that it contained no data on the event due to its being full prior to initiation of the flight and not, therefore, having any memory available.

1.11.1. *Solid-state flight data recorder (SSFDR)*

The aircraft was fitted with an Allied Signal solid-state flight data recorder, model 980-4700, part number (P/N) 980-4700-042 and serial number (S/N) 5502, capable of recording a total 128 words per second and 54 hours of flight. It registered a total 600 analogue and digital parameters.

Prior to its delivery to CIAIAC, and in response to a request by the manufacturer of the aircraft, the data it contained were downloaded at the facilities of the maintenance provider and sent raw to the manufacturer for evaluation of the problem that had occurred and with a view to placing the aircraft in service.

Once the recorders were in the hands of CIAIAC, the flight data recorder was read in the recorders laboratory, the data were translated into engineering units and the information was set out in graphic and tabular formats.

From the information obtained, the activation of the Master Caution that had appeared in the cockpit during the flight (the parameter known as the master warning) was identified. This had also been activated during a flight made by the aircraft on April 18th, and again on April 19th, immediately prior to the date of the incident, without its coinciding with any action by the crew (such as disconnection of the auto pilot) that might have caused it.

Furthermore, in the light of the information obtained, three aspects warrant special mention:

- As from the moment of disconnection of the automatic flight systems and flight directors, these remained disconnected up to the end of the flight.
- The alternating current (1 and 2) and direct current (1 and 2) busses and the alternating and direct current essential services busses remained connected throughout the entire flight.
- Erroneous data were recorded at three instants in the flight, all with a duration of 1 second, at 19:30:32, 20:29:52 and 20:34:36 h.

Presented below in graphic format are the data corresponding to the two approaches and the landing of the aircraft on runway 27 of Seville airport, and the basic information obtained therefrom is set out in detail.

This is followed by a representation of the path taken by the aircraft during the two approaches and the landing, and its path during final approach and on the ground, both plotted on aerial photographs.

1.11.1.1. First approach

From the data extracted from the SSFDR, the following information on the first approach may be singled out:

- The approach was performed with the two auto pilots (A/P1 and A/P2) connected, in accordance with the Airbus procedure for capturing of the ILS localiser.
- At ILS/DME 27 8NM, the flaps were actuated to CONF 2 (15° deflection).
- At 6.7 NM, the landing gear lever was actuated, indicating locking at 20:19:15.
- At 5.9 NM, the flaps were selected to CONF FULL (35° deflection).
- Almost coinciding with the deployment of the flaps to 35°, 21 seconds after the landing gear locking indication, the nose landing gear was recorded to be in the ground position (shock absorber compressed), this being identified by the turning of the wheel in the air, at 20:19:36.
- At 20:20:31, the two auto pilots disconnected, and 17 seconds later the autothrust disconnected. These were not reconnected during the remainder of the flight. At this

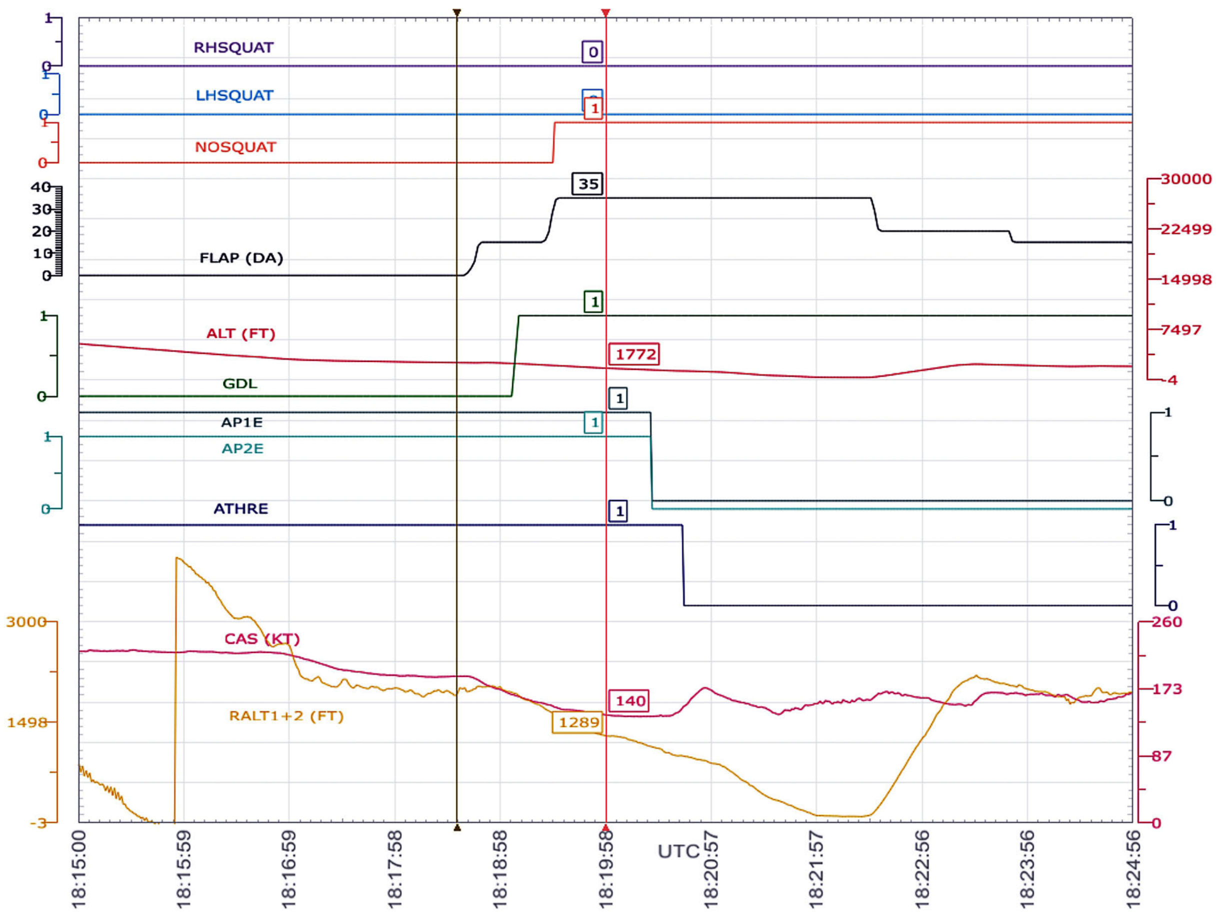

Figure 5. Graph showing SSFDR data on first approach

point the aircraft was 992 ft above the ground, 2.9 NM from the localiser and at a speed of 151 kt.

- A low pass was performed 100 ft above the ground and at a speed of 160 kt, from 0.16 NM to 1.14 NM as from the head of runway 27. In other words, the aircraft covered a distance of practically 1 NM (6,000 ft) above the runway in order for the configuration of the landing gear to be checked from the ground.
- As from this moment, the aircraft initiated an ascent with the flaps configured at CONF 3 (20°deflection) to an altitude of 2,000 ft. On reaching this altitude, at 20:23:54, and at a speed of 170 kt, the crew retracted the flaps to CONF 2 (15° deflection), leaving the landing gear extended.

1.11.1.2. Second approach and landing

From the data extracted from the SSFDR, the following information on the second approach and the landing may be singled out:

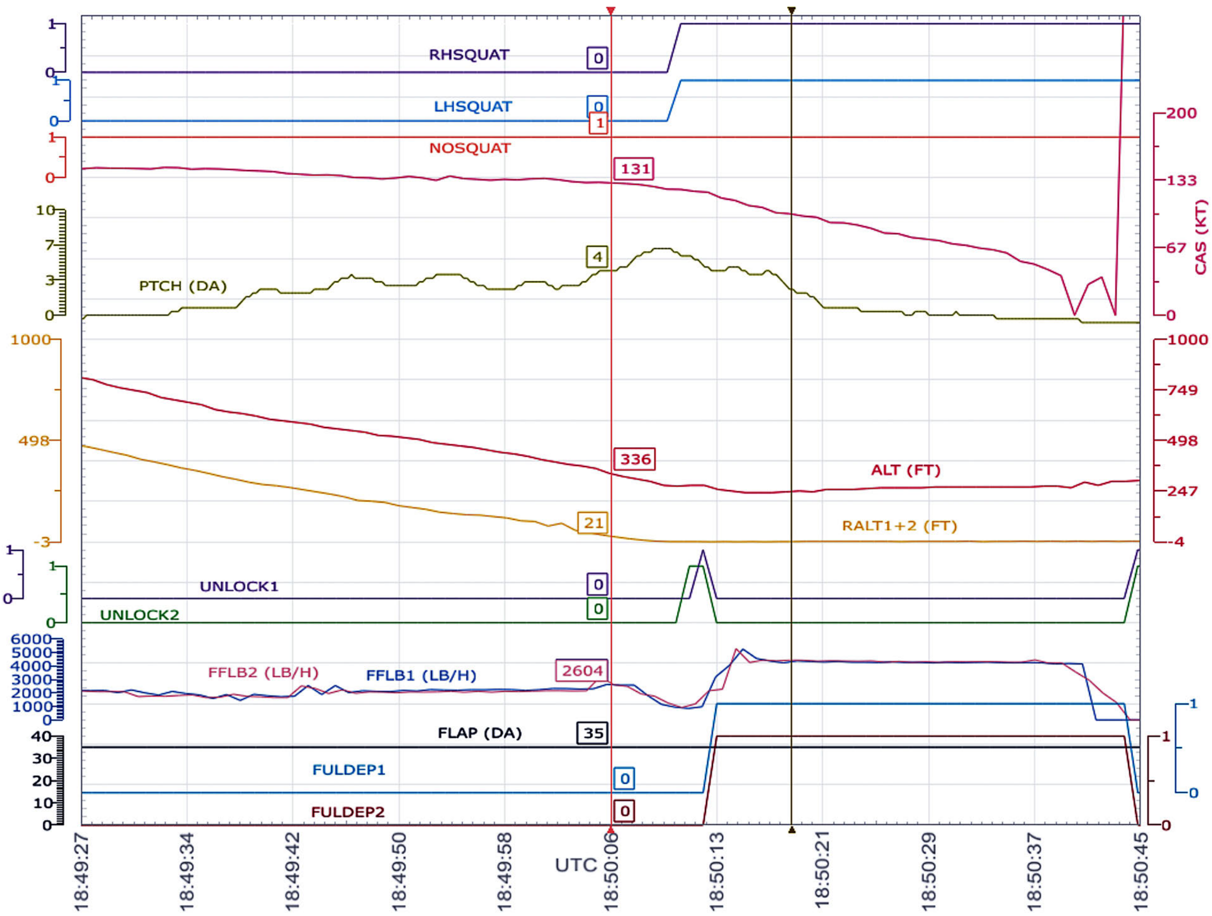

Figure 6. Graph showing SSFDR data on second approach and landing

- The final phase of the approach was performed in manual mode with the landing gear extended and the flaps in CONF FULL (35° deflection), maintaining a speed of 135 kt.
- At a height of 43 ft above the field, the flare or roundout was initiated, an angle of attack of 6° being reached.
- As soon as the main landing gear was in contact with the runway, at a speed of 123 kt, ground spoilers and reverse thrusts were deployed.
- The nose up configuration was maintained for 10 seconds.
- A time of 34 seconds passed between touchdown and the aircraft coming to a halt.
- The engines were shut down with the aircraft at a speed of 28 kt with respect to the ground, the aircraft coming to a complete halt five seconds later.
- The landing distance was 4,056 ft (1,236 m). The aircraft touched down on the runway at the aiming point sign and stopped at the junction with quick exit E3.

1.11.1.3. Path of the aircraft

The data obtained from the flight data recorder were used to plot the path followed by the aircraft during the two approaches and the landing. This path is shown below, along with details of the final approach and the trajectory of the aircraft on the ground.

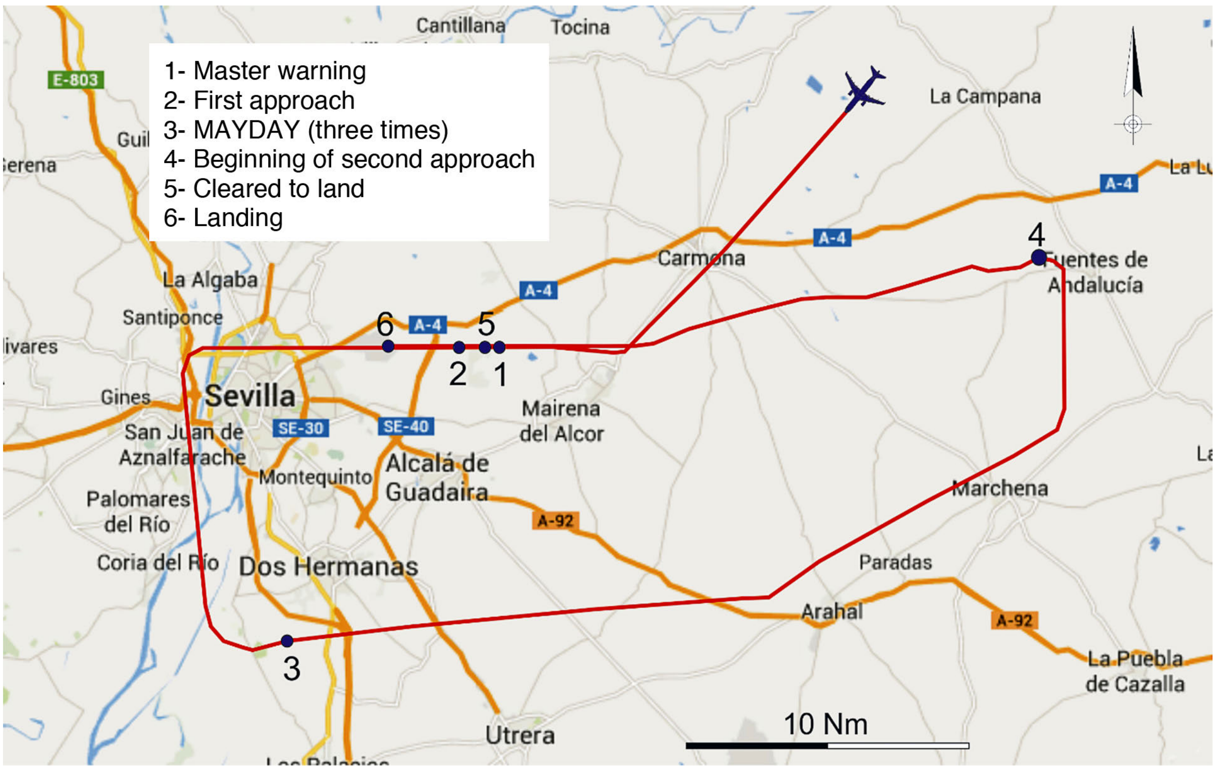

Figure 7. Path of the aircraft during the two approaches and the landing

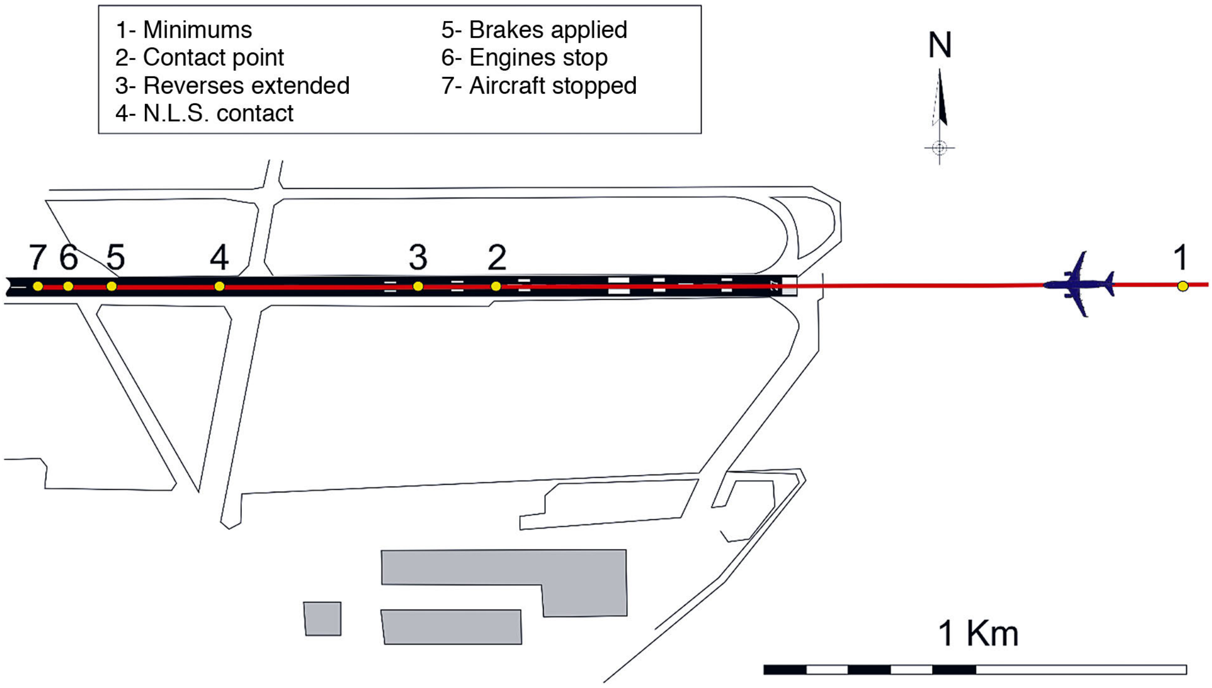

Figure 8. Path of the aircraft during final approach and landing

1.11.2. *Cockpit voice recorder (CVR)*

The aircraft was equipped with a Sundstrand Data Control cockpit voice recorder, model AV557C, part number 980-6005-076 and serial number 10077, in which the information was recorded on magnetic tape.

This equipment had four recording channels on which the operating sounds corresponding to the last 30 minutes (nominal value) of operation of the aircraft were continuously recorded. Sounds from the following were recorded on each channel:

- Channel n.º 1: Passenger address system.
- Channel n.º 2: Co-pilot's microphone and headset.
- Channel n.º 3: Pilot's microphone and headset.
- Channel n.º 4: Ambient microphone.

Once the recorders were in the hands of the CIAIAC, the cockpit voice recorder was read in its recorders laboratory, and from the initial audition of the recordings it contained it was determined that these would be of use for the investigation.

The total duration of the recording was 33 minutes and 34 seconds. The first 22 minutes and 50 seconds corresponded to the approach, preparation for landing and the landing of the aircraft at Seville airport, the rest covering the actions of the maintenance personnel in carrying out their work subsequent to the landing.

The 22 minutes and 50 seconds corresponding to the flight were transcribed and the conversations contained in the CVR were synchronised with the data obtained from the SSFDR.

Described below are the most interesting conversations relating to the operations performed:

- At 20:29, the aircraft contacted Seville approach and declared an emergency (Mayday, Mayday, Mayday), asking about the possibility of using foam during the landing in order to minimise possible damage. Information was provided on the number of persons on board, range and absence of hazardous goods.
- At 20:31, the captain handed over the control of the aircraft and communications to the co-pilot and communicated with the senior flight attendant to coordinate with the cabin crew. During this communication there was a reference to an incident that had occurred with an aircraft belonging to the company Jet Blue[10], which had presented similar characteristics.
- At 20:33, the captain once again took charge of the controls and asked the co-pilot to make an announcement to the passengers, commenting on the situation. This announcement was made by the co-pilot at 20:35.
- At 20:36, Seville approach informed the crew that no foam would be available, the co-pilot replying and requesting the presence of the fire brigade in case any possible sparks might cause a problem of fire.
- At 20:37, the captain commented on his intention to apply maximum reverse thrust and not use the automatic braking.
- At 20:39, the co-pilot, considering the similarity of this case to that of the Jet Blue event, pointed out to the captain that he should lower the nose without allowing the speed to decrease overmuch, in order to have elevator control. He recommended not having the nose up for very long.
- At 20:40, the cabin crew gave the cabin secured signal, with which the pilots initiated the approach and carried out the APPROACH procedure.
- At 20:43, the co-pilot suggested that the landing emergency checklist for abnormal landing gear position (LDG WITH ABNORMAL L/G) be read, the captain giving his approval.
- At 20:45, they discussed when to shut down the engines, in the light of the information provided by the emergency checklist, which created some confusion.
- At 20:46, the captain told the co-pilot that they would use the reverse thrust and shut down the engines as soon as the nose wheel touched down and the aircraft began to decelerate, to which the co-pilot replied that his interpretation of the procedure was that the engines should be shut down prior to touchdown of the nose wheel, as a result of which they agreed that the reverse thrust would be deployed after touching down with the main landing gear and the engines shut down before nose wheel touchdown.

[10] Incident affecting the Airbus A320 aircraft with registration number N536JB, operated by Jet Blue Airways (flight JBU292), on September 21st 2005 at Los Angeles International (California – USA). NTSB reference: LAX05IA312.

At this moment they were transferred back to the Tower for the final approach.

- At 20:48, the configuration for landing was initiated and the landing checklist (LANDING) was read.
- At 20:48, they contacted the Tower and reported that they would leave the runway blocked due to lack of steering capacity.
- At 20:49, the co-pilot gave the brace for impact signal.
- At 20:50, the aircraft touched down and the engines were shut down once it had come to a halt. When the engines were cut, the aircraft deenergised and the recording was interrupted.

1.11.3. *Information on affected flight*

Described below are the relevant events that occurred during the flight, from take-off in Barcelona until the aircraft came to a halt on the runway at Seville airport.

The time reference taken is that of the transcriptions of the communications with the air traffic control installations, referred to local time.

Local time	Relevant information on flight
19:01:47	The aircraft rotates at 154 kt (CAS)
19:02:00	The aircraft lifts off at 159 kt (CAS). The auto thrust (ATHR) is connected from the start of the take-off run.
19:04:11	AP1 (auto pilot No 1) engagement at 229 kt (CAS) and with the radioaltimeter indicating 1,183 ft .
20:18:54	FLAPS 15°
20:14:58	AP2 (auto pilot No 2) engaged. Altitude 5,716 ft and speed 220 kt (CAS).
20:18:58	Landing gear down lever selected.
20:19:15	Landing gear down and locked.
20:19:30	Flaps movement initiated.
20:19:36	Nose landing gear SQUAT activated (GROUND indication). This indication continues until after the landing. The main landing gear indication continues to be AIR.
20:19:38	Flaps 35°
20:20:31	AP1 and AP2 didengaged
20:20:33	Activation of Master Warning for 3 seconds.
20:20:46	FD1 (flight director N.° 1) disengagement
20:20:47	FD2 (flight director N.° 2) and of ATHR disengagement

Local time	Relevant information on flight
20:22:29	92 ft radioaltimeter at 158 kt (CAS). Low pass flight over runway.
20:28:23	Initiation of recording on CVR.
20:29:12	The crew declares an emergency and reports a problem with the nose landing gear. They request the fire brigade and ask if there is foam.
20:29:51	They report on the number of persons on board, without ATC so requesting: 150 passengers and 7 crew.
20:30:23	The crew reports that there are no hazardous good on board.
20:37:01	The captain reports that they will not use the autobrake; it will be a manual braking and they will apply reverse thrust immediately on landing.
20:38:22	Heading north selected.
20:38:33	The co-pilot remembers the JETBLUE event[11] and recommends that the nose gear not be kept up for long. It should be lowered when they still have speed (GS 90 kt when the nose wheel touches down).
20:40:54	Approach checklist initiated.
20:42:40	Abnormal Gear Position Landing checklist referred to.
20:45:25	Discussion on whether to use reverse thrust during landing or cut engines after touchdown. Finally decide to use reverse thrust and cut the engines when the nose wheel touches down and they still have speed. The engines are finally cut at 28 kt (GS), with the aircraft practically stopped.
20:47:34	Flaps extended to 20° and immediately after to 35°
.20:47:39	Landing checklist run through.
20:48:40	Authorisation to land.
20:48:48	Brace for impact
20:49:54	Minimum
20:50:18	Touch down. 124 kt (CAS) and vertical acceleration 1.21 G.
20:50:20	Max Reverse thrust and ground spoilers fully deployed.
20:50:30	The nose landing gear wheel touches down.
20:50:37	Application of brakes initiated.
20:50:42	Engine master off, 1 and 2 (announced by co-pilot and the fuel flow to both engines drops to 0 after 5 seconds).
20:50:52	Registered speed 1 kt (GS). The aircraft has stopped.
20:50:54	Date recording interrupted.

[11] Incident affecting the Airbus A320 aircraft with registration number N536JB, operated by Jet Blue Airways (flight JBU292), on September 21st 2005 at Los Angeles International (California – USA). NTSB reference: LAX05IA312.

1.12. Wreckage and impact information

Not applicable in this case.

1.13. Medical and pathological information

Not applicable in this case.

1.14. Fire

No fire occurred.

1.15. Survival aspects

Not applicable in this case.

1.16. Tests and research

1.16.1. *Declarations by crew*

1.16.1.1. Declaration by the captain

This was the third leg of the session scheduled for that day. They had previously carried out a Barcelona-Rome-Barcelona flight without any incidents with the same aircraft. This aircraft had not flown previously that day. On this leg he was the PF, while the co-pilot undergoing instruction acted as PNF and the third pilot supervised operations.

The departure from BCN was normal. The first event occurred at flight level FL350, after passing the FIR Madrid, when an amber warning appeared on the ECAM (ILS1 FAULT). At this moment he realised that the PFD No 1 monitor had gone completely blank. Two or three (2-3) seconds later, this signal cleared, the PFD was recovered and another ECAM warning (WHEEL NW STEER FAULT) appeared.

He had read a previous note on this fault in the technical log book (TLB). He did not consider the warning to be excessively problematical; there were no ECAM actions. They consulted the FCOM3 and the QRH, observing that the QRH computer reset page indicated that they should reset; however, he decided not to do this.

He also read the MEL to see whether it provided any information. He decided to continue to Seville, considering the airport to be adequate and the closest to them.

At that moment he decided to switch the pilots, the expert co-pilot taking over as PNF.

He sent an ACARS message to the company requesting maintenance. He was now aware of what might happen and that the problem might get worse.

During the first contact with Seville APP, they explained the situation and declared PAN, PAN. They thought that under these conditions they would be unable to clear the runway. He also remembers having spoken with Maintenance over the radio. He performed an operational briefing with the second, considering the operation to be normal except for the problem with the nose wheel steering (NWS), which would imply the aircraft being left on the runway. The entire flight was performed in automatic mode, from the beginning.

During the final approach, and on lowering the landing gear, the second warning appeared, with three green lights (struts locked), this being the ECAM L/G SHOCK ABSORBER FAULT. At this moment the auto pilot (A/P), auto thrust (A/T) and flight director (FD) were lost. Manual control of the aircraft was taken over, without managing to recover the automatisms. The co-pilot remembered the JetBlue incident, immediately realising what the situation was.

They decided to make a low pass in front of the tower at a height of some 200 ft AGL. To do this, they changed the landing configuration to CONF2. The tower confirmed that the landing gear was down, but with the nose wheel turned. They requested, and received authorisation from the tower, not to carry out the established abort manoeuvre, since there was cumulo nimbus to the north. They decided to fly a wide circuit to the south, avoiding the city of Seville. An altitude of around 3,500 ft was maintained.

They flew an extended leg with a tailwind. He knew that there were no applicable engineering bulletins (OEB's) because of a modification to the software of the aircraft.

They decided to declare an emergency landing during the tailwind leg. He spoke with the senior flight attendant to explain the situation. The communication was made after the low pass.

They requested vectors for the approach. They requested foam but there was none available at the airport.

They performed a normal approach, reading the "Landing with abnormal L/G" checklist. He asked the co-pilot not to shut down the engines at touchdown, since he intended to use reverse thrust to control any possible asymmetrical braking.

Touchdown occurred at a speed of some 130 kt, with the nose lowered at around 90 kt. He began to brake gently when the wheel touched the ground. He maintained the centreline alone, without having to make any corrections. He considered the landing to have been normal, without vibrations but with a little more noise than usual. The deceleration was normal.

He cut the engines when the aircraft came to a halt. They read out the evacuation checklist as a precaution. In contact with the tower, the fire fighters confirmed that there was no fire, so they decided to disembark normally.

There was a smell of burnt rubber, but not particularly strong.

An announcement was made to the passengers, who did not show any signs of panic at any time.

1.16.1.2. Declaration by the co-pilot

He had been assigned to the flight as a back-up pilot.

EC-GRH is an old aircraft and the jump seat is uncomfortable. For this reason he went to sit in the passenger cabin during cruising.

He was called when the first ECAM warning (NW STEER FAULT) appeared, and replaced the pilot who was under instruction. He consulted the MEL and the FCOM and saw that there was no applicable procedure.

They continued towards Seville, declaring a situation of urgency. He explained the nature of the problem to the control centre (ACC).

When the landing gear was lowered, the ECAM SHOCK ABSORBER FAULT warning appeared. Faced with this warning, he declared that they had already talked about the possibility of the nose wheel being positioned at 90º.

They flew a low pass and then a circuit to the left of the runway. They applied the LDG WITH ABNORMAL L/G checklist, although he recognised that this list is not for this situation.

He was concerned about the remaining fuel. In addition, the auto pilot (A/P) and the flight director (F/D) had failed.

He contemplated the possibility of the nose wheel strut breaking. He left the option of using the reverse thrust up to the captain.

They cut the engines on coming to a halt. There was no fire or the need for any evacuation, although the possibility was coordinated with the cabin crew.

They were assisted by the fire brigade.

He had already flown aircraft with steering failures. In his previous companies (Air Madrid and Clickair) he had worked as a test pilot.

He also reported that he had attended training as a test pilot, completing the following courses:

- NTPS graduate, Mojave.
- Test pilot short course.

- Introduction to fixwing test flying.
- Avionic System test flying.

1.16.1.3. Declaration by the co-pilot undergoing training

The co-pilot who was in the practical training phase was interviewed but did not provide any additional information. His work had been limited to assisting the co-pilot when asked to do so and to reading out the emergency checklists.

1.16.1.4. Declaration by the senior flight attendant

The senior flight attendant provided a written report in which she described the events:

> *During the cruising phase of flight Vy 2220, Barcelona-Seville, I entered the cockpit and the captain informed me that we had a problem with the nose landing gear. The wheel was turned but we would make a normal landing. I passed on this information to the cabin crew.*
>
> *We were given 20 minutes to landing and we secured the cabin as per normal operations. Once the landing gear was deployed, we received a message from the cockpit to for us to remain in our seats as the landing had been aborted.*
>
> *After a few minutes I received a call from the captain and entered the cockpit. He informed me that we had to make an emergency landing and gave me the appropriate information. He told me that we had 10 minutes to touchdown and that he would call out "Finish preparation" twice 2 minutes before touchdown and "Brace Brace", also twice, one minute before.*
>
> *I went out into the cabin and called the crew together in the front area to pass on the information I had received from the captain. As from that moment I made the emergency announcement to the passengers and we started the procedure; we repositioned the able-bodied passengers (abps) and instructed the handicapped (pmrs) and babies, securing the cabin. Despite the situation, the passengers collaborated at all times and obeyed all the orders we were giving. We sat on the crew jump seats and waited for orders from the captain. We shouted "brace, brace" to the passengers right up to the landing.*
>
> *Once the aircraft had come to a complete halt, we heard the message "Attention crew at stations" twice from the cockpit. After a minute the captain came out from the cockpit and told us that everything was fine. I passed on this message to the crew members in the rear of the aircraft.*

While we were waiting for them to bring the stairs up and for the buses to arrive to disembark, both the captain and the co-pilot made announcements to the passengers, informing them of what had happened and explaining that we were waiting to disembark. I walked through the cabin to check on the passengers, calm them down and make sure that the attendants at the rear of the aircraft were OK.

I should especially like to mention the excellent CRM from the cockpit, both with the auxiliary crew and with the passengers. They transmitted security to us at all times, despite the situation. I should also like to underline the good teamwork by the auxiliary crew, their professionalism and attitude and their capacity to address the situation.

1.16.2. *Inspection of remains of aircraft*

In accordance with the instructions received from the manufacturer of the aircraft, inspections and tests were performed on the alternating current feed systems and the nose landing gear steering system of the aircraft. It should be pointed out that during inspection of the alternating current feed system, clear indications of electrical arcing were found on one of the connectors of the cable bundle connecting IDG No 1 (alternating current generator and constant speed transmission assembly, coupled to the left-hand engine) to the electrical system of the aircraft.

As a result of the work performed, IDG N.º 1 and the cable bundles associated with it were replaced, as were the nose landing gear and its extension-retraction and steering command and control elements.

On completion of this work, and following the corresponding tests, with satisfactory results, the aircraft returned to service on May 1st 2011.

1.16.2.1. Warnings in previous flights

On the two days prior to the incident, WHEEL NWS FAULT warnings had occurred in this aircraft, on April 18th, during a flight from Barcelona to Venice, and on April 19th, during a flight from Rome to Madrid. In both cases corrective actions were performed, consisting of replacing elements of the nose landing gear steering control and actuation system. In addition, on April 19th 2011, multiple faults had been recorded in the post flight report (PFR), affecting electrical feed bus No 1 of the aircraft, for which reason its generator N.º 1 control unit had been replaced.

The items removed from the aircraft as a result of this incident, and on the two days previous to it, were kept for the investigation. Agreements were reached regarding the inspections and tests to be performed and the information to be compiled, with a view to establishing a scenario covering the origin and development of the event.

1.16.2.2. Components disassembled

The following table shows the components disassembled from the aircraft, the work performed on each and an indication of the possible influence of the results obtained regarding the incident.

Group of elements	Description	Part N.°	Serial N.°	Tests performed	Evidence
LANDING GEAR (ATA 32) Disassembled following incident	NOSE LANDING GEAR (NLG) ASSY	D23175001-19	B119 30203	Inspection at facilities of Messier-Bugatti-Dowty (MBD) in Gloucester (UK)	NO
	NOSE LANDING GEAR (NLG) FORESTAY ASSY	D23073000-8	UL49-B79		
	SWIVEL SELECTOR VALVE	C24747000-1	871094	Inspection at facilities of MBD in Molsheim (FR)	NO
	3GC GEAR BOX	C24764000	B270		NO
	4GC GEAR BOX	C24764000	B295		NO
	3GC COM RVDT SENSOR	C24763000	B425		NO
	4GC MON RVDT SENSOR	C24763000	B317		NO
	5GC ELECTRICAL (TOWING) BOX	D23119000	B04		NO
	6GC HYDRAULIC CONTROL UNIT (HCU)	C24736001	U182		YES/ Steering selector valve locked in open position
	LANDING GEAR CONTROL LEVER (LGCL)	210TS07Y01	252	Functional testing at Iberia facilities in Madrid (SP)	NO
				Inspection at ZODIAC AEROSPACE facilities in Niort (FR)	NO
	BRAKE AND STEERING CONTROL UNIT (BSCU)	C202163392E35	5109	Inspection at MBD facilities in Massy (FR)	YES/ Faults recorded in Internal memory

Group of elements	Description	Part N.°	Serial N.°	Tests performed	Evidence
LANDING GEAR (ATA 32) Disassembled prior to incident	3GC COM RVDT SENSOR (Disassembled on 19/04/2011)	C24763000	B734	Standard maintenance at Iberia facilities in Madrid (SP)	NO
	6GC HYDRAULIC CONTROL UNIT (HCU) (Disassembled on 18/04/2011)	C24736001	H2361	Standard maintenance at Iberia facilities in Madrid (SP)	NO
ELECTRICAL SYSTEM (ATA 24) Disassembled following incident	Integrated Drive Generator (IDG)	7401194H	3456	Standard maintenance at Iberia facilities in Madrid (SP)	
	ELECTRICAL HARNESS	238W0903-507	IB006POW		N/A
	ELECTRICAL HARNESS	238W0904-531	N/A		N/A
	ELECTRICAL HARNESS	D95401005000AD	Q281740070	Inspection at AIRBUS facilities in Toulouse (FR)	YES/ Connector arced and assembly incorrect
	CONTACTOR	558CA01Y1	1182		
	LGCIU	664700500A4D	513	Standard maintenance at Iberia facilities	N/A
	LGCIU	664700500A4D	2427		N/A
	GCU	740120B	1856		N/A
Others	BRAKE ASSY	C20225510	10555	N/A	N/A
	NLG WHEEL	3-1531-3	7951	N/A	N/A
	NLG WHEEL	3-1531-3	7774	N/A	N/A
	FMGC	C13042AA03	C13042013281	Standard maintenance at Iberia facilities in Madrid (SP)	NO
	FMGC	C13042AA03	6127		NO
	RUNWAY LH	50-0177	NIL		NO
	RUNWAY RH	4236534	IB013		NO
	WHEEL PRESSURE TRANSDUCER	1338-1450	7130		NO

1.16.2.3. Studies performed and results obtained

Described below are the studies performed on those items in which evidence was found in relation to the investigated event, the evidence encountered and its possible influence on the development of the incident.

1.16.2.3.1. Electrical harness (S/N Q281740070) and contactor (S/N1182)

The contactor is part of the electrical junctions box located on the engine pylon, and to it is connected the electrical harness coming from the integrated drive generator (IDG) coupled to the engine of the aircraft. In this case, the items in question are located on its left-hand side.

As has been pointed out above, during the inspection of the alternating current feed system performed after the incident, clear signs of electrical arcing were discovered on one of the connectors of the cable bundle connecting IDG N.° 1 to the electrical system of the aircraft, specifically on the one corresponding to alternating current phase C, and on the terminal corresponding to the connector.

These elements were inspected at the AIRBUS Operations laboratory in Toulouse (France). During the inspection, evidence of previous connector maintenance operations was discovered.

- Tangential abrasion on the surface of the pins corresponding to phases A and C, with damage to the gold plating, allowing the copper base material to be visible at certain points. This abrasion was considered to be the result of cleaning of the terminals with abrasive tools or products, a practice that is not recommended for this type of items, which must be replaced in the event of any type of damage being discovered.

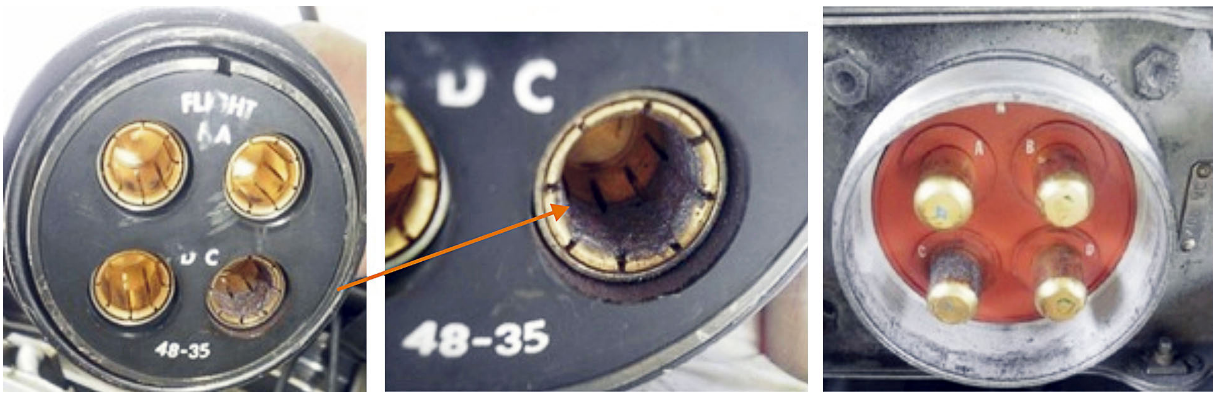

Figure 9. Detail of contact elements

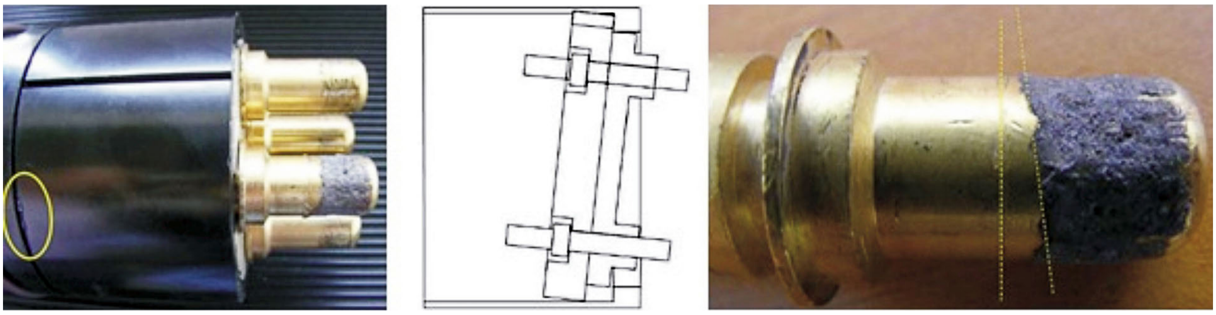

Figure 10. Detail of assembly of terminals on connector

- The four cables were of different lengths: A = 390 mm, B = 375 mm, C = 380 mm and D = 368, and in all cases were shorter than the 450 mm that they should have measured in length originally.
- The terminals installed on the cables corresponded to two different manufacturers, one pair to each. The four were valid for installation on these cables.
- Damage to the edge of the connecting plate, caused by a tool, probably a screwdriver, used as a lever.
- Incorrect positioning of the connecting plate and evidence of the entry of fluid as a result of incorrect re-assembly during a previous maintenance. The mating plate was found broken and the missing part was no longer present at the time the component expertise.

These evidences underline the existence of problems during earlier maintenance and lead to the conclusion that the incorrect positioning of the connecting plate, that led to insufficient insertion of terminal C in its housing, was probably the primary cause of a deficient contact condition that gave rise to the fluctuations in the electrical current experienced, these being the origin of the incident.

1.16.2.3.2. Hydraulic control unit (6GC, S/N U182)

This unit had been installed in the aircraft on 18/04/2011, two days before the incident.

As regards its expertise, a visual inspection was first performed, several non-conformities being found with respect to the provisions of the component maintenance manual (CMM).

Subsequently, functional tests were performed on the complete unit and it was discovered that, regardless of whether the unit was electrically activated or deactivated, the steering selector valve remained hydraulically open, i.e., stuck in the open position.

In order to isolate the fault, the electrical and hydraulic components of the unit were disassembled and certain additional non-conformities were discovered.

Functional tests were performed on each of the components and they were all determined to be within the established tolerances, with the exception of the steering selector valve, which remained hydraulically open regardless of it whether it was electrically activated or deactivated.

The steering selector valve was disassembled, and the plunger (70 in figure 11) was found to be located alongside the core (60 in figure 11). It was not possible to determine whether it had been in this position initially or whether it had moved to it during removal of the seat (80 in figure 11) in which it is housed.

The steering selector valve was reassembled with all its original components in the correct position, and new functional tests were performed. The valve operated correctly, opening and closing the hydraulic steering circuit as required. A further re-assembly with the plunger put in the incorrect position (as found after the first disassembly), followed by a functional test as required post maintenance, allowed to confirm reoccurrence of the selector valve jamming.

As a result of the study performed on the hydraulic control unit, it can be concluded that, on the one hand, it presented several non-conformities with respect to the

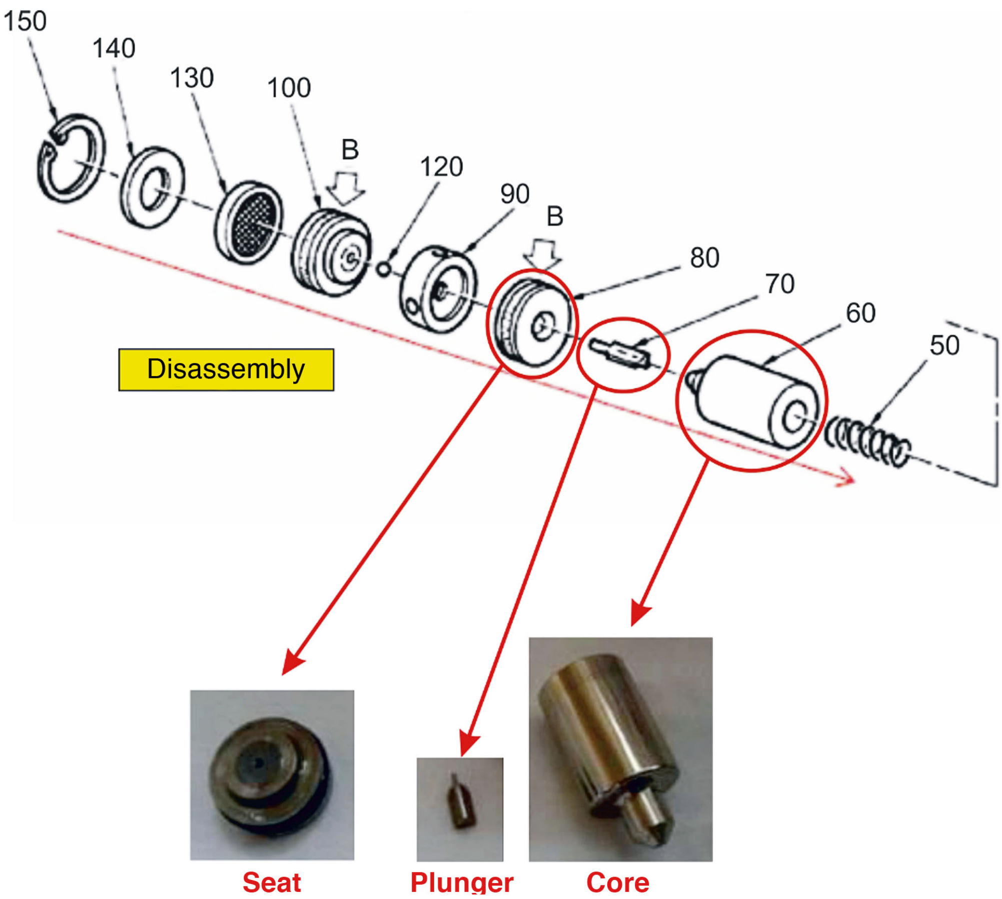

Figure 11. Internals of the HCU

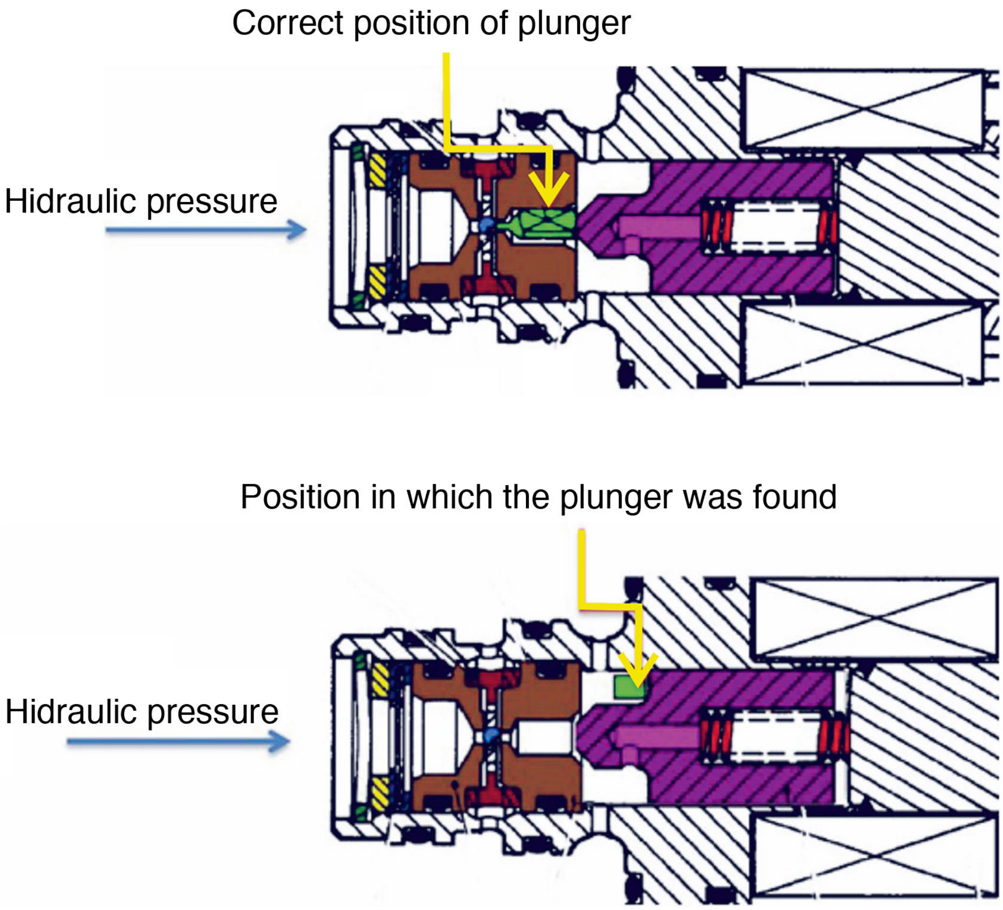

Figure 12. Positions of the plunger in the HCU

requirements of the component maintenance manual, which did not directly affect its performance, and, on the other hand, that the steering selector valve was stuck in the open position, which is consistent with the plunger not being in the correct position as a result of a previous incorrect re-assembly.

1.16.2.3.3. Brake and steering control unit (BSCU, S/N 5109)

This unit had been installed on the aircraft on 10/04/2011 and was disassembled on 22/04/2011, after the incident.

Its expertise was carried out in two phases: the preliminary phase focussed on the component itself, while the second covered the actuation of the component as part of the aircraft's steering system.

The preliminary study was carried out in accordance with the requirements of the component maintenance manual (CMM), and consisted of a visual inspection, the manual tests required to verify its status and the feasibility of performing automatic testbench tests, and the performance of the latter.

During the visual inspection and the manual tests, no abnormal conditions or evidence were discovered preventing the performance of the automatic tests.

Automatic tests were carried out on the automatic test equipment complex (ATEC) testbench for the built-in test equipment (BITE), and the information contained therein was read and decoded correctly. No fault was found on the unit itself. All the faults detected by the aircraft's systems and previously known as a result of the post flight reports (PFR) obtained from the centralised fault display interface unit (CFDIU) were seen to have been recorded. In addition to these there were certain faults (Class 3) recorded that, due to system design criteria, are stored in the internal memory of the BSCU and not displayed in the PFR's.

Presented below are the significant faults related to the incident and their interpretation:

- Decoding of the information stored in the internal memory of the component and corresponding to the flight affected by the incident.

  — Class 1 faults (produced by electrical feed transients):

    – The following faults occurred in System 1 at 19:29 h:

      › RVDT COM not valid: This fault was produced by the active system as a result of secondary voltage fluctuations in the RVDT sensor box (RVDT1 + RVDT2 < 5.4V). The corresponding fault message is STEERING FEEDBACK CONTROL SENSOR 3GC, which appears in the PFR.
      As a result of this fault, the value detected by RVDT MON remained fixed in the active system.
      › LVDT not valid: This fault was produced as a result of secondary voltage fluctuations in the LVDT steering servovalve (ULVDT1 + ULVDT2 < 8.5 V). The corresponding fault message is STEERING ELECTRO HYDRAULIC MODULE 6GC, which appears in the PFR.

    The coincidence of these two faults indicates a loss of steering and explains the appearance of the WHEEL NWS FAULT warning on the ECAM at 19:29 h.

    – The following faults occurred in System 1 at 20:19 h:

      › Discrepancy between the angles detected by RVDT COM 3GC and RVDT MON 4GC: This fault is produced by the active system if the angles detected by RVDT COM 3GC and RVDT MON 4GC differ by more than 10° (10.12° in this case). The corresponding fault message is BSCU OR STEERING FEEDBACK SENSOR, which appears in the PFR.

As a result of this fault, the active system changed from 1 to 2, the latter remaining active without detecting the same fault. This happened because, as a result of the RVDT COM not valid fault that occurred at 19:29 h, the value detected by RVDT MON remained fixed in system 1, which was active at the time, but not in system 2. Consequently, system 2 did not have the same reference as system 1 and did not detect the same fault.

› Loss of separation of proximity sensors N L/G EXT PRX SSNSR 24GA and 25GA: Produced respectively by LGCIU 1 and 2; when the nose landing gear is turned more than 6° to the right or to the left, the proximity sensors become misaligned with their respective reference elements and emit the same signal as in the case of loss of separation.

This fault explains the L/G SHOCK ABSORBER FAULT warning that appeared on the ECAM at queue 20:19 h.

— Class 3 faults:

The L/G Lever fault was registered in both systems (1 and 2) at 19:01 h. This fault corresponds to detection of the landing gear actuation lever in the up position during the take-off run: Lever up and aircraft on ground with a reference speed of between 40 and 50 m/s.

- Decoding of the information stored in the internal memory of the component and corresponding to the two days prior to the incident.

  At 16:07 h on 18/04/2011, and at 17:03 h on 19/04/2011, the same class 1 faults occurred as were registered at 19:29 h during the flight affected by the incident, and generated similar ECAM warnings.

  Additionally, at 17:39 h on 19/04/2011, a BSCU reset was registered with the aircraft in flight.

- Decoding of the information stored in the internal memory of the component and corresponding to all the flights recorded.

It was determined that the class 3 fault registered during the flight affected by the incident (L/G Lever) had occurred during all the flights recorded in this unit since it was installed on this aircraft.

- Decoding of the information stored in the internal memory of BSCU S/N 2081.

  In the light of what is indicated in the previous point, an analysis was performed on the information extracted during the standard maintenance carried out on BSCU S/N 2081, the unit mounted in the aircraft prior to the current one. It was found to have registered the same type of fault in both systems and in all flights since 30/03/2011.

Once the information corresponding to the studies and tests performed on all the elements removed from the aircraft as a result of the incident, and during the two days prior to it, was available, the second phase of the study of the BSCU was carried out, this consisting of an investigation of its actuation as a component of the aircraft's steering system.

A manual testbench for A320 aircraft BSCU's was used, this providing the capacity to simulate the operating conditions of the aircraft and its braking and steering system components. Three scenarios were contemplated and the tests were performed using a laboratory BSCU and the unit that was installed on the aircraft during the flight affected by the incident.

The scenarios contemplated and executed were as follows:

1. Complete flight cycle at ambient temperature: BSCU active, actuation of the steering system, take-off, gear up manoeuvre, cruising, deployment of landing gear, functional testing, landing and application of brakes.
2. Complete flight cycle at ambient temperature reproducing the conditions of the flight throughout the entire flight, actuation of the steering system, take-off, gear up manoeuvre, cruising, 115 V feed voltage drop in RVDT's and LVDT's (simulated by reducing the secondary voltages), deployment of landing gear, simulation of flow across HCU servovalve, landing and application of brakes.
3. Actuation of the BSCU in response to transient 115 V feed voltage drops, using actual RVDT's and LVDT's.

From the results obtained it may be seen that the two units acted in the same way under all the conditions to which they were subjected. For each scenario:

1. Complete flight cycle at ambient temperature. The performance of the BSCU was correct.
2. Reproduction of the conditions of the affected flight:

   - BSCU active, landing gear up signal sent to BSCU throughout the entire flight, actuation of the steering system, take-off, gear up manoeuvre, cruising, 115 V feed voltage drop in RVDT's and LVDT's (simulated by reducing the secondary voltages): the RVDT COM and LVDT not valid in system 1 faults were registered, the nose landing gear wheels steering control was deactivated in the two systems, the two systems issued the WHEEL NWS FAULT warning and the corresponding measures were applied.
   - Deployment of the landing gear and simulation of flow across the HCU servovalve: once the nose landing gear was down and locked, the steering began to turn without control; when the 10° position was reached, a discrepancy was registered between the angles detected by RVDT COM 3GC and RVDT MON 4GC, system 2 became active and, with the steering control deactivated, the turning continued until the 95° physical limit was reached.

- Landing and application of brakes: the brakes were fully operable during the landing.
- The landing gear up signal in the BSCU points to the pre-landing test not being performed.
- As the pre-landing test was not performed, the fact that the steering selector valve was stuck in the open position went undetected.

3. Actuation of the BSCU in response to transient 115 V feed voltage drops, using actual RVDT's and LVDT's: The voltage drop to the 50 to 80 V range on the phase feeding system 1 of the BSCU, gave rise to the faults registered during the event, which led to the deactivation of the steering control of the nose landing gear wheels.

In summary, the following conclusions were drawn from the study of the BSCU:

- Systems 1 and 2 of the BSCU lost steering control as a result of fluctuations in the 115 V feed current.
- Once the nose landing gear was down and locked, the steering began to turn without control; when the 10° position was reached, a discrepancy was registered between the angles detected by RVDT COM 3GC and RVDT MON 4GC, system 2 became active and, as this system had the steering control deactivated, the turning continued until the 95° physical limit was reached and the BSCU did not activate steering faults.
- Loss of the steering function is irreversible in the event of the faults corresponding to discrepancies between the angles detected by RVDT COM 3GC and RVDT MON 4GC being generated.
- Resetting the BSCU allows the steering function to be restored if the fault condition has disappeared. Nevertheless, the Airbus FCOM does not allow the BSCU to be reset in flight, except when the *BRAKES SYS 1(2) FAULT* warning is displayed on the ECAM.

1.16.2.3.4. Landing gear control lever (LGCL, S/N 252)

As has been indicated in the table in section 1.16.2.2, one of the components removed from the aircraft and subsequently investigated was the landing gear control lever. Functional tests were performed using this component during the initial phase of the investigation, with satisfactory results.

In view of the fact that the class 3 fault (L/G Lever) registered during the flight affected by the incident had occurred in all the flights and in two different BSCU's since 30/03/2011, the LGCL was inspected at the manufacturer's facilities. New functional tests were performed and the internal components were removed and inspected. No evidence of incorrect operation of any of the components of the unit was encountered. In addition, a check was made of the maintenance history of the aircraft that had had BSCU S/N 5109 installed previously, the one that had subsequently had BSCU S/N 2801 installed, and of the aircraft that had experienced the incident. In general, no anomalies relating to the incident were found and, in particular, the class 3 fault (L/G Lever) was not repeated.

1.16.3. *Study of operation*

As regards operational aspects, the activities of the crew have been investigated from the moment in which the first warning occurred to the end of the flight; in particular, consideration has been given to the information included in the documentation of the manufacturer and the operator, available on board the aircraft.

1.16.3.1. Airbus emergency procedures

The procedure for the nose wheel steering fault (WHEEL N/W STG FAULT) published by the manufacturer in section 2.32 of its flight crew operations manual number 3 (FCOM 3 Rev 42) includes a note with information on the possibility of the nose wheel being left positioned 90° with respect to the longitudinal axis in the event of the shock absorber fault (L/G SHOCK ABSORBER FAULT) appearing. If this happens, the only action that can be taken is to delay the touchdown of the nose wheel to the extent possible during landing. In addition, automatic rollout is not permitted.

In the event of a shock absorber fault being displayed (L/G SHOCK ABSORBER FAULT), the note establishes the same for the case of subsequent appearance of the steering fault warning (WHEEL N/W STG FAULT).

No further specific instructions are provided for consideration during landing operations.

WHEEL N/W STRG FAULT

STATUS

CAT 3 SINGLE ONLY	INOP SYS
R *Note: 1. If the L/G SHOCK ABSORBER FAULT is also displayed, then the nose wheels may be at maximum deflection. (turned 90 degrees from center). During landing, delay nose wheel touchdown as long as possible.*	CAT 3 DUAL N/W STRG
2. As specified in the QRH 5.04, automatic rollout is not permitted.	

Figure 13. Note in the steering fault procedure

1.16.3.2. Abnormal and emergency situations

Given the high density of air traffic, it may be stated that every day some abnormal or emergency situation occurs on board some aircraft, their importance varying from situations that are highly threatening and critical as regards timing to others that are relatively "trivial".

The response of the crew to certain situations is clearly rehearsed and analysed. But there are others that, because of their low frequency of occurrence, are not only not covered in training but have not even been considered for the development of procedures aimed at combatting them.

Abnormal and emergency situations rarely end in accidents, but even though the crew manages to land safely, analyses generally point to shortcomings in the checklists/ procedures performance, training, the coordination of the crew and emergency management. These shortcomings potentially reduce the safety margin under certain circumstances.

The procedures and checklists available to crews to respond to abnormal and emergency situations are key factors for the solving of such situations.

The following are specific characteristics of abnormal and emergency procedures:

- They focus on specific systems of the aircraft rather than on the situation overall.
- They are rarely practised (twice a year or less) and are used very little.
- They depend at a very high level on fragile cognitive processes.
- They may include procedures to be carried out by memory.
- When needed, they must be applied correctly.

The lists of procedures must be a useful instrument and accessible to the flight crew.

Consequently, in both their format and their contents, consideration must be given to scientific issues from the point of view of human factors, making them an adequate tool to act as an interface between the crew and the aircraft.

The suitability of the design of the checklist might be determined from its acceptance and reliable use by pilots.

During the design of the checklist it is important to bear in mind that whatever it might be, any design may be open to human error. The crew members may omit an action, skip it or respond inadequately, believing that they have seen something that, in fact, was what was expected rather than what was actually performed. The potential risk of an accident or incident increases with the incorrect interpretation and application of a checklist as a result of poor design.

In order to avoid the problems and errors that might arise during the execution of the lists, the following aspects should be considered in their design:

- Tasks to be performed.
- Environment in which the checklist is executed.
- Workload of the crew at each moment in time.
- Human limitations (stressful situation).

It should be remembered that the nature of the situations is variable, with their severity being affected by other factors in the environment. An important dimension to be considered is the level of risk and the threat to the capacity of the crew to keep the flight under safe and controlled conditions. The speed with which the crew has to respond is also a factor that varies from one situation to the next. Determining the severity of a time-critical situation and its level of threat for the flight may be complicated when the data presented to the crew are contradictory or ambiguous.

Likewise, the degree of complexity of the situation, any increase in workload and understanding of or familiarity with the situation are other variables to be considered when dealing with abnormalities and emergencies.

These variables imply that not all aspects can be covered in the procedures published, this challenging the members of the crew to determine which response is most adequate from their point of view. Furthermore, if the situation involves faults in multiple systems, without any apparent relationship between them, the complexity of the scenario will be extreme.

The way in which this wide range of situations may appear seriously affects the way they should be addressed and the final result.

1.17. Organizational and management information

Not applicable in this case.

1.18. Additional information

1.18.1. *Background on similar events*

As regards the characteristics of the incident, the manufacturer of the aircraft has registered 17 cases of landings with the wheels of the nose landing gear turned 90° in the past in A320 type aircraft, these corresponding to seven different failure modes. The investigation of this incident has determined that a different mode occurred from those described above.

It should be pointed out that the manufacturer has reported on seven similar events that have occurred since the year 2000, including the one dealt with in this investigation, and has stressed that in all these cases the crews managed to keep the aircraft on the runway using habitual piloting techniques.

Described below is one of these cases, referred to in the conversations of the flight crew as they managed this emergency.

1.18.1.1. Incident affecting Jet Blue Airways flight JBU292 on 21st September 2005

On 21st September 2005, an Airbus 320 aircraft operating the regular passenger flight JBU292, landed at Los Angeles airport (United States of America) with the nose wheel turned 90° with respect to its longitudinal axis. No member of the 6-man crew or any of the 141 passengers was hurt.

The nature of this incident, with its lengthy emergency performance time, led to its being widely covered by the media, with a large volume of graphic information being broadcast. Given its spectacular nature and the ease of access to the information, it was widely commented on throughout the aeronautical community and, as has been pointed out in section 1.11.2, was referred to in the conversations of the crew members during the flight covered in this report.

The aircraft took off from Burbank (California) on a direct flight to JFK airport in New York. The flight was carried out under instrument flight rules in visual meteorological conditions.

Unlike the incident analysed here, when retracting the landing gear the crew received a shock absorber fault indication (L/G SHOCK ABSORBER FAULT) on the ECAM. When they became aware of this indication, they redeployed the landing gear, obtaining the nose wheel steering fault (WHEEL NW STEER FAULT) warning.

They ascended to 14,000 ft and addressed the situation, noting in the flight documentation (FCOM) the possibility of the nose wheel being turned 90°. They made a low pass at Long Beach airport (California) for the people there to visually confirm the abnormal configuration of the landing gear.

After flying for several hours to burn fuel and reduce the landing weight, the crew decided to proceed to Los Angeles airport (California), since its conditions were optimum in terms of the length of the runway and available emergency services.

Flight JBU292 touched down at 120 kt and applied normal braking at 90 kt. The nose wheel was kept in the air as long as possible, and at a speed of 60 kt the crew decided to shut down the engines. They did not use ground spoilers, automatic braking or reverse thrust.

The aircraft made a smooth touchdown and bringing the nose wheel down was delayed as long as possible and no reverse thrust was applied, this preventing a negative moment of the nose that might increase the weight borne by the wheel and cause more damage to the wheel strut. The aircraft was 53 seconds decelerating from touchdown to full stop, 40 of these with the nose wheel on the ground. Immediately on touchdown, the tyres deflated and were shredded, the rims contacting the runway, leaving a spray of sparks and being worn to the axle.

In view of the absence of any fire, the passengers disembarked by the usual procedure.

As soon as the aircraft landed, the nose wheel tyres deflated and were shredded, the two rims being worn down to the axle of the wheel and producing a great many sparks in the process. The aircraft suffered damage to the entire nose wheel support assembly, which was burnt.

The NTSB determined that the probable cause was the fatigue-induced failure of the anti-rotation lugs, as a result of repeated pre-landing test cycles. These allowed the nose wheels to deviate from the 0° position during retraction of the landing gear. A contributing factor was the design of the brake and steering control unit (BSCU) logic, which prevented the centering of the nose wheels. Also identified as a contributing factor was the absence of any procedure for attempts to be made to reset the BSCU system under these conditions.

The BSCU standards potentially affected by the JBU292 incident scenario are limited to L4.5 and L4.8. The current BSCU software standard (from L4.9b and onwards) have corrected the issue.

1.18.2. *Coating of runways with foam*

As has been pointed out above in sections 1.9.1 and 1.11.3, the crew of the aircraft asked the Seville approach control centre whether the airport had foam to cover the runway, the reply being that none was available.

The coating of runways with foam is contemplated in the Airport Services Manual, ICAO Doc. 9137-AN/898, Part 1 "Rescue and extinguishing of fires", Chapter 15, which is included as APPENDIX A to this note.

This issue was already dealt with by the CIAIAC as part of the investigation of the reference incident, IN-019/2005, with section "2.2. Landing" including a summary of that chapter, which is reproduced below:

"Part 1 of the ICAO Airport Services Manual, which refers to rescue operations and the extinguishing of fires, contains a specific chapter on the coating of runways with foam in the event of emergency landings, analysing: a) the theoretical benefits of coating runways with foam, *b*) coating techniques and c) the operational problems that this generates.

a) As regards the first of these aspects, the document points out that study of the available data on emergency landings performed on runways covered with foam, and not so covered, leads to the conclusion that applying foam has not significantly reduced the risk of fire or the magnitude of the damage suffered by the aircraft. Neither is there any evidence demonstrating that covering runways with foam provides any psychological benefit for the pilots.

b) Furthermore, this document indicates that fluoroproteinic foams and aqueous film forming foams (AFFF's) are not considered suitable for the purpose, due to their short drainage time, and states that proteinic foam should be used for these operations.

c) As regards the operational problems that such actuations pose, the following may be:

- A certain minimum time is required to coat the runway, during which period the aircraft must remain in flight.
- Application of the layer of foam on the runway should not be carried out using the vehicles of the airport's fire extinguishing service, unless it is possible to achieve the level of protection required of the airport with the rest of the vehicles.
- The foam application operations, and subsequent cleaning after the emergency, may have an impact on the capacity of the airport, especially if it has a single runway.

Finally, and as regards the question as to who is responsible for taking the decision to request coating the runway with foam, the document indicates that it must be the pilot in command or the operator of the aircraft.

In view of these considerations, it may be concluded that coating runways with foam does not provide any substantial improvement in safety conditions, and does pose major operational problems for airports. As a result, for several years the tendency among both operators and airports has been increasingly to rule out covering runways with foam in the event of an emergency landing, such that few airports currently have proteinic foam and the resources required for its application available".

Furthermore, ICAO Appendix 14 ("Aerodromes") and the "Technical Standards for the design and operation of aerodromes for public use" in force in Spain do not contemplate the rendering of such a service.

1.18.3. *Actions taken by the manufacturer*

Airbus has taken actions to incorporate the lessons learnt from the investigation of this incident and in particular:

- TSM (Trouble Shooting Manual) task 24-21-00-810-846 revised to facilitate capturing IDG connector faults: New entry in TSM "PFR with multiple failures of systems electrically supplied by a same side".
- ESPM (Electrical Standard Practice Manual) 20-48-23/20-48-24 and AMM tasks for repair of IDG 400VC revised: Repairs by shortening the cables no longer authorized (cables replacement required), and Individual contact pins replacement no longer authorized (all four pins replacement required)
- New BSCU standard L4-10 changes from a class 3 to a class 1 the L/G lever position fault. This new BSCU standard is available from end 2015, with associated retrofit Service Bulletin A320-32-1432.

1.19. Useful or effective investigation techniques

Not used.

2. ANALYSIS

2.1. Information on flight

On Wednesday April 20th 2011, the Airbus A320 aircraft registered as EC-GRH, operated by the company Vueling, took off from Barcelona airport at 19:02 h to fly the regular flight VY2220 to Seville Airport. On board there were 150 passengers, 4 passenger cabin staff and 3 technical crew members (one captain and two co-pilots, one undergoing training).

With the aircraft established at flight level 350, an amber warning (Master Caution) appeared at 19:29 h, accompanied by an ILS1 FAULT[12] message on the electronic centralised aircraft monitor (ECAM). At the same time the captain's primary flight display (PFD1) went completely blank. Seconds later, and without any corrective action having been taken, this warning cleared, the PFD1 was recovered and a new message appeared WHEEL NWS FAULT[13].

At 20:19 h, during final approach, a second warning L/G SHOCK ABSORBER FAULT[14] appeared on lowering the landing gear. At this moment the auto pilot (A/P), auto thrust (A/T) and flight director (FD) were lost, the navigation equipment remaining operable.

The emergency procedure corresponding to the WHEEL N. W. STEER FAULT[15] warning includes a note that establishes that if the L/G SHOCK ABSORBER FAULT is also displayed, there is a possibility that the nose wheels are turned 90° with respect to the longitudinal axis of the aircraft. This was confirmed from the control tower when the crew flew a low pass for that purpose.

The aircraft was authorised to carry out a direct ILS approach to runway 27 at 20:45 h, and three minutes later was authorised to land, with a 10 kt wind at 240°. During the landing, the aircraft remained on the centreline and decelerated correctly, coming to a halt on the runway at the junction with quick exit E3 and with the right-hand wheel of the nose landing gear burst. Once the absence of fire had been confirmed, the passengers disembarked using the normal procedure.

2.2. Aircraft behaviour

Section 1.16.2 has described the inspections and studies performed on the aircraft overall and on the items removed from it as a result of the incident and of warnings appearing during previous flights.

[12] CM1 ILS equipment failure.
[13] Failure of nose wheel steering system.
[14] Failure of landing gear shock absorber.
[15] A318/A319/A320/A321 Vueling FCOM, Abnormal and Emergency, Landing Gear, section 3.02.32, page 9.

This process underlined the coincidence in time of three independent faults on the same aircraft. It was possible to determine the cause of two of these faults, but not the cause of the third. In summary, the faults were as follows:

a) Voltage fluctuations in electrical circuits fed by phase C of the alternating current generated by IDG N.° 1

During the inspection of the alternating current feed system performed after the incident, very clear and characteristic signs of electrical arcing were found in one of the connectors of the bundle of cables connecting IDG N.° 1 to the electrical system of the aircraft, specifically the one corresponding to alternating current phase C, and in the corresponding connector terminal.

The study described in section 1.16.2.3.1 pointed to aspects relating to inadequate maintenance having resulted in incorrect condition of the contact elements and incorrect connecting plate position following disassembly/reassembly operations. This led to insufficient insertion of terminal C in its housing, probably being the primary cause of a deficient contact condition that led to the electrical current fluctuations that occurred.

b) Nose landing gear steering hydraulic control unit (HCU) locked in open position.

The study described in section 1.16.2.3.2 underlined on the one hand that the HCU presented a series of non-conformities with respect to the provisions of the component maintenance manual, which did not directly affect its operation, and, on the other, that the steering selector valve was stuck in the open position, probably due to the corresponding plunger not being in its correct position as a result of inappropriate assembly.

c) BSCU gear up signals from the landing gear control lever (LGCL).

The study described in section 1.16.2.3.4 showed that the corresponding fault had been registered on two different BSCU's installed on the aircraft, that the LGCL did not present any anomalies that might have given rise to the fault and that no anomalies were detected in the aircraft or in others in which these BSCU's were installed. It should be pointed out that the rest of the systems of the aircraft that use the LGCL position signal received it correctly. Consequently, it was not possible to determine the cause of this fault.

The study performed on the BSCU installed in the aircraft at the time of the incident, reflected in section 1.16.2.3.3, showed that the unit itself did not present any faults, but decoding of the information stored in its internal memory pointed to faults detected by it that would explain the WHEEL NWS FAULT warning, related to the fault described in a), and the L/G SHOCK ABSORBER FAULT warning related to the faults described in *a*) and *b*). Likewise, the fact that the wheels of the nose landing gear ended up turned 95° with respect to the longitudinal axis of the aircraft would be related to the three faults described.

Finally, the tests performed with the BSCU that was installed in the aircraft at the time of the incident and another laboratory unit confirmed the scenario in which it had occurred. The evidence encountered underlined the faults that had given rise to this event, but it has not been possible to draw any conclusions regarding their origin.

2.3. Crew performance

2.3.1. *Operational aspects*

According the declarations made by the captain, once they had received the WHEEL N.W. STEER FAULT warning, and after consulting with the FCOM 3, they were aware of the possibility of the nose wheel being deployed at 90° with respect to the longitudinal axis of the aircraft. As regards this possibility, the procedure establishes only that touching down of the nose wheel should be delayed as long as possible during the landing run.

When the landing gear was lowered and the L/G SHOCK ABSORBER FAULT warning signal appeared, the situation was confirmed, this being confirmed also with the help of the tower controller when the decision was made to fly a low pass.

As from this moment, the operation focussed on preparing for an emergency landing.

The crew declared that they remembered a previous event of similar characteristics that, in view of its spectacular nature, had been widely dealt with by the media and commented on by the aeronautical community, and that had affected another Airbus 320 operated by the company Jet Blue Airways at Los Angeles airport (United States of America) on September 21st 2005. The captain referred to this case as an example when explaining the situation to the cabin crew.

The Jet Blue flight touched down at 120 kt and applied normal braking at 90 kt. The nose wheel was kept in the air as long as possible, and the crew decided to shut down the engines at 60 kt. Neither ground spoilers nor automatic braking or reverse thrust were used.

From the data obtained from the graphic information on the touchdown of the Jet Blue flight it may be appreciated that the aircraft made a smooth landing, delayed the touchdown of the nose wheel to the extent possible and did not apply reverse thrust[16].

[16] This prevents a negative moment of the nose from causing greater downforce and increasing the damage to the strut.

It took 53 seconds to decelerate from touchdown to full stop, 40 of them with the nose wheel on the ground. As soon as the aircraft touched down, the tyres deflated and were shredded, and the rims rubbed against the runway, leaving a shower of sparks and wearing down to the axle.

In the case in hand here, touchdown was smooth, the manoeuvre of lowering the nose wheel to contact with the ground was delayed as long as possible and reverse thrust was applied. From the moment of touchdown to full stop, 34 seconds elapsed, 24 with the nose wheel on the ground. There was a lot of smoke but no sparks.

The Vueling crew decided to apply reverse thrust, thereby making the run much shorter. The time difference between the two cases is quite significant. The JetBlue aircraft took 17 seconds longer in decelerating, the nose wheel being kept up for 3 seconds longer than in the case of the Vueling flight, but 16 seconds more on the ground, bursting the tyres and causing sparks due to the friction of the rims, as a result of which the damage was more serious.

During preparations for the emergency landing, the crew of the Vueling aircraft considered the following aspects:

- Not reducing speed before the nose wheel was lowered, in order to maintain steering control with the rudder, this being contrary to what is indicated in the procedure.
- They read the landing checklist for abnormal landing gear configuration in the QRH (LDG WITH ABNORMAL L/G), this list not being applicable in this case, as pointed out in FCOM 3 "*The procedure is intended for use when the nose or main landing gear fail to extend and/or lock down following the application of the L/G GRVTY EXTN procedure*".

However, in QRH Rev 44D, of March 8th 2011, this note does not exist, although there is a precaution that establishes that this procedure will be applicable only if at least a green triangle is shown by the landing gear strut indication on the WHEEL page of the ECAM, which was the case as **they had no landing gear locking problems.**

From this list they extracted the following information:

- No use of automatic braking (autobrake) on touchdown.
- Check that the A/SKID & N/W STRG switch is in the Off position.
- Open the RAM AIR to depressurise the aircraft.
- Keep the nose up and then lower it before losing elevator control, as opposed to the instruction to keep the nose up as long as possible expressed in the WHEEL N/W STG FAULT procedure.
- Shut down the engines before touching down of the nose wheel (Engine masters off before the nose impact!). The captain commented to the co-pilot that this would leave them without reverse thrust, so they would switch off the engines when the

aircraft came to a halt. They discussed this important part of the procedure without leaving it clear how it would be carried out, the captain proposing that they shut off the engines when the nose wheel touched down, in order to be able to apply reverse thrust. Finally, the captain shut down the engines when the aircraft had practically stopped.

2.3.2. *Training*

To a large extent, training mitigates the appearance of errors in responding to emergencies. The need for a high degree of coordination among the members of the crew of the aircraft in responding to an off-normal situation requires a high level of training and preparation. A study by NASA confirms that there are a large number of errors in responding to emergencies not contemplated in the manuals compared to those that are dealt with correctly in the documentation.

The problem is that not all situations can be foreseen and that synthetic training resources (simulators) have their own limitations.

Additionally, the level of automation of aircraft may lead to pilots experiencing difficulties when flying manually, when required to do so in an emergency, since their skills are lost due to a lack of training and habit.

The design of the checklists should be evaluated in appropriate training scenarios, verifying that they facilitate effective handling by the crews.

Cabin resources management (CRM) training is probably the best context for the transfer of theoretical knowledge relating to checklists, as an essential tool within the framework of the man-aircraft interface.

Furthermore, the very reason for CRM is to be found in the processes of coordinating the members of a crew, this being the same essential element as is involved in consistently executing a checklist.

2.3.3. *Human limitations*

It should be borne in mind that the increased workload that exists in the cockpit in these situations, along with the critical nature of time constraints and the inevitable doubt as to the optimum response to the abnormality or emergency and its consequences, lead to a high level of stress that might affect human behaviour.

In these situations, crew errors and less than optimum responses may be linked directly to the limitations inherent to the human cognitive process. These limitations appear when people face threats, are in situations of stress or are overburdened with essential tasks. This may lead to the simplest things being omitted or overlooked in abnormal situations.

When affected by stress, human attention is narrowed, a phenomenon known as the tunnel effect (Bundensen, 1990). The tunnel effect consists of the capturing of stimuli from the environment being restricted, with the individual focussing on what stands out most and ignoring everything else. This means that a pilot under stress might pay attention only to an abnormal indication and not be aware of others that might be relevant to solving the situation.

Likewise, the retentive capacity of the memory is reduced, as a result of which analysis of the situation by the individual is limited.

Consequently, when stress and a heavy workload are experienced, crews are vulnerable to the possibility of not considering important indications relating to the situation and are susceptible to difficulties in associating different aspects of the available information that might give some sense to what is actually happening.

It is absolutely impossible to develop procedures and checklists that cover all possibilities. Nevertheless, both the manufacturer and the operator should analyse the weaknesses of the system and revise their procedures if they detect an abnormally high frequency of a given event.

2.3.4. *Crew performance*

In the case of the type of incident dealt with in this investigation, the manufacturer has detected 18 similar events, caused by 8 different sets of circumstances, including this one. This variety of underlying causes leads to the conclusion that a similar event might occur again in the future, and not necessarily for reasons already known.

From the performance of the crew in this case it may be deduced that, despite the successful resolution of the emergency, there was a sensation of anxiety and desire to place the aircraft in the best possible situation that led them to consider the indications provided by the written procedure as insufficient. As a result, they looked to a procedure that was not applicable in this case for guidance as to the best way to complete the landing. This procedure leads to conflicting situations or options being considered, options that, were they to have been implemented (engine shutdown), might have led to an outcome of the incident with worse consequences.

Likewise, the different possibilities for performing landings with this abnormality, observed in the different cases that have occurred, may help the manufacturer to obtain information as to which is the best technique to minimise the damage caused and increase the safety of the aircraft.

Different reference documents, among them most significantly the CAP 676 document by the United Kingdom's CAA[17], establish that both the manufacturer and the operator of the aircraft are responsible for working jointly in the process of designing, developing and modifying abnormal and emergency checklists in order to ensure that, following a fault, the system is left in an optimum configuration based on application of the best operational practice.

In view of what has been pointed out in the preceding paragraphs, it is proposed that a recommendation be made to the manufacturer of the aircraft for the development of a specific procedure for cases in which the wheels of the nose landing gear are turned through 90º, or are suspected to be in this configuration, in order to give confidence to the crews by providing instructions on the best landing technique to minimise damage and increase operational safety.

2.3.5. *Aircraft manufacturer's procedures*

The manufacturer's applicable procedures do not contemplate any action or include any note that might favour the possibility of foreseeing an incident during landing that would require the emergency evacuation of the aircraft and facilitate survival. For example, the option of depressurising the aircraft in order to facilitate the opening of the doors is not considered, and the possibility of the rear door ramps not being operable if the nose strut collapses and the aircraft is left inclined forward is not dealt with.

If errors are detected in the execution of the procedures, it is necessary to analyse them and consider possible modifications to the corresponding checklists. In such analysis it is essential that the factors causing and contributing to the errors be identified. In addition, it is necessary to consider the operating conditions of the crew at the moment in which the errors are made, the policies and procedures of the company and the design of the checklists and the location of the actions in them.

[17] CAP 676 "Guideline for the design, presentation and use of Abnormal and Emergency checklists" of the CAA (United Kingdom Civil Aviation Authority).

3. CONCLUSIONS

3.1. Findings

- The crew of the aircraft were adequately qualified and experienced and were in good physical conditions, and their licences, authorisations and medical certificates were valid and in force.
- The aircraft had been maintained in accordance with the established Maintenance Schedule and had a valid Certificate of Airworthiness and Certificate of Registration.
- The weight and centering of the aircraft were within the established limits.
- During the flight, the *WHEEL NWS FAULT* warning occurred, followed by the *L/G SHOCK ABSORBER FAULT* warning. The emergency procedures corresponding to each of these faults indicate that in the event of the other also occurring, the wheels of the nose landing gear might be left turned 90°.
- The operational documentation of the manufacturer of the aircraft includes recommendations for landing with the wheels of the nose landing gear turned 90° with respect to the longitudinal axis of the aircraft.
- The crew assessed the situation on the basis of the documentation available on board and their own experience, and decided to perform the landing in the way that seemed most appropriate to them at the time.
- The investigation performed on the components of the aircraft involved in the incident pointed to the coincidence in time of three independent faults affecting the same aircraft; it was possible to determine the cause of two of these, but not of the third.
- The evidence discovered during the investigation clarified the faults that had given rise to this incident, but it was not possible to reach any conclusions regarding their origin.
- The ground-air communications worked correctly at all times.
- The navigating aids used by the aircraft were operable and worked correctly at all times.
- Operations at Seville airport were suspended throughout the duration of the emergency; the airport services were kept on local alert and acted in accordance with the corresponding emergency plan.
- Throughout the entire landing run the aircraft remained along the centreline of the runway and came to a halt on the latter.
- The crew solved the emergency effectively. The aircraft sustained practically no damage and the passengers disembarked using the habitual means.

3.2. Causes

The incident occurred due to the wheels of the nose landing gear of the aircraft turning irreversibly to the physical limit of 95° with respect to their longitudinal axis, in the air and with the nose landing gear locked in the down position.

During the course of the investigation, it was determined that three independent faults giving rise to the incident had coincided in time, although it was not possible to determine their origin.

4. SAFETY RECOMMENDATIONS

During the course of the investigation it was appreciated that, although the emergency was dealt successfully, the lack of a specific procedure to address it produced a sensation of anxiety in the crew regarding the placing of the aircraft in the best possible configuration for a safe landing. As a result, they looked to a procedure that was not applicable in this case for guidance as to the best option to perform the landing. This led them to consider conflicting situations or options that, were they to have been implemented, might have led to an outcome of the incident with undesirable consequences.

Furthermore, in the different events that have occurred the crews have been seen to use different techniques for touchdown with this abnormality, and it has been seen that there is no action or note in the manufacturer's applicable procedures that might favour the possibility of foreseeing an incident during landing that would require the emergency evacuation of the aircraft.

In view of the fact that this type of situation might occur again in the future and that the existence of a specific procedure to address them would allow the crews to perform the landing more effectively and safely, the following Operational Safety Recommendation is issued:

REC 63/15. AIRBUS S.A.S. is recommended to develop a specific procedure for A320 type aircraft that contemplates the event of landing with the wheels of the nose landing gear turned 90° with respect to the longitudinal axis of the aircraft, or suspected to be in this position.