COPY Nr. __

**MINISTÉRIO DAS OBRAS PÚBLICAS, TRANSPORTES E COMUNICAÇÕES**

GABINETE DE PREVENÇÃO E INVESTIGAÇÃO DE ACIDENTES COM AERONAVES

**(G.P.I.A.A.)**

INCIDENT REPORT
WITH AN AIR LUXOR **AIRBUS**,
MODEL **A-320**, REGISTRATION

# CS-TQE

OCCURRED IN MADEIRA AIRPORT
ON THE 2ND OF JANUARY OF 2004



**TECHNICAL REPORT Nr. 01/INCID/2004**

**NOTE**

In accordance with Annex 13 to the International Civil Aviation Organisation Convention, Chicago 1944, Council Directive 94/56/EC, 21st NOV 1994, and nº 3, article 11th of Decree-Law nº 318/99, 11th AUG 1999, the sole purpose of this investigation is to prevent aviation accidents. It is not the purpose of any such accident investigation and the associated investigation report to apportion blame or liability.

## SYNOPSIS

During a departure preparation for a flight from Madeira to Oporto, on the 2nd of January 2004, at 20:48 UTC, after push-back from stand A06, while starting nr. 1 engine, the Air Luxor aircraft Airbus A-320, registration marks CS-TQE, suffered an unexpected and uncommanded nose landing gear retraction. The aircraft nose stroke the ground, on taxi lane A, suffering severe damage on nose gear doors, nose gear leg, forward fuselage and engine cowls.

The 6 crew and 172 passengers on board were unhurt and left the aircraft by themselves, using front passengers door. The ramp official, assisting the flight, was hit by the fuselage and suffered minor injuries.

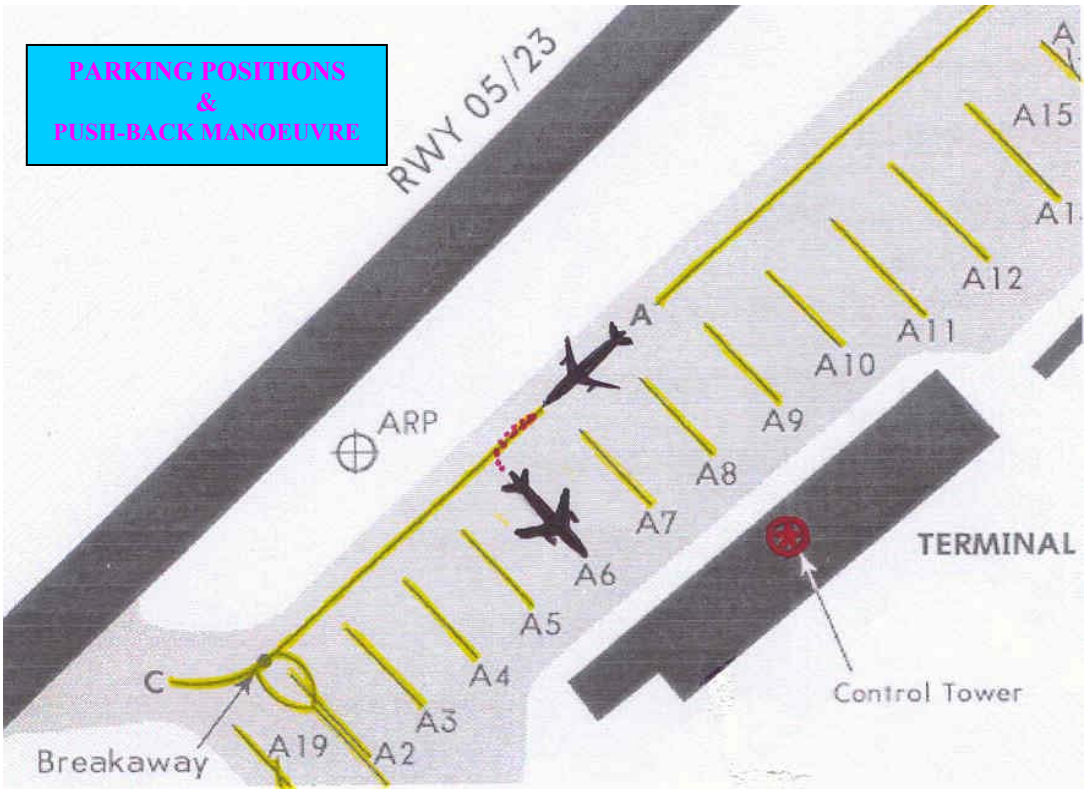
# 1. FACTUAL INFORMATION

## 1.1 HISTORY OF THE FLIGHT

On the 2nd of January 2004, an Airbus A-320 aircraft, registration marks CS-TQE, was parked on stand A06 at Madeira airport, preparing for a passenger's flight to Oporto.

Around 20:45 UTC[1], with 172 passengers and 6 crew members on board, the Captain initiated the departure procedures.

Once cleared from Tower (TWR), assisted by a ramp official, the Capt. initiated the "push-back" into taxi lane A (*picture nr. 1*), starting engine Nr. 2 during the manoeuvre.




**Picture Nr. 1**

[1] *-All time references in this report are UTC (Universal Time Coordinated). UTC Time = Local Time.*

Push-back completed and tow bar disconnected, the Capt started engine Nr. 1.

During engine #1 start, the ramp official noticed the aircraft nose was going down, smoothly first and then quickly, while nose gear was moving forward.

He ran away but was hit by the fuselage, getting minor injuries in his left arm and leg.

The nose down movement stopped only after the fuselage hit the ground and the wheels smashed the gear doors inside nose gear bay (*photos in annex A*).

At this time engine cowls contacted the ground and got damaged.

The flight crew shutdown both engines, called TWR, requesting assistance, passengers safety was guaranteed and, once the situation was clarified, the crew started a controlled disembarkation of all passengers through the front passengers door.

## 1.2 INJURIES TO PERSONS

No injuries were registered to crew and passengers. Only the ramp official got some minor injuries .

| INJURIES | CREW | PASSENGERS | OTHERS |
|---|---|---|---|
| **Fatal** | 0 | 0 | 0 |
| **Serious** | 0 | 0 | 0 |
| **Minor/None** | 6 | 172 | 1 |

## 1.3 DAMAGE TO AIRCRAFT

Due the collision with ground, nose gear and doors, front fuselage, nose gear lights, GPU connecting box and engine cowls were damaged.

## 1.4 OTHER DAMAGE

No other damage was registered.

## 1.5 PERSONNEL INFORMATION

The crew was composed by one captain, one first officer and four cabin assistants and all of them were dully qualified to operate this type of aircraft.

Flight crew information as table bellow:

| DESIGNATION | CAPTAIN | F / O |
|---|---|---|
| Genre | M | F |
| Age | 43 | 27 |
| Nationality | Portuguese | Portuguese |
| Type of license | ATPL | CPL |
| Validity of license | 2004/12/20 | 2004/12/18 |
| Date of last medical examination | 2003/11/13 | 2003/12/18 |
| Total flying hours | 8 687:40 | 2 042:20 |
| Total flying hours on type | 1 544:00 | 436:45 |
| Flying on last 30 days | 44:10 | 28:05 |
| Flying on last 7 days | 05:10 | 11:00 |
| Flying on last 24 hours | 01:40 | 01:55 |

## 1.6 AIRCRAFT INFORMATION

| AIRCRAFT | |
|---|---|
| Maker: EADS | |
| Type: Airbus | Model: A-320 |
| S/N: 221 | Made in: 1991 |
| MTOW: 77 000 kgs | Max. POB (crew/pax): 2+4/180 |
| Airworthy certificate nr.: 2453/1 | Issued by: INAC (Port. CAA) |
| Date of issue: 2003/07/02 | Validity: 2004/03/31 |

| ENGINES | | | |
|---|---|---|---|
| **DESIGNATION** | **Nr. 1** | **Nr. 2** | **APU** |
| **Maker** | CFM International | | |
| **Model** | CFM 56-5A3 | | N/A |
| **S/N** | 731506 | 731515 | |

| FLIGHT TIMES | | | | |
|---|---|---|---|---|
| **DESIGNATION** | **AIRFRAME** | **ENGINE 1** | **ENGINE 2** | **APU** |
| **TSN** | 37888 | 35670 | 34814 | N/A |
| **TSO** | N/A | 1875 | 1341 | N/A |
| **LAST INSPECTION** | 2003/10/28 | | | |

## 1.7 METEOROLOGICAL INFORMATION

It was a clear night with wind 050/11 kts, QNH 1024 and Temp. 16º C.

Not relevant for the occurrence.

## 1.8 AIDS TO NAVIGATION

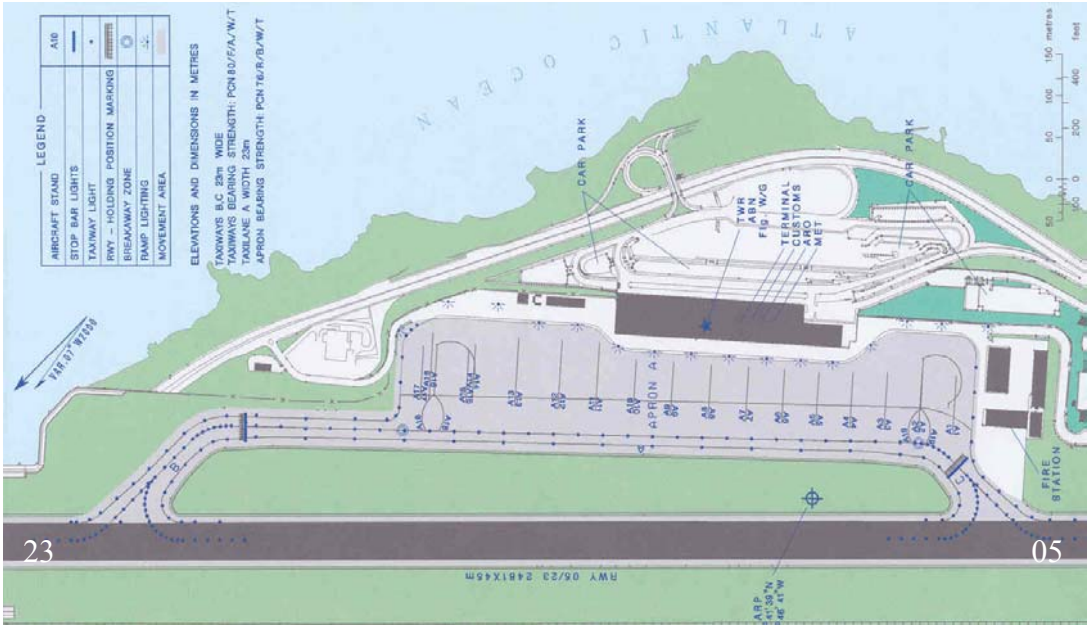
Not applicable.

## 1.9 COMMUNICATIONS

Not applicable.

## 1.10 AERODROME INFORMATION

Madeira International Airport has a 2481 x 45 metres runway and an apron with 15 narrow body aircraft capacity, with two opposite taxiways to access the runway (*picture nr. 2*).




**Picture Nr. 2**

Neither airport configuration nor airport operational procedures were relevant for this occurrence.

## 1.11 FLIGHT RECORDERS

Flight recorders:

- DFDR – Allied Signal P/N 980-4700-003, S/N 4148
- VCR – Fairchild A 100A, P/N 93-A100-80, S/N 52153

were removed from the aircraft and submitted to decoding and analysis by certified organisations in order to retrieve the necessary information.

CVR data was inconclusive and DFDR had no information regarding electric power generators. Even so, it was possible to determine the exact moment of gear unlocking and retraction and compare it with engine parameters evolution, ascertaining that the uncommanded gear retraction happened when engine nr. 1 was accelerating through 15% N1.

## 1.12 WRECKAGE AND IMPACT INFORMATION

Nose gear doors remained closed and were smashed by the wheels, retracting inside the nose wheel bay, confirming the uncommanded gear operation.

All other damages were in accordance with aircraft geometry and event's succession. No detached parts were present.

## 1.13 MEDICAL AND PATHOLOGICAL INFORMATION

Not applicable.

## 1.14 SURVIVAL ASPECTS

Not applicable.

## 1.15 FIRE

There was no fire.

## 1.16 TESTS AND RESEARCH

### 1.16.1 Aircraft

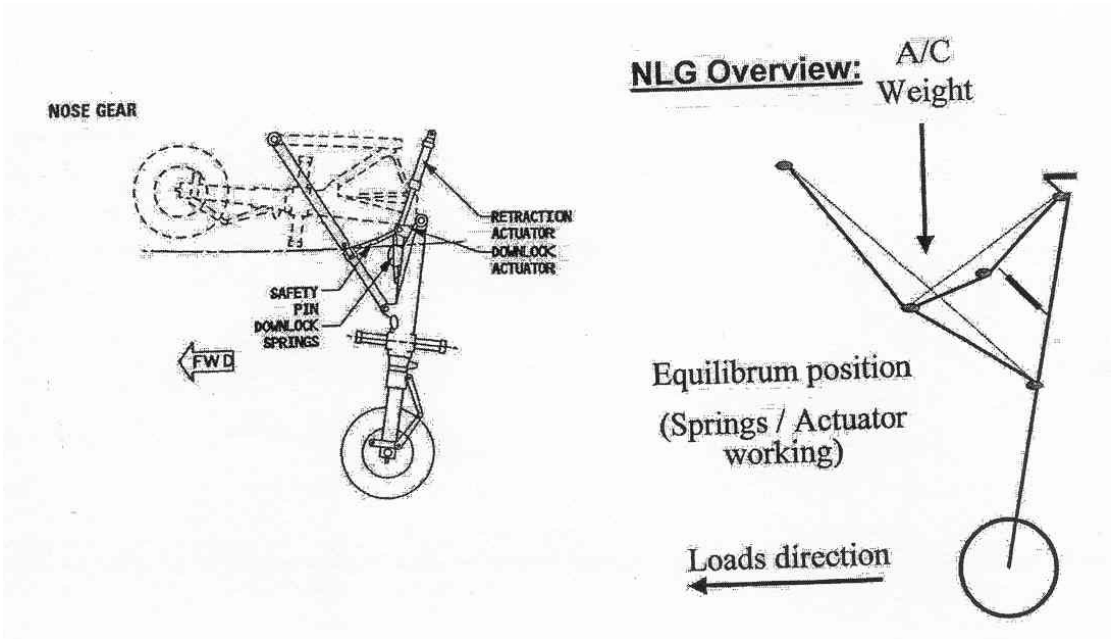
After passengers and crew disembarkation, the aircraft was lifted with pneumatic bags and as the aircraft was rising the nose gear was descending freely until it locked down.

Once an evaluation of damages and recommended repair actions were performed, the aircraft flew to Toulouse where complementary tests started, trying to replicate the chain of events.

The occurrence could not be reproduced, but serious clues indicated a hydraulic malfunction, so the landing gear selector valve was removed and sent to the factory (Smiths Aerospace) for further checks.

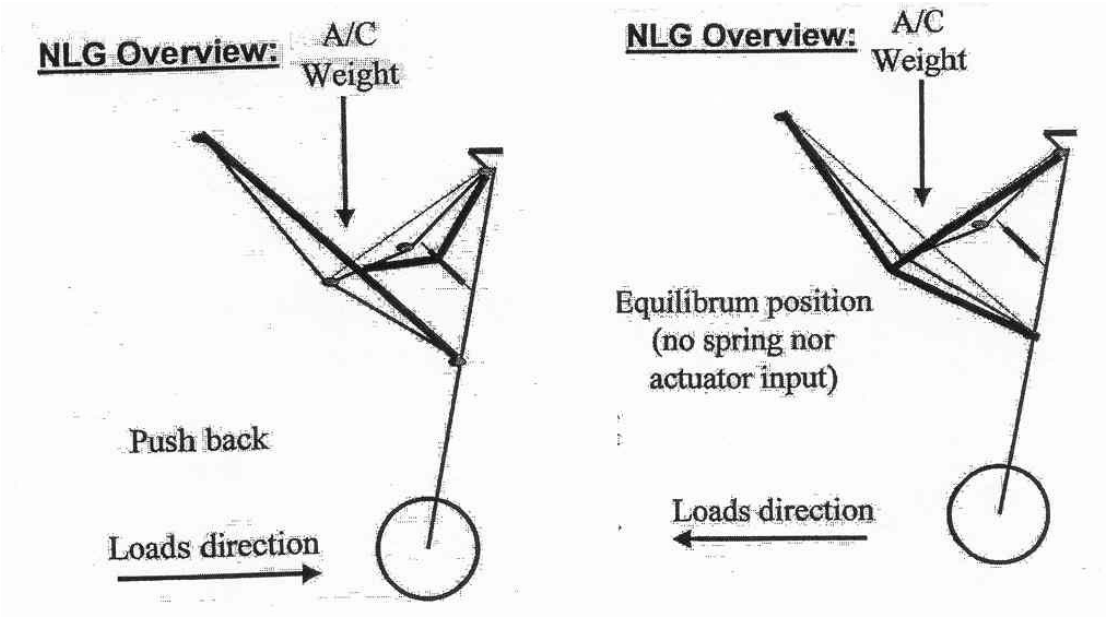
### 1.16.2 Landing gear

Landing gear geometry grants that, once locked down, the gear can not be raised unless the hydraulic system is operated to deactivate the down locks and undo the geometric locks (*pictures 3 & 4*).



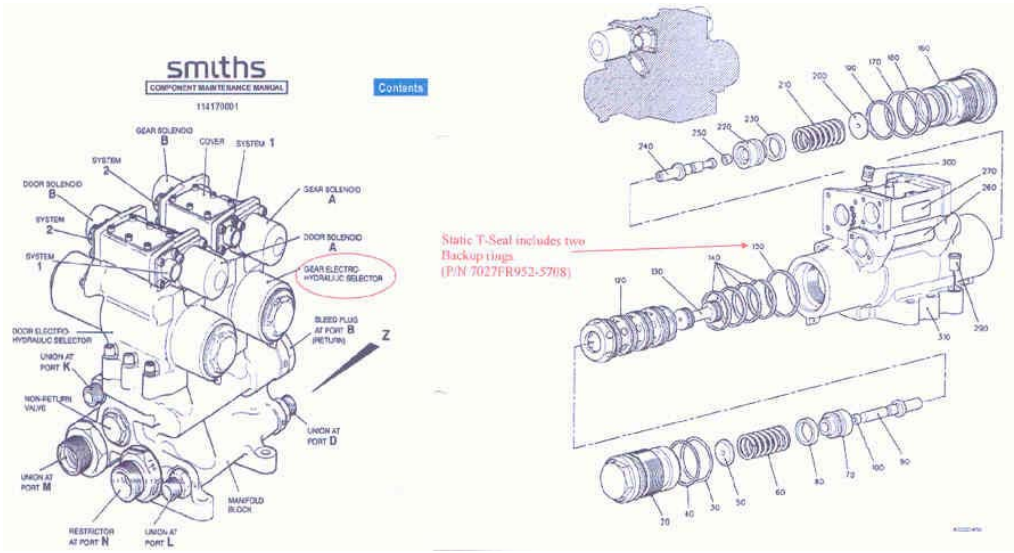

**Picture Nr. 3**

Even during push-back or other ground manoeuvres, this geometry grants the gear locking and makes impossible its mechanical retraction (*picture nr. 4*), unless there is a structural failure.




**Picture Nr. 4**

Taking into account these principles we shall investigate the hydraulic operation of landing gear, more precisely the landing gear selector valve (*picture nr. 5*), looking for clues.




**Picture Nr. 5**

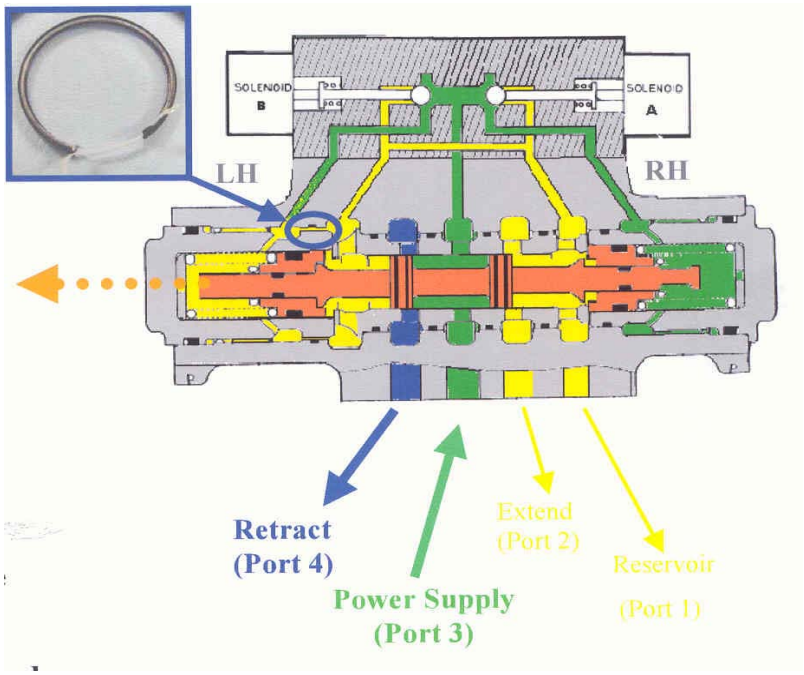
### 1.16.3 Landing gear selector valve

Once removed from the aircraft, the valve was sent to the manufacturer (Smiths Aerospace) were it was submitted to complementary tests.

After disassembly (*picture 5 & 6*) an installation error was detected regarding a sealing ring (*P/N 7027FR952-5708*).

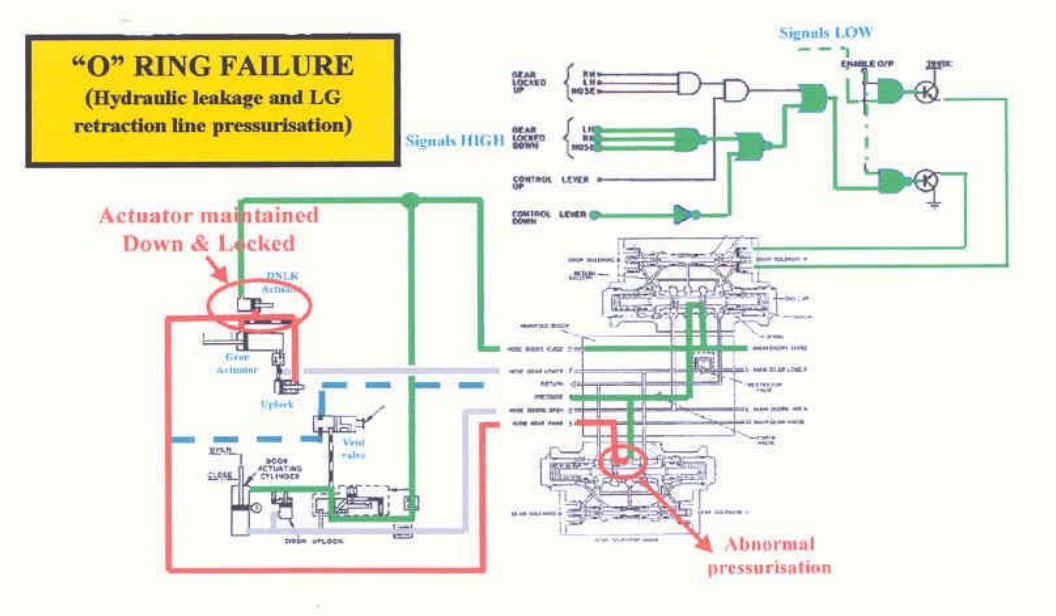

**Picture Nr. 6**

This irregularity allowed the oil to pass into return line and actuate the valve, pressurising the gear retraction line (*picture 7*).




**Picture Nr. 7**

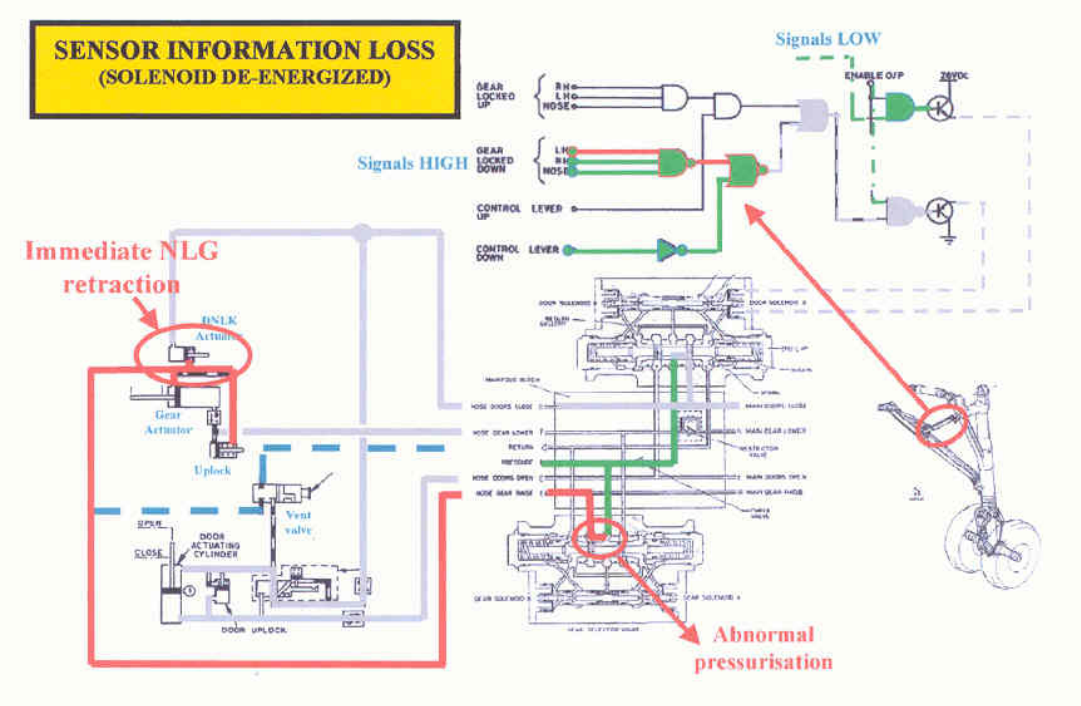
Even so, this pressurisation should be no sufficient to raise the gear because the LG doors closing line should be pressurised and securing the LG downlocks (*picture 8*), once "A" solenoid was supposed to be energized.




**Picture Nr. 8**

Afterwards, Airbus technicians continued the investigation looking for the cause for the downlock to be withdrawn.

During complementary tests a proximity sensor on LHM gear strut was found momentarily deficient, suggesting it could de-energize the valve solenoid and permit a pressure drop in door closing line, allowing the NLG downlock to be withdrawn by gear raising pressure (*picture 9*).




**Picture Nr. 9**

This erratic failure, in conjunction with abnormal pressurisation of gear retraction line (due to sealing ring anomaly) could lead to the uncommanded gear retraction.

### 1.16.4 Documentation

Aircraft technical log was checked, looking for previous reports regarding landing gear abnormal behaviour, but no such registries were found, concluding this was the first event. Electronic recordings (NVM devices) were also checked and no previous anomalies were found.

## 1.17 ORGANISATIONAL AND MANAGEMENT INFORMATION

### 1.17.1 Operations & management

The operator is an air transport carrier, dully licensed, owning an Air Operator Certificate (AOC) issued by Portuguese Civil Aviation Authority (INAC), and all its operations are carried according national and international requirements, as laid down on its Flight Operations Manual (FOM), observing JAR-OPS 1 guidelines.

No deviation was found in relation to those principles and requirements, which could contribute to this incident.

### 1.17.2 Maintenance

Aircraft and equipments maintenance is granted by the operator and it is performed in house or by contracted enterprises, according Maintenance Management Exposition (MME) (approved by INAC), following aircraft maker specifications and recommendations.

There is no evidence of any malpractice or omission that could be associated to this occurrence.

The inspection carried out by Smiths Aerospace confirmed an installation flaw during selector valve manufacture process.

## 1.18 ADDITIONAL INFORMATION

There is no other information to report.

## 1.19 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

All evidence and information regarding this report were obtained by the Investigating Team directly or through recognized and certified entities.

# 2. ANALYSIS

## 2.1 GENERAL

The crew followed all normal and recommended procedures laid down on Aircraft Flight Crew Operating Manual (FCOM) and Company SOPs.

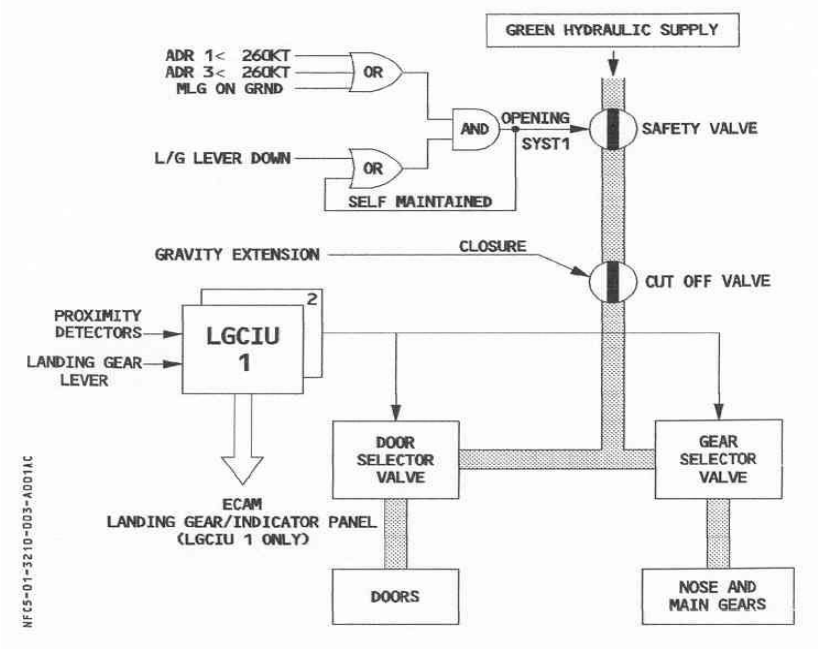
Gear lever was selected to "*gear down*" position and no other selection was performed.

## 2.2 NORMAL OPERATION OF LANDING GEAR

### 2.2.1 General

A-320 landing gear comprises two main legs, retracting sideways inboard, and a nose leg, retracting forward. Wheels are stowed inside respective bays, enclosed by hydraulic actuating doors.

**(Landing gear operation – Schematic)**




**Picture Nr. 10**

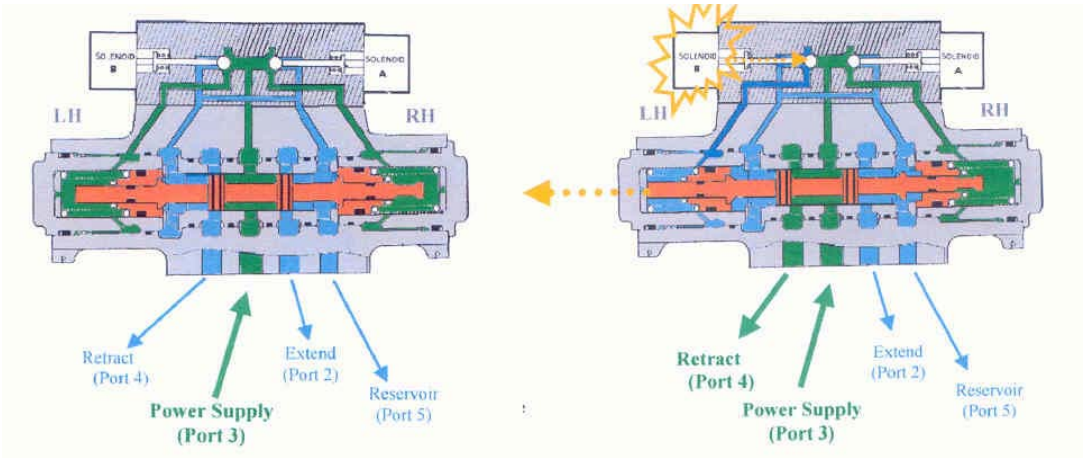
Landing gear is hydraulically actuated, but electrically controlled through two electronic units (LGCIU), which automatically switch over from one to another, after each complete gear cycle or in case of failure.

Every LGCIU controls gear retraction and extension, coordinates doors movement, provides gear indications and sends signals to other systems operation.

In case of electrical or hydraulic failure the gear can not be raised but it is possible to mechanically extend it.

### 2.2.2 Pressurisation of gear retraction line

Gear retraction line is pressurised when gear selector valve is activated, by energizing "B" solenoid (*picture 11 "B"*).




**"A"**
**Valve Neutral**

**"B"**
**Gear retraction**

**Picture Nr. 11**

This solenoid is activated when gear selector lever is positioned to "*up*" and gear doors reach the "*open*" position.

With gear retracting line pressurised, downlocks are withdrawn and gear raises.

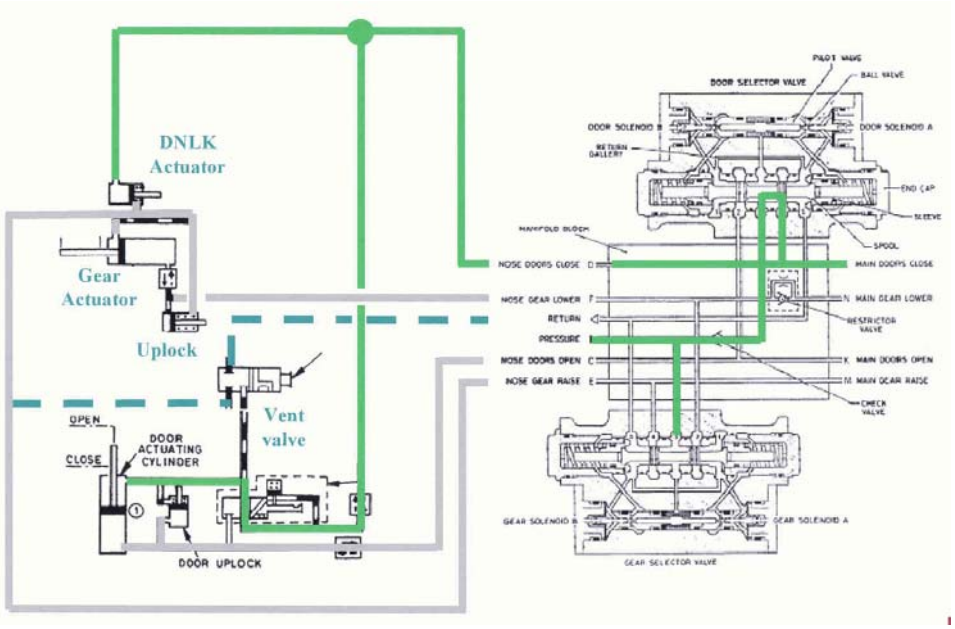
Once retracted and uplocks set, the solenoid is deactivated and the line is depressurised

### 2.2.3 Gear doors solenoid operation

Gear doors are operated by the doors selector valve, which is controlled by the activation of respective solenoids ("A" to close and "B" to open).

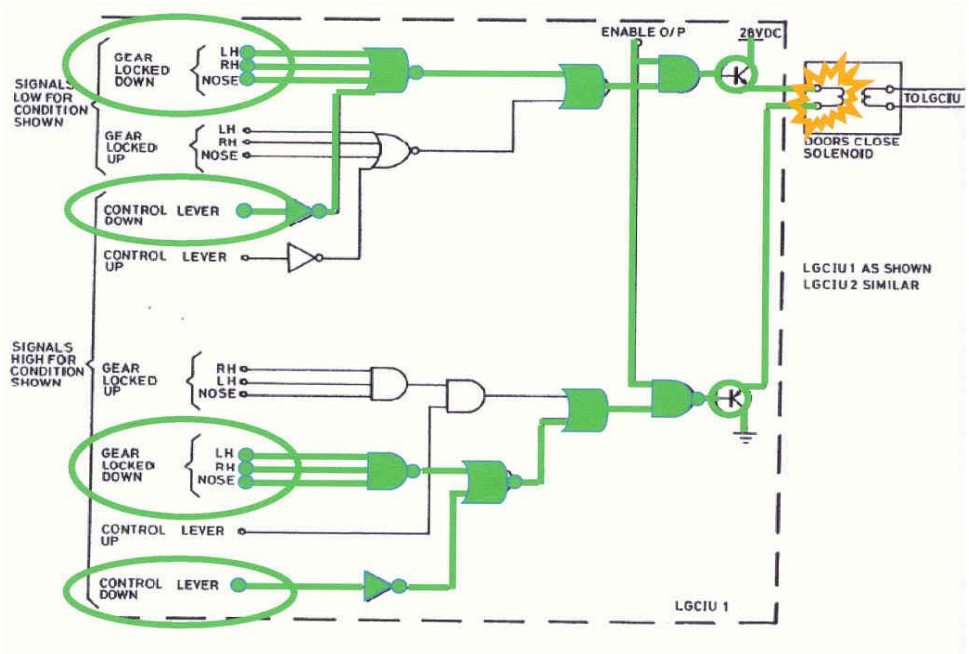
The activation of these solenoids is determined by the active LGCIU, depending from gear lever selections and dedicated sensors signals.

When the aircraft is on the ground, with gear down and locked (*picture 12*), the active LGCIU sends a command to energize the "A" solenoid and pressurise the line to close gear doors and keep gear downlocks set. The line is kept pressurised in order to allow nose wheel steering operation.




**Picture Nr. 12**

Picture 13 shows schematic and logical arrangement of sensor signals that energizes the solenoid "A", which activates closing doors operation.




**Picture Nr. 13**

Every LGCIU has an independent set of sensors and a built-in control & assessment system which, in case of any malfunction or sensor failure, transfers control to the other unity (***A-320 FCOM 1.32.10 – Landing gear system interface***). This provides a reliable system.

For a solenoid and respective valve malfunction to occur, it is necessary to have a double failure.

## 2.3 UNCOMMANDED GEAR OPERATION

According landing gear conception and geometry, it's necessary to pressurise the retraction line and withdraw gear downlocks in order to raise the gear.

This is normally performed by selecting LG selector lever to "UP".

As there was no LG lever selection (it remained in "DOWN" position) the occurrence has to be classified as an uncommanded gear retraction due to an extraordinary chain of events.

### 2.3.1 Abnormal pressurisation of gear retraction line

For the retract line to be pressurised, the gear control valve core must move to the left (*picture 11*). This is achieved when command pressure drops on left side (normally accomplished by energizing "B" solenoid).

As we mentioned on 1.16.3, the faulty seal (*P/N 7027 FR 952-5708*) was responsible for this to happen (*picture 7*) and the line was pressurised (*picture 8*).

Even so, this fault was not enough for the gear to be raised. Pressure in gear doors closing line was sufficient to keep gear downlocks activated and prevent gear retraction. A pressure drop, in this line, was needed to allow the downlocks to be withdrawn (*picture 9*).

### 2.3.2 Unexpected de-energizing of gear doors operation valve "A" solenoid

Door operating valve solenoids are commanded by either LGCIU, in response to gear lever selection and dedicated sensor signals (*picture 13*).

During tests carried on by Airbus, one of these sensors (*LH main gear down and locked*) was detected faulty, in some circumstances, and it was considered

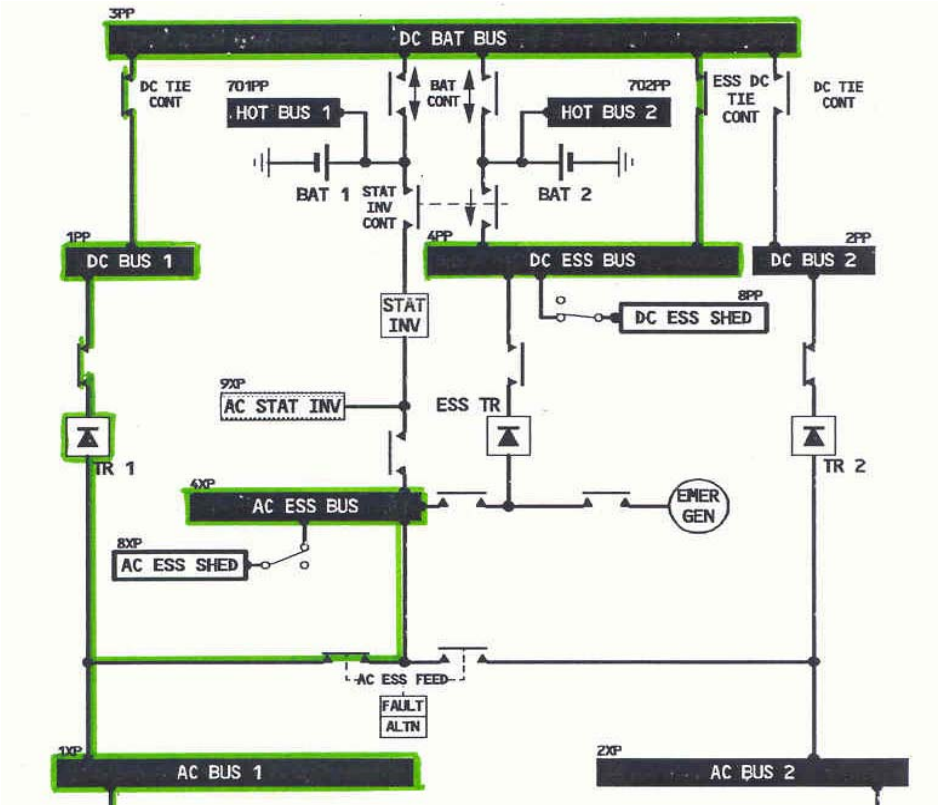
this could induce the solenoid de-energizing and cause a drop in door closing line pressure, allowing LG downlocks withdrawal and making LG retraction possible.

This seems to be a hasty conclusion, considering there are two LGCIUs with independent sensors, any LGCIU will switch over to the other, in case of malfunction or sensor signal loss, and a warning will be displayed in cockpit.

After checking all technical reports and repair and maintenance orders no registry of any LG malfunction was detected. In addition there is some information confirming these sensors have been adjusted during tests performed at Madeira airport before ferry flight of the aircraft to Toulouse.

### 2.3.3 Aircraft electrical system behaviour

As per aircraft electrical system the LG doors operating valve solenoids are fed by "DC ESS BUS", which is normally powered by "AC BUS 1" (*picture 14*).



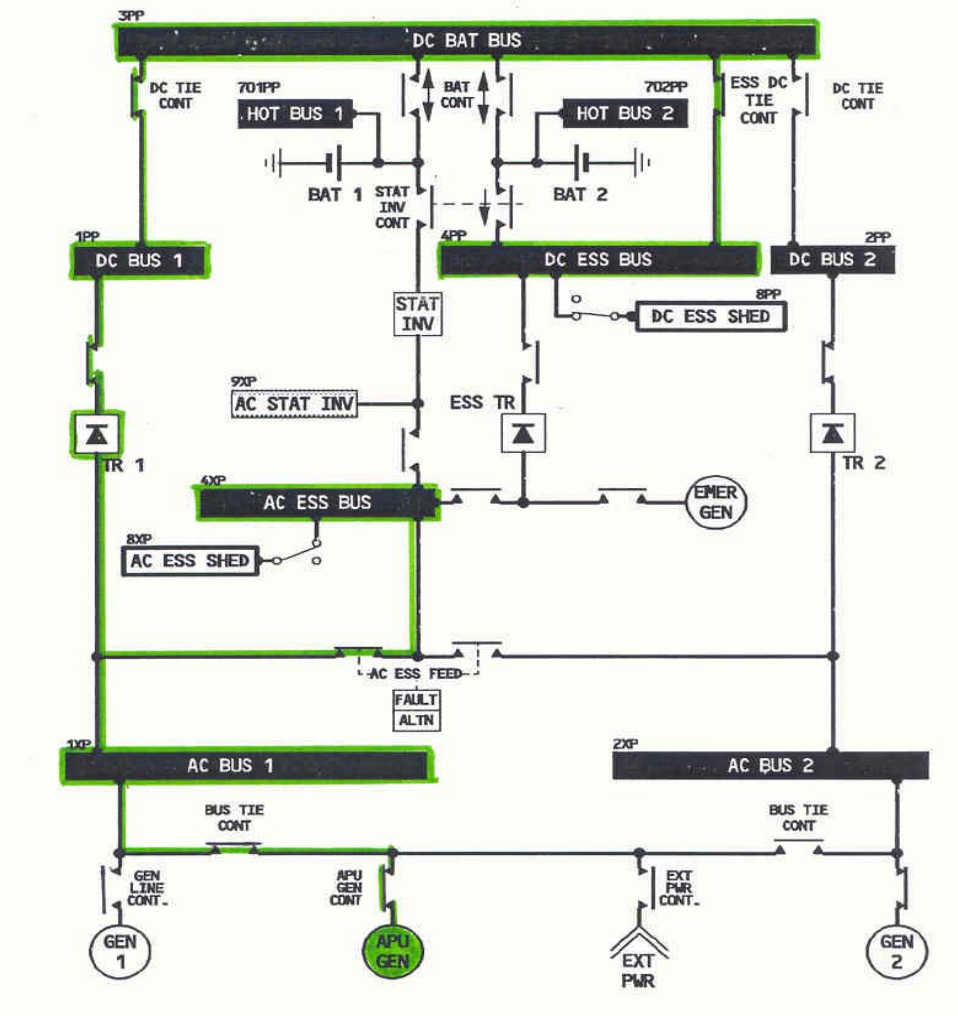

**Picture Nr. 14**

As stated by Airbus philosophy, engine generators have priority over APU or GPU generator and the same bus can't be fed simultaneously by two different sources.

So, prior to switch on one generator to one bus, the previous source has to be disconnected.

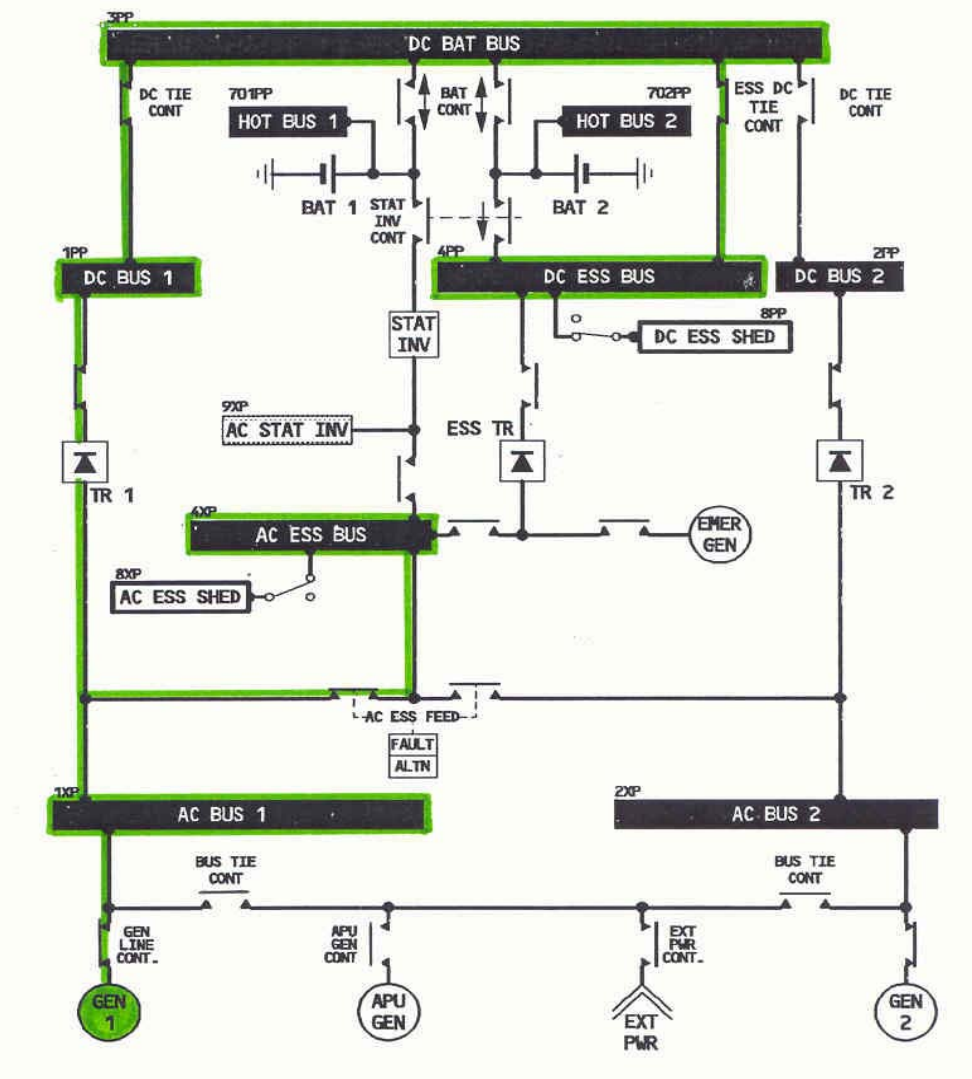
At stand, the aircraft electrical system was powered by the APU generator.

During push-back, AC BUS 1 was powered by APU and AC BUS 2 was power by APU, until engine 2 was started and accelerated to a regime where engine generated electrical power reached the necessary properties to supply AC BUS 2 (*picture 15)*.



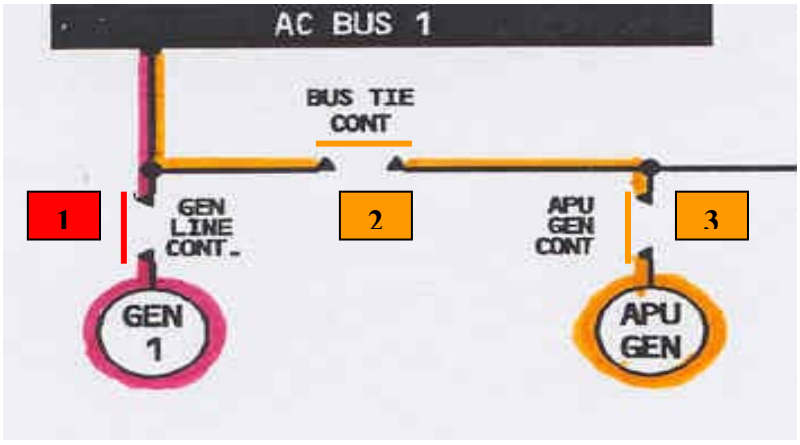

**Picture Nr. 15**

Once finished the push-back, Capt started engine #1 and, as soon as current met required properties, generator #1 automatically switched over and started feeding AC BUS 1, whilst APU generator was disconnected from operating buses (*picture 16*).




**Picture Nr. 16**

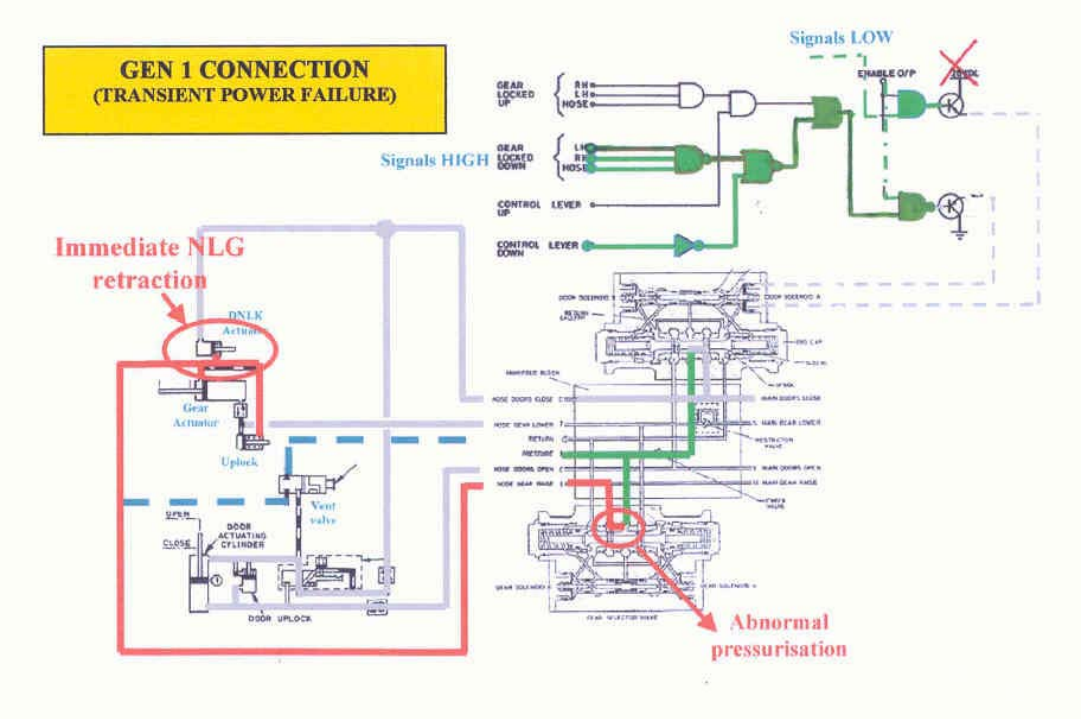
Whenever there is a power transfer, there is a transient, momentary period, during which the respective bus is not powered (*picture 17*).




**Picture Nr. 17**

When engine #1 was started and GEN 1 got ready to supply AC BUS 1 (*picture 17*), the BTC (2) was opened, cutting APU power from AC BUS 1, thus allowing GLC (1) to close and feed AC BUS 1, without mixing currents from different generators.

At that precise moment AC BUS 1 and, consequentially, DC ESS BUS were unpowered and the LG doors operating valve solenoid "A" was de-energized. LG doors selector valve reverted to neutral position and hydraulic pressure in doors closing line dropped momentarily. LG retracting line abnormal pressure could then withdraw LG downlocks and NLG was retracted (*picture 18*).




**Picture Nr. 18**

These transients are common with this kind of electrical system and they never let a registry on flight recorders, which may explain the absence of landing gear malfunction or abnormal indication reports.

# 3. CONCLUSIONS

## 3.1 FINDINGS

3.1.1 The crew was qualified to operate the aircraft and acted within their capacity and competence.

3.1.2 No crew action was detected as having contributed to the occurrence.

3.1.3 The aircraft was operative and certified for this kind of operation.

3.1.4 No registry was found relating abnormal operation or faulty indication of landing gear, before the incident.

3.1.5 Push-back manoeuvre and engine #2 start up were normal and within recommended operation procedures.

3.1.6 Engine #1 was started after push-back, with aircraft still and brakes set.

3.1.7 During engine #1 start (15% N1) nose landing gear suffered an unexpected and uncommanded retraction.

3.1.8 No gear lever actuation was performed during this manoeuvre.

3.1.9 Tests performed couldn't replicate the occurrence but showed some default in the system.

3.1.10 During complementary tests, performed by manufacturer, a faulty seal was detected in landing gear selector valve.

3.1.11 This anomaly was due to a deficient manufacture process.

3.1.12 This anomaly induced an abnormal pressurisation of landing gear retracting line.

3.1.13 Complementary tests, performed by Airbus, detected an erratic fault on a LHM gear sensor.

3.1.14 DFDR registry shown the nose gear unlocking and retraction occurred during engine #1 starting, when N1 reached 15% RPM.

3.1.15 At this regime usually occurs the AC BUS 1 power transfer from APU GEN to ENG #1 GEN.

3.1.16 During a GEN power transfer there's a momentary period of power loss in the associate buses.

3.1.17 This transient power loss could momentarily de-energize the LG doors selector valve "A" solenoid and allow the LG downlocks withdrawal.

## 3.2 CAUSES AND CONTRIBUTING FACTORS

Considering landing gear geometry and conception philosophy, in view of all protections introduced in the system and the absence of gear selector lever actuation, the Investigation Commission concluded that the unexpected and uncommanded nose gear retraction was due to a combination of two factors:

1 A faulty seal (P/N 7027 FR 952-5708), resulting from a defective manufacture process, allowed an abnormal pressure build up in landing gear retracting line ;

2 The landing gear downlocks withdrawal, most probably caused by a momentary de-energizing of landing gear door's selector valve "A" solenoid, during the transient period of power transfer from APU GEN to ENG #1 GEN.

This combination created the necessary condition for the nose landing gear to be retracted, without intentional pilot action.

## 4. SAFETY ACTION

In view of these findings and considering that the recommendations 4.2, 4.3 and 4.4 stated in SCF/SYS/N/09/7430 have been implemented, the Investigation Commission recommends that Airbus issues a Service Bulletin to mandate all operators, using the same type of landing gear selector valve, to perform an inspection of static seals for any assembly fault.

Lisbon, 2005/10/24

The Investigator In Charge,

A. A. Alves

# INDEX

# INDEX (continued)