CIAIC

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Report IN-010/2017

Incident involving an AIRBUS 330-243 aircraft, registration G-VYGL, operated by AirTanker Ltd at the Tenerife South airport on 27 June 2017.

GOBIERNO DE ESPAÑA

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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) nº 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.

Contents

Abbreviations

°C	Degrees centigrade
ACC	Area control center
ADIRU	Air data inertial reference unit
AMSL	Above mean sea level
APP	Approach control service
APU	Auxiliary power unit
ARINC	Aeronautical Radio, Incorporated
ATIS	Automatic terminal information service
ATPL(A)	Airline transport pilot license (airplane)
BITE	Built-in test equipment
BSCU	Braking and steering control unit
CAS	Calibrated airspeed
CPL(A)	Commercial pilot license (airplane)
EASA	European Aviation Safety Agency
ECAM	Electronic centralized aircraft monitoring system
FCOM	Flight crew operating manual
FI(A)	Flight instructor rating (airplane)
FL	Flight level
FO	First officer
fpm	Feet per minute
ft	Feet
GCTS	Location indicator for the Tenerife South airport
GS	Ground speed
h	Hours
hPa	Hectopascals
Hz	Hertz

IAF	Initial approach fix
IAS	Indicated airspeed
IFR	Instrument flight rules
ILS	Instrument landing system
IR(A)	Instrument rating (airplane)
Kg	Kilograms
Kt	Knots
LDR	Landing distance required
LV	Low visibility
m	Meters
mb	Millibars
ME	Multi-engine
MEP(A)	Multi-engine piston rating (airplane)
METAR	Meteorological aerodrome report
MHz	Megahertz
Min	Minute
MRTT	Multi-role tanker transport
MTOM	Maximum takeoff mass
N	North
ND	Navigation display
NM	Nautical miles
P/N	Part number
psi	Pounds per square inch
QAR	Quick access recorder
QNH	Altimeter sub-scale setting to obtain elevation when on the ground
RWY	Runway
SEP(A)	Single-engine piston rating (airplane)

s	Seconds
SE	Single-engine
SD	System display
S/N	Serial number
SP	Single pilot
SSE	South-southeast
T	Tons
TDZ	Touchdown zone
TWR	Tower
TRI	Type rating instructor
UTC	Coordinated universal time
VMC	Visual meteorological conditions

Synopsis

Operator:	AirTanker Ltd
Aircraft:	Airbus A-330-243
	Registration G-VYGL
Date and time of incident:	27 June 2017 at 12:40 UTC[1]
Site of accident:	Tenerife South airport
Persons on board:	329, not injured; 3, minor injuries
Type of flight:	Commercial air transport – Scheduled – International – Passenger
Flight rules:	IFR
Phase of flight:	Landing – Landing run
Date of approval:	30 January 2019

Summary of event:

On Tuesday, 27 June 2017 at 12:40 UTC, an Airbus A-330-243 aircraft, registration G-VYGL and operated by AirTanker Ltd with 332 persons on board, experienced a blowout of the four rear main gear tires while landing at the Tenerife South airport, after which the aircraft continued traveling on the runway until it came to a stop.

After the firefighters responded, all the passengers were disembarked normally. The wheels and brake assemblies on the affected tires were damaged, as was the pavement. The runway remained closed for 5.5 h, after which the aircraft was towed and parked on the apron.

The investigation focused primarily on the manufacturer's analysis of the main components in the braking system, and specifically on the braking and steering control unit, the servo valves and tachometers on the affected wheels.

[1]. All times in this report are in UTC. The local time in the Canary Islands is UTC + 1.

1. FACTUAL INFORMATION

1.1. History of the flight

On 27 June 2017, an Airbus A-330-243 aircraft, registration G-VYGL, operated by AirTanker LTD, was flying from the Manchester airport (United Kingdom) to the Tenerife South airport (Spain). Its callsign was EXS917. On board were a total of 332 people: 11 crew and 321 passengers.

The aircraft had taken off from Manchester at 08:37 UTC and the flight lasted approximately 4 h. At 12:40 UTC, after touching down on runway 07 at the Tenerife South airport, and without the pilot taking any action to cause it, the four rear main landing gear wheels suddenly and simultaneously locked. The aircraft continued traveling until it came to a stop on the runway, causing the tires on said wheels to blow out. There was also damage to the gear structure and to the associated rims.

The friction between the tires and rims left marks on the asphalt that were approximately 1000 m long.

After being assisted by the airport firefighters and determining that no fire had broken out, the passengers were disembarked and the baggage containers were removed, after which tractors were used in an unsuccessful attempt to move the aircraft. It was then decided to replace two of the damaged wheels with spare wheels that were transported on board the aircraft. This required using two large capacity cranes to raise the aircraft and place a jack underneath the wheels, which allowed wheels 5 and 7 to be replaced.

Once the wheels were replaced, the aircraft was towed along the runway to the parking stand. The runway was reopened at about 18:10 UTC.

The flight recorders were then removed and the aircraft examined with support from Airbus technicians.

The aircraft remained parked until 9 July, when it was transferred to the United Kingdom on a low-level flight with the gear down for subsequent repair.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal				
Serious				
Minor				
None	11	321	332	
TOTAL	11	321	332	

1.3. Damage to aircraft

The aircraft sustained damage to its four rear tires and their associated rims, as well as to the main gear. There was also slight damage to the inboard flap and the corresponding fairing on the left wing.

1.4. Other damage

There was damage to the pavement along the path taken by the aircraft caused by the rims on the locked wheels.

1.5. Personnel information

The aircraft's captain, a 46-year old British national, had an ATPL(A) license issued by the United Kingdom's Civil Aviation Authority on 15 September 2010, with the following ratings:

- TRI A330/350 valid until 31 March 2020
- TRI A320 valid until 31 March 2020
- A320/IR/LV valid until 31 December 2017
- A330/350/IR/LV valid until 28 February 2018

He also had a class-1 medical certificate that was valid until 8 June 2018. He had a total of 13,500 flight hours, of which 800 had been on the type.

The aircraft's copilot, a 28-year old British national, had a CPL(A) license issued by the United Kingdom's Civil Aviation Authority on 11 July 2008, with the following ratings:

- FI(A) valid until 31 January 2018
- SEP(land) valid until 31 December 2017
- MEP (land) valid until 31 August 2017
- IR/SP/ME class/SE valid until 31 August 2017
- A330/350/IR/LV valid until 28 February 2018

He also had a class-1 medical certificate that was valid until 14 April 2018. He had a total of 3,600 flight hours, of which 30 had been on the type.

1.6. Aircraft information

The Airbus A-330-243 aircraft, registration G-VYGL and serial number 1555, has a certificate of airworthiness issued by the British Civil Aviation Authority on 9 March 2016. The aircraft was manufactured in 2013 and has two ROLLS-ROYCE RB211 Trent 772B-60 engines. It has a MTOM of 233,000 kg.

At the time of the incident, it had an airworthiness review certificate that was valid until 8 March 2018. It had about 1000 flight hours.

The aircraft had originally belonged to Airbus Defence and Space and was sold to the company AirTanker Ltd[2], its current owner, in 2016.

Although listed in the civil aircraft registry, the aircraft has a configuration known as MRTT (Multi-Role tanker Transport), and has an EASA certification and equipment supplied by Airbus Defence and Space to carry out air-to-air refuelings, transport passengers and cargo, and do medical evacuations. These operations are carried out by AirTanker primarily for the Royal Air Force and Armed Forces of the United Kingdom.

Figure 1. Aircraft G-VYGL

[2]. At the time of the incident, the aircraft was being operated under a lease agreement to the airline Jet2.

The positions of the main landing gear wheels are as shown in Figure 2.

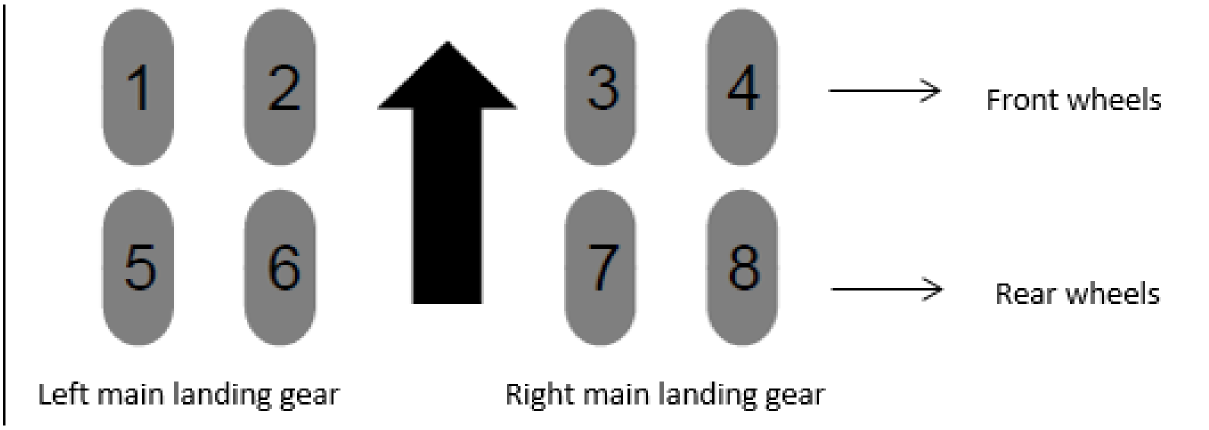

Figure 2. Arrangement of main gear wheels

The maintenance records provided by the company show that the most recent activities before the incident involving the main landing gear, in keeping with the approved maintenance program, were as follows:

- Detailed inspection of the gear crossbar (25/07/16).
- Detailed inspection of the gear pivot pin (06/09/16).
- Functional verification of the nitrogen pressure charge in the struts (17/11/16).
- Visual inspection of the locking springs, axis sheathes, struts, buffer stop and flow regulator control valve (11/05/17).
- Lubrication of gear and doors (20/06/17).

The activities performed involving the brakes:

- Visual inspection of the wear indicators (22/02/16).
- BITE test of normal braking system and functional check of the fluid level in the low-pressure brake reservoir (17/11/16).
- Functional check of the nitrogen pressure charge in the parking brake accumulators (11/05/17).
- Check of the emergency brake lockout valve and operational check of the parking brake control valve (11/05/17).
- Check of the brake temperature system (11/05/17).
- Functional check of the tire pressure system (11/05/17).

The last service bulletins issued by the manufacturer involving the braking and steering control unit since 2010 are:

The last bulletins issued after the manufacture of the aircraft in 2013 had not been implemented, being bulletins recommended but not mandatory. Consequently, the BSCU software version was 9C.

SERVICE BULLETIN	DESCRIPTION
C20293-32-050 Rev. 3 (10/06/10)	Replacement of obsolete SRAM 32K X 8 memories
C20293-32-051 Rev. 2 (01/06/10)	Modification to LDO card (CCOMORA) to replace R35 resistance with P/N RS71Y1K78F due to out-of-spec voltage in ATE.
C20293-32-052 Rev. 2 (01/06/10)	LDS (CCOMALM): Adjust OBSELV monostables. Adjust currents on CBSELV and CSTRSELV selector valves.
C20293-32-111 Rev. 2 (01/06/10)	Upgrade software to 9C standard.
C20293-32-144 (08/11/11)	Replace plastic support in the socket of the 68332 processor in the LDO and LDP cards to ensure proper connection. Replacement of obsolete diode P/N BYW80-150.
C20293-32-146 (04/01/12)	Replace obsolete integrated circuit P/N A1256851 in LDO and LDR cards with P/N E29489AA.
C20293-32-156 (17/01/12)	Replace the resistance P/N A1239018 in LDO card P/N 40419341 with resistance P/N F1446658.
C20293-32-179 (14/11/14)	Replace resistances R29, R30 and R182 in the LDQ module to improve resistance to change in the compensation voltage at the output of comparator LM2901 at high temperatures (above 60° C).
C20293-32-195 (01/07/16)	Upgrade functional software to 9D standard (replaceable modules 1, 2 and 3) to improve steering and braking functions.

The last bulletins issued after the manufacture of the aircraft in 2013 had not been implemented, being bulletins recommended but not mandatory. Consequently, the BSCU software version was 9C

1.7. Meteorological information

According to the information provided by the National Weather Agency, the following METARs were issued for the Tenerife South airport for the time period when the incident occurred:

GCTS 271030Z 07021KT CAVOK 31/13 Q1015 NOSIG=

GCTS 271100Z 07024KT CAVOK 32/12 Q1014 NOSIG=

GCTS 271130Z 06023KT 9999 FEW020 33/12 Q1015 NOSIG=

GCTS 271200Z 03013G28KT 350V080 9999 FEW020 32/16 Q1015 WS R07 NOSIG=

GCTS 271230Z VRB06KT 9999 FEW025 29/19 Q1015 WS R07 NOSIG=

The 12:00 UTC METAR indicates winds averaging 13 kt from the northeast, gusting to 28 kt, shifting from 350° to 80°. The windshear alert system was activated at 11:34 and remained in effect until 14:00.

1.8. Aids to navigation

Not applicable.

1.9. Communications

Not applicable.

1.10. Aerodrome information

The Tenerife South airport (GCTS) is located 60 km southwest of the city of Santa Cruz and is at an elevation of 209 ft. It has one runway in a 07/25 orientation that is 3,200 m long. Both thresholds have an ILS approach.

1.11. Flight recorders

The data taken from the aircraft's flight recorders were used to analyze the approach and landing, as well as the performance of the braking system.

1.11.1 Flight data recorder

The aircraft was outfitted with an FA 2100 flight data recorder made by L-3 Aviation Recorders.

The aircraft flew to its destination at a cruise level of FL400 and a calibrated airspeed (CAS) of 245 kt.

At 12:02:57, the recorded registered the autobrake position being selected to LOW.

At 12:08:43, the crew started the continuous descent maneuver, staying on magnetic heading 199º until FL157, where the course was changed to 180º.

At 12:31:53, crossing through 4580 ft, the course was changed to 115º and the descent continued to 3000 ft, where the runway 07 ILS localizer was intercepted on this same course at a CAS of 180 kt and in CONF 1 (17º slats).

At 12:35:51, the aircraft intercepted the runway 07 ILS glide slope at a CAS of 170 kt and in CONF 2 (21º slats and 14º flaps).

At 12:36:41, the ground spoilers were armed and at 12:36:55, descending through 2100 ft at a CAS of 165 kt, the gear was lowered and locked.

At 12:37:10, crossing through 1900 ft, the crew selected CONF FULL (24º slats and 32º flaps), and the speed was reduced to a Vapp of 132 kt.

At 12:38:13, crossing through 1170 ft, the crew increased the Vapp to 135 kt.

The approach parameters from 1000 ft until landing maintained the stabilization criteria specified in the manufacturer's FCOM, namely:

- The aircraft held the glide slope and localizer.
- The aircraft was fully configured for landing.
- The thrust was stable above idle to hold the target speed (Vapp of 135 kt) on the glide slope.
- There were no excessive parameter deviations.

At 12:39:13, crossing 420 ft, the crew disengaged the autopilot (AP1 and 2). From then on, the FDR recorded pitch commands to the captain's sidestick.

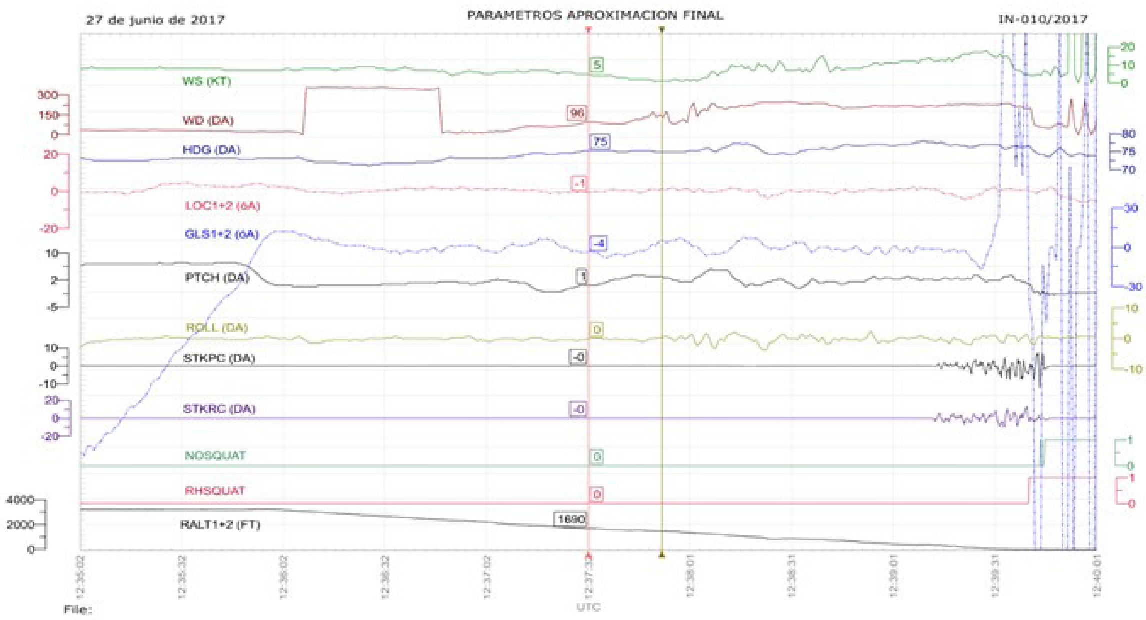

Figure 3. Final approach parameters

In the last 1000 ft, the recorded wind direction varied from 198° to 249°, and its intensity between 6 and 18 kt, reaching the highest values in the final 300 ft before touchdown.

The captain started the flare at an altitude of 35 ft, increasing the pitch angle from 2° to 4° by moving the sidestick in the nose-up direction through half of its range of travel.

Contact (change from air to ground mode) was recorded at 12:39:40 in both main gear legs, at a pitch angle of 1° and a vertical speed of -256 fpm. The vertical acceleration value recorded was 1.16 g.

The nose wheel contact, which included a small bounce, was recorded four seconds later.

Simultaneously with the contact, the brake pressure in the affected wheels (5, 6, 7 and 8) rose to values of up to 2496 psi (2560 psi in #7). Of note are the following:

- The pressure in wheel #5 rose continuously to its maximum value, where it remained for 22 s[3].
- The pressure in wheel #6 swung rapidly between its maximum and minimum values, taking on a value of 0 at 16 s.
- The pressures in wheels #7 and 8 rose continuously to their maximums, providing a longer braking action (see graph).

[3]. The brake pressure values are recorded once every 4 seconds, alternating between the various wheels. This means that the time values shown are difficult to calculate, though they are close to reality.

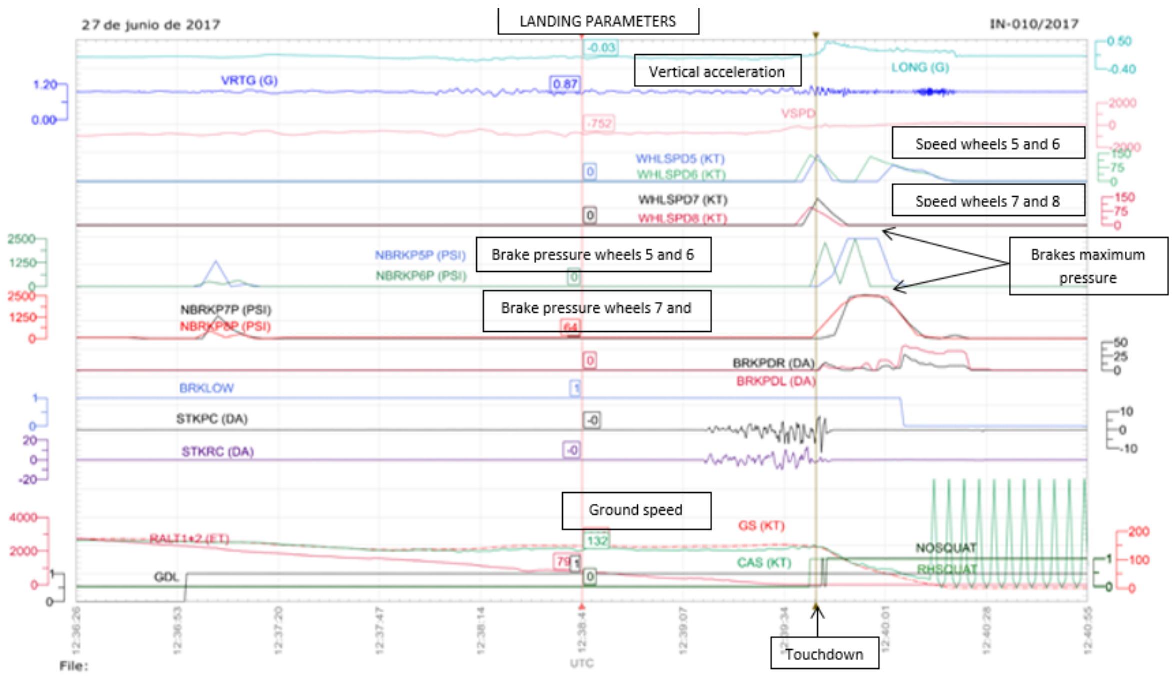

Figure 4. Landing parameters

The wheel speed parameter rose to values close to those of the aircraft's ground speed (GS) and then quickly decreased. Wheels #5 and 6 continued turning after locking up briefly. Wheels # 7 and 8 remained locked after the first speed increase.

The FDR recorded small braking inputs to the brake pedals. A 42° deflection of the left pedal disengaged the autobrake.

The reverse thrust was set to maximum from touchdown until the aircraft's ground speed fell to 50 kt.

1.11.2 Cockpit voice recorder

The cockpit voice recorder, manufactured by Cobham Avionics, had four tracks lasting 2 h 4 minutes.

At 12:00:38, the crew made contact with the Canaries ACC on 126.5 MHz, which instructed them to proceed direct to point GANTA.

Eight minutes later, after doing the approach briefing, the crew requested to descend. They were cleared to descend to FL250.

During the descent, the crew updated the weather information by listening to ATIS "C".

During the cruise and descent phase, the captain provided information on the approach techniques to use.

During the maneuver, they were transferred to ACC on 126.1 MHz, and to Tenerife South Approach on 127.7 MHz, which cleared them to descend to FL080 and then to FL070.

The TFS APP controller informed them that a preceding traffic had been forced to go around and that there were reports of windshear at 300 ft, with a variable tailwind, during the approach.

In light of this information, the crew reviewed the go-around procedure and discussed going to the Las Palmas airport as an alternate.

The APP controller reported the wind values at both thresholds, which varied, but they were within the approved values for the approach.

After receiving vectors for the ILS Z localizer for runway 07, they began the approach. They noted the slight tailwind values they had. The captain decided to increase the target Vapp to "have more margin in case of windshear".

The wind information received from the tower before reaching the approach minimums was 240º at 10 kt.

After landing, and before the crew requested it, the tower told them they were dispatching the firefighters.

Once stopped, the controller asked if they intended to stop the engines. The captain asked if they saw fire from the tower. The tower replied that initially there had been flames, but not at that moment.

After turning on the APU, the captain asked to turn the engines off and to have the firefighters report on the status of the wheels, noting that his reading indicated that wheels 5, 6, 7 and 8 had blown out.

The CVR recording ends a few seconds after the event occurred.

1.12. Wreckage and impact information

Not applicable.

1.13. Medical and pathological information

Not applicable.

1.14. Fire

There was no fire.

1.15. Survival aspects

Not applicable.

1.16. Tests and research

1.16.1. Analysis of the aircraft

Figure 5 shows the final condition of the rear main gear wheels 5 and 6 (left) and 7 and 8 (right) after the aircraft came to a stop.

Figure 5. Condition of main landing gear after the incident

In order to remove the aircraft from the runway, it was hoisted using a crane and wheels 5 and 7 were replaced so that the aircraft could be towed to the apron, where it was parked. Airbus technicians and company personnel were later involved in examining the landing gear.

It was noted that wheels 5 and 6 locked after landing, and that at some later point they turned again, since they exhibited damage and marks along the entirety of the rims. Broken hydraulic lines were also discovered. Figure 6 shows the rims on wheels 5 and 6.

Figure 6. Rims of wheels 5 and 6

Wheels 7 and 8 also locked but they did not rotate at any subsequent point, since they exhibited wear and damage due to friction only along part of their circumference, while the rest of the rim on both wheels was intact. The blown out tires were still on the rims when the aircraft stopped. Figure 7 shows the condition of the rims on wheels 7 and 8.

Figure 7. Rims on wheels 7 and 8

There was no damage to wheels 1, 2, 3 or 4 on the gear.

There was minor damage to the inboard flap and its associated fairing on the left wing.

Figure 8. Damage to flap and fairing

The braking and steering control unit (BSCU) was removed, along with the servo valves and tachometers from the wheels, in order to have them analyzed by the manufacturer.

The BSCU is shown in Figure 9.

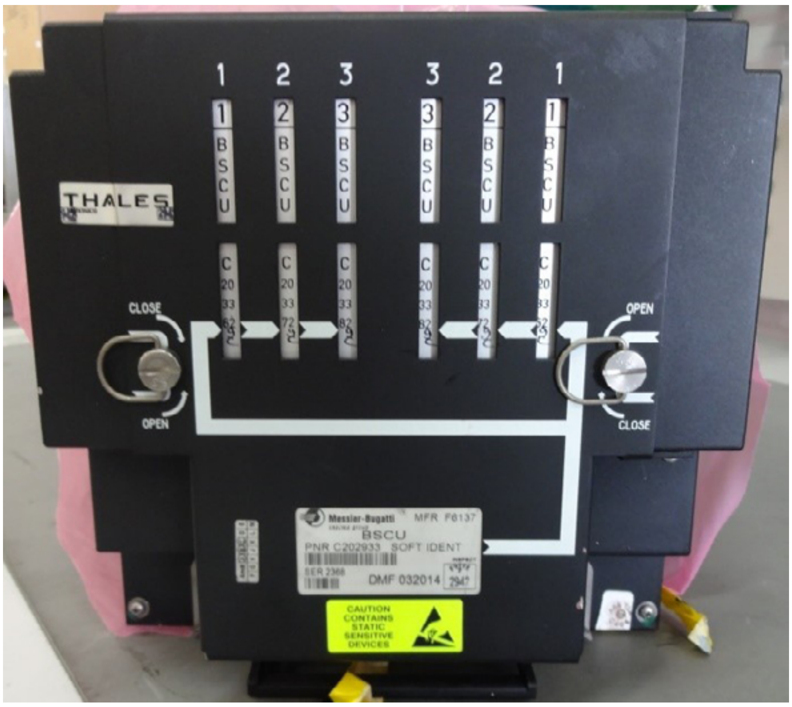

Figure 9. Braking and steering control unit

The BSCU that was removed had the following identification:

- P/N: C2029339C9C9C
- S/N: 2368

1.16.2. Captain's report

EXS917 was a training flight from MAN to TFS. The aircraft was serviceable. During pre-flight planning, it was identified that the surface wind at TFS was gusty (up to 35 knots), so I elected to operate this sector as handling pilot. Due to the blustery conditions, known windshear phenomena at TFS and to enable additional option should a diversion be necessary, an additional 2000kg of fuel was carried. The departure fuel was 29000kg.

The flight up to top of descent was uneventful. Several training topics were discussed during the flight, including winter operations and also windshear. Windshear was selected as a topic due to the potential for an even into TFS.

Prior to descent, a thorough briefing was given. This included the following:

- Potential for a shortened routing – mitigated by commencing descent early and incorporating some gates in the Flight Plan to ensure sensible workload should a shortcut be given.
- Likelihood of a tailwind on early approach turning to a headwind at 500' – mitigated by review of windshear procedures, decision to be fully configured and stable by 1500', so that any reasonable IAS increase at 500' could be considered a transient shift and not part of a rushed approach.
- Action in the event of a go-aroun
- Fuel state and holding/diversion options
- Terrain factors and safety altitude
- The unusual stop 'level' on the go-around and altimetry requirements
- The taxi restrictions for an aircraft with our wingspan and category

In the latter descent, below FL100, ATC advised that the preceding aircraft had done a missed approach due to wind conditions and that aircraft had experienced tailwind conditions on short finals. A wind report was given and indicated and easterly wind gusting to 28 knots for RW25 and a SSE wind gusting to 28 knots for RW07. It was clear that this was beyond aircraft limits, so we re-briefed our fuel options in the event of a missed approach. We established that we had sufficient fuel to execute a go-around, hold for 15 minutes, execute a second approach and divert to LPA.

The preceding aircraft was being vectored downwind ahead of us. Wind reports were now indicating a wind of 180/5 with occasional gusts to 13 knots. A wind calm report was also given. It was clear that there was some unusual wind activity. The preceding aircraft made a successful approach and landing, so our approach was continued.

I had looked earlier during the flight and had established that at 160000kg and with a 10 knot tailwind, the LDR was no more than 7500 ft. This was adequate as TFS has a landing distance beyond threshold of 10,499ft.

As briefed, we established on the ILS and configured the aircraft to be Conf Full and Stable by 1500'.

During the approach we had asked for an additional wind-check. We discussed that it was within limits for landing.

The approach was normal and monitoring of the wind vector on the ND showed a wind from 160v220/5-18 knots.

A final wind report was received from tower at approximately 500ft of 240/10. It was determined that this was within limits for landing. I glanced at the ND and noticed the wind occasionally peaking above 10 knots (I recall seeing 13 knots once), but considered the ATC wind as accurate so continued.

The flare manoeuvre was normal, however a slight float occurred and the aircraft landed slightly long in the latter part of the TDZ. The touchdown was normal. Standard procedures were followed on touchdown and the FO recalls seeing the green DECEL light in the autobrake. I recall applying some manual brake.

Shortly after touchdown, the brakes applied fiercely and the nosewheel dropped violently towards the runway. A tyre pressure ECAM annunciated. The aircraft then began to shudder violently with vibration throughout the airframe. I recall looking at the SD and seeing a number of amber crossed on the WHEEL Page (I think on wheels 7 and 8). I maintained the centreline, brought the aircraft to a standstill and set on the PARK BRAKE. I immediately put the 'Crew at Stations'. The aircraft was stopped between RET's B4 and B5 and on the runway centreline.

ATC had already enabled the fire services as they had observed the issue on touchdown. The fire services were in attendance within a minute. I communicated with the fire chief via ATC and once the APU was started and engines shutdown he established that there was no fire. ATC advised that the fire crews believed that the passengers could deplane with steps. I made a brief PA to pacify the passengers'. Once the fire crew aircraft had confirmed that the aircraft had been secured and chocks in place and after a brief interface with the FO, I put the crew at 'normal operations'.

A ‘purser to the flightdeck’ call was then made a NITS brief given.

N – Typre burst no sign of fire

I – deplane with steps

T – 20 minutes (but subject to the airport authority)

S – I would make a PA from the cabin to the passengers.

I was advised that there were no serious injuries and that 2 people wanted to get medical attention due to bags falling from the lockers.

Once the FO and I had confirmed that the Aircraft was secure, I recall doing a ‘doors for arrival’ PA to ensure all slides were disarmed.

I gave him control and went to brief the passengers. The cabin was calm and they were most appreciative of my address. The service from TFS Airport was excellent and steps, busses, and baggage carts were at the aircraft within 20 minutes.

When the steps arrived, I went to briefly inspect the main gear before allowing the passengers to disembark. I felt that the current environment was safest in the short term. Once the FO and I were content as to the aircraft status and that all outstanding checklists had been done, we agreed to release the passengers.

I again made a PA to the Passengers and they disembarked from doors L1 and L2 and were taken to the terminal. Once this activity had been completed, I gathered the cabin crew together to check welfare. I also notified the company and Chief Pilot in line with company procedure.

The damage to the aircraft undercarriage was significant with wheels 5,6,7,8 damaged and tyres burst. There was also damage to the torque links and some cosmetic damage to the left inner flap fairing and a small hole in the inner flap. Engineering support was on-site within minutes.

The runway was blocked and the airport authority wanted it moved. The crew were sent by coach to the JET2 office and the FO and I remained on the aircraft. In order to move the aircraft a tyre had to be fitted to each bogie. This took several hours and required the use of a crane to lift the bogie enough to enable a jack to be inserted. Once the wheel replacement had occurred, the aircraft was towed to the apron and then handed to an engineer. The FDR and CVR were pulled and the aircraft quarantined.

1.16.3. Marks left on the pavement during the landing run

The aircraft approached and landed on runway 07. Marks were found on the pavement made by the rear main landing gear wheels, consisting of the tracks left by the tires as well as the marks made by the rims. Figure 10 shows the approximate lengths of these marks.

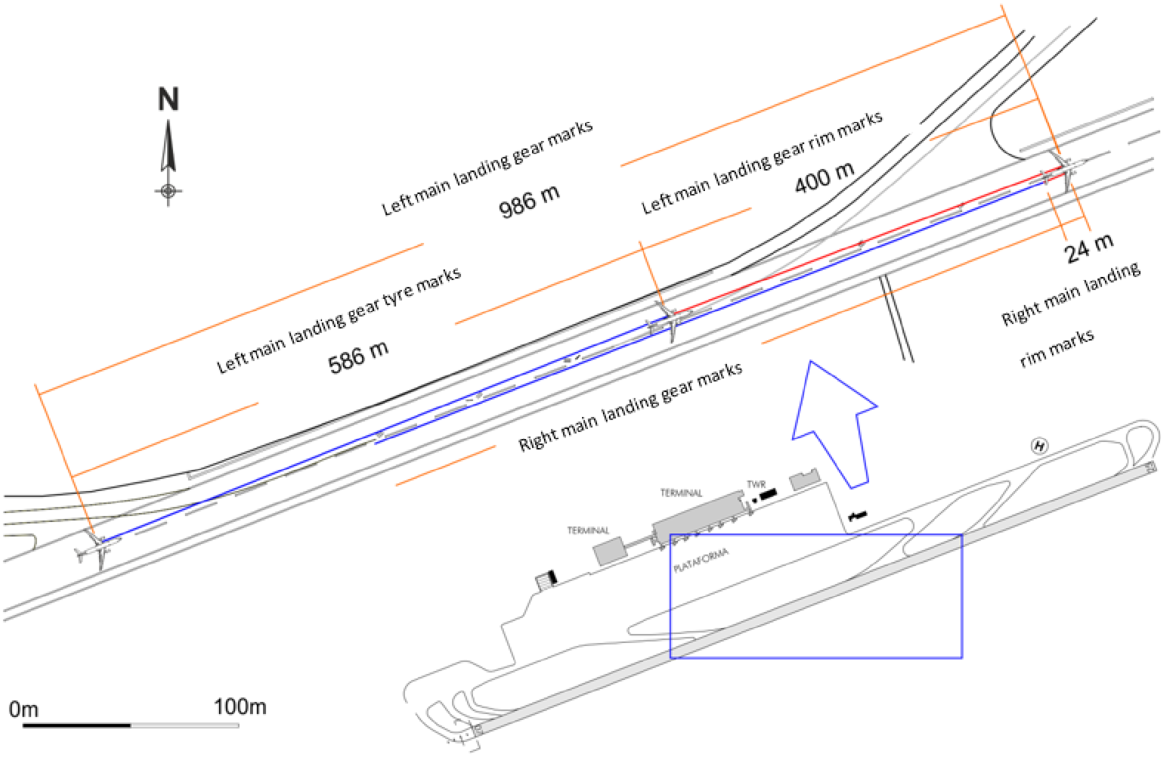

Figure 10. Diagram of marks on runway

The photograph below shows part of the marks left on the runway before the aircraft came to a stop.

Figure 11. Marks left on pavement

1.16.5. *Analysis of the elements involved in the incident*

The manufacturers of the landing gear and braking and steering control unit, Safran and Thales, respectively, analyzed the various elements involved (tachometers, servo valves and BSCU) and carried out tests in an effort to reproduce the situation that caused the incident.

1.16.5.1 Tests conducted by the landing gear manufacturer

The landing gear manufacturer conducted an initial test on the unit to determine its condition. After this, simulations were conducted on an avionics test bench in order to reproduce the operation of the BSCU in the aircraft in different scenarios, specifically:

- Scenario 1: operation of the BSCU at ambient temperature.
- Scenario 2: complete flight cycle at ambient temperature.
- Scenario 3: landing phase from flight phase at ambient temperature.

Escenario 1: funcionamiento de la BSCU a temperatura ambiente.

- Escenario 2: ciclo completo de vuelo a temperatura ambiente.

- Escenario 3: fase de aterrizaje desde la fase de vuelo a temperatura ambiente.

The tachometers and servo valves were also checked. Nothing unusual was found in any of these components.

1.16.5.2 Tests conducted by the manufacturer of the unit

1.16.5.2.1 Initial test

The outside of the unit was inspected to verify its condition, after which the unit was tested on an avionics test bench, according to the maintenance manual. The front panel was then opened to verify that the various interchangeable modules were properly connected and that their connectors were in good condition. The unit was also operationally tested on an avionics test bench using test modules. No abnormalities were found.

1.16.5.2.2 Temperature test

The unit was subjected to the usual temperature test used during the production process, which entails having the unit undergo 20 temperature cycles over a 48-h period.

In each cycle the temperature varies between -40° C and 70° C. When the temperature stabilizes at these values, the operation of the unit is monitored on a test bench by monitoring discrete inputs and outputs, analog inputs, servo valve output currents, tachometer input frequencies and the core.

Each cycle lasts approximately 2.45 h. Figure 12 shows the change in temperature during one such cycle.

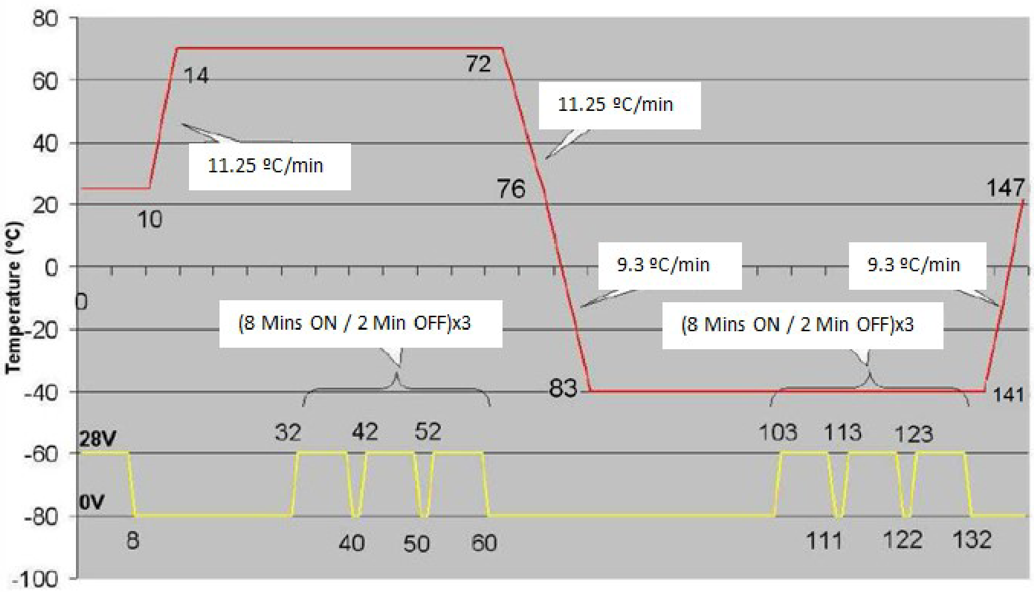

Figure 12. Temperature cycle

No abnormalities were detected in the unit's operation during the test.

1.16.5.2.3 Test on avionics test bench after completing the temperature test

After the temperature test, the test was repeated on the avionics test bench. No abnormalities were detected.

1.16.5.2.4 Vibration test

The unit was subjected to the usual vibration test employed during the manufacturing process by removing the top and bottom panels and attaching the unit to a vibration bench, as shown in Figure 13.

Figure 13. BSCU on vibration bench

After this the unit was energized and, after 5 minutes, it was vibrated perpendicular to its longitudinal axis for 20 minutes.

The range of vibrations applied to the unit spanned from 10 to 2000 Hz.

During the vibrations, the same parameter monitoring process was used as in the temperature test. No abnormalities were detected in the unit.

1.16.5.6 Test on avionics test bench

After the vibration test, a new test was carried out on the avionics test bench, with satisfactory results.

1.16.5.7 Additional tests

An additional temperature test was performed to check the unit's operation in the following temperature ranges:

- from +25° C to +70° C
- from +70° C to -40° C
- from -40° C to +25° C

This was done by running a test sequence on the unit for every +/- 1° C temperature change, as shown in the graphs in Figure 14. The test lasted 44 h.

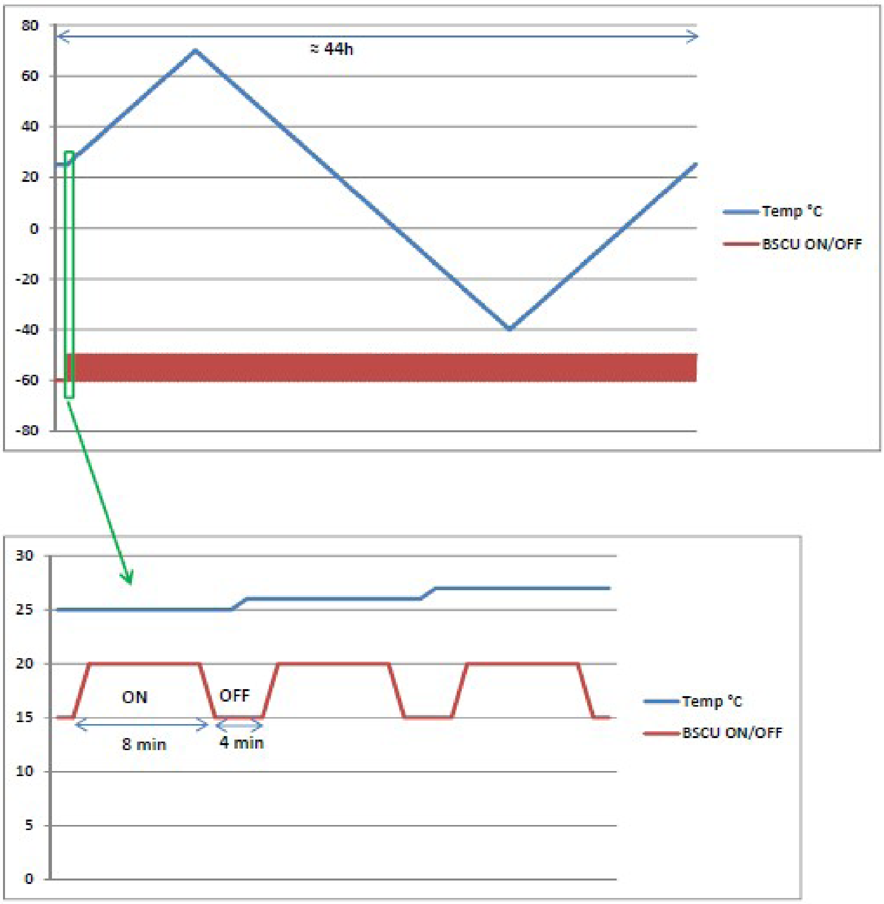

Figure 14. Additional temperature test profiles

A fault was detected in tachometer 8 in system 1. This system was in stand-by mode during the incident investigated herein.

After this, the following additional tests were conducted:

- test on avionics test bench after additional temperature test
- initial visual inspection for the purpose of identifying defects in the unit's hardware
- additional vibration test
- test on avionics test bench after additional vibration test
- second visual inspection

The visual inspections performed consisted of:

- General inspection of the unit
- Disassembly of the unit for a general visual internal inspection
- Inspection of internal circuits with a binocular magnifier
- Local inspection with binocular lens and endoscope
- X-ray inspection of components in the various printed circuits

The tests conducted failed to reproduce the condition that resulted in the incident or to identify any fault in the BSCU. As a result, it was not possible to identify the cause of the incident.

Both manufacturers stated that they would review the viability of making improvements once a new BSCU standard is defined.

1.17. Organizational and management information

Aircraft G-VYGL, owned by AirTanker, was being operated by said company under a lease agreement with the airline Jet2 at the time of the incident.

AirTanker has Part-M and Part-145 organization certificates, meaning the company itself manages and performs the maintenance of its aircraft.

1.18. Additional information

1.18.1 Characteristics of the braking system

The main landing gear wheels are outfitted with multi-disc brakes that can be actuated by means of two independent braking systems:

- Normal system: The brakes are controlled through the brake pedals or the autobrake. The BSCU and servo valves provide individual anti-skid control to each wheel. If the hydraulic actuating system fails, control is automatically switched to the alternate system.

- Alternate system: The brakes are controlled through the brake pedals. The autobrake is inoperative. Individual anti-skid control is available with alternate braking with anti-skid mode. This is done through the BSCU and the servo valves.

Figure 15 shows a schematic of the braking system.

It shows the signals to the BSCU, which are supplied by the brake selector switches, the captain's and copilot's pedals, and the tachometers, and the control signals sent to the normal and alternate servo valves and to the normal selector valve.

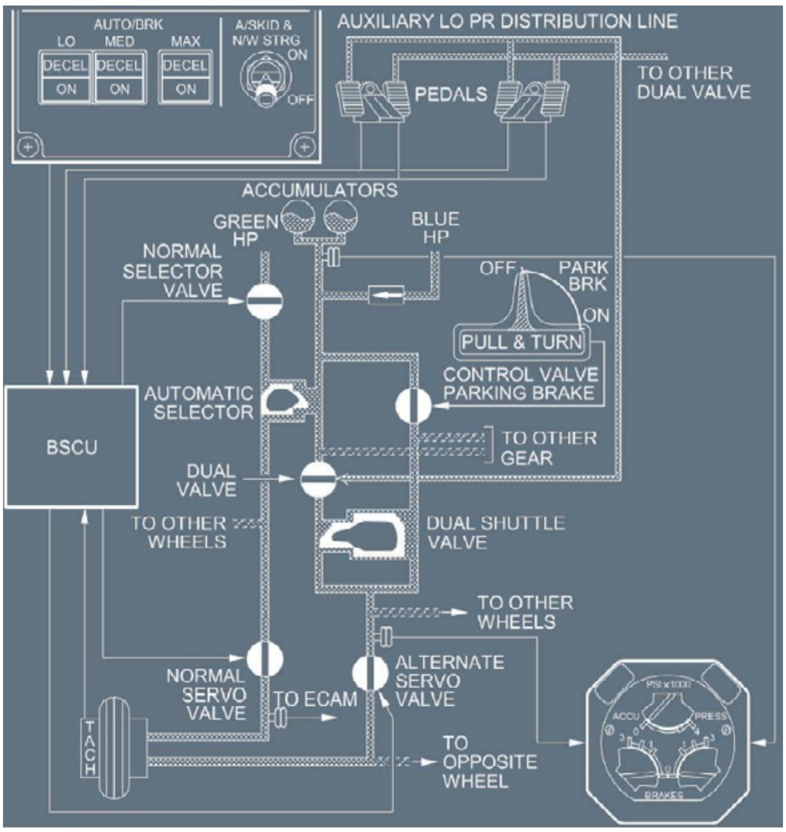

Figure 15. Braking system diagram

1.18.2. Anti-skid system

The anti-skid system provides maximum braking efficiency by keeping the wheels at their skidding limits. This system is deactivated when the ground speed is below 10 kt.

An ON/OFF switch activates and deactivates the system, along with nose wheel steering. It works by comparing the speed of each main gear wheel, measured using tachometers, against the aircraft's speed (reference speed). When the speed of the wheel drops below 0.88 times the reference speed, a command is generated to release the brakes to maintain the skidding at that value in order to achieve the best braking efficiency.

In normal operations, the reference speed is determined by the BSCU through the horizontal acceleration from ADIRU1, 2 or 3. If the ADIRUs fail, the reference speed is the maximum speed on any of the main gear wheels.

1.18.3. Autobrake system

The purpose of the autobrake system is to reduce the speed and stop the aircraft. The only pilot action is to select the relevant deceleration control switch in the cockpit. The autobrake is only available in NORMAL mode, and features the following three functions:

- Manage the control signals and the signal indicating lights in the cockpit.
- Control the braking when the signals from the spoilers are present.
- Generate a programmed speed, which is reduced at the deceleration rate selected by the pilot and supplied as a reference speed to the anti-skid circuits.

The deceleration rates available are LOW and MED (used on landing) and MAX (for maximum braking in the event of an aborted takeoff). The switches in the cockpit for arming the system read MAX, MED and LOW. The autobrake can be disarmed by actuating the pedals and pressing the switches in the cockpit. It is also disarmed after takeoff.

1.18.4. Braking and steering control unit (BSCU)

The braking and steering control unit (BSCU) is a rectangular box that measures 193x190.5x382.7 mm and weighs approximately 11 kg.

This unit controls the braking on the eight main gear wheels and the nose wheel steering. It provides:

- braking control in manual or automatic mode
- braking regulation
- nose wheel control
- brake temperature indication
- testing and monitoring functions

The analog signals input to it are processed by an analog-digital interface. The output signals are processed by a digital-analog interface. The input data are acquired using a variable frequency scan that, depending on the parameter type, ranges from 10 Hz to 400 Hz. The output data are updated at variable frequencies, depending on the parameter type, ranging from 10 Hz to 400 Hz.

The BSCU allows braking in several configurations:

- Normal ON: allows braking in manual mode by actuating the pedals, or in automatic mode by selecting the deceleration rate (MAX, MED or LO).
- Alternate ON: only allows manual mode with braking regulation.
- Alternate OFF: only allows manual mode with no braking regulation. No nose wheel control is provided.

It also controls the parking brake (PARK) and the landing gear retraction (UP).

As for the main control signals, the braking system is controlled by the BSCU when the unit receives the following commands:

- voltage from the captain's or copilot's brake pedals
- discrete MAX, MED or LOW (autobrake) information from the AUTO BRK switches
- discrete UP information from the main gear control lever
- discrete PARK information from the parking brake

The BSCU controls the following brake system components:

- brake selector valve
- eight normal servo valves
- four alternate servo valves

The BSCU processes the information provided by the brake temperature monitoring units and generates ARINC messages to display the temperature and alerts in case the brakes overheat. It also provides test and monitoring functions, doing tests on the internal components and on the availability of the autobrake modes and nose wheel steering, and it monitors parameters.

The BSCU consists of two identical and independent systems, SYSTEM 1 and SYSTEM 2, which can carry out all the functions, with one always active and the other in stand-by. If one system fails, the other can take over.

Each system consists of five modules:

- one power supply monitoring circuit (CMONALM)
- one power supply control circuit (CCOMALN)
- 1 braking control circuit (CCOMFRE)
- 1 monitoring circuit (CMONCPU)
- 1 nose wheel steering control circuit (CCOMORA)

Each system can provide information on whether it is in active or stand-by mode, whether it is ready to take control, and whether it can provide autobrake and nose wheel steering control for category IIIB landings.

The anti-skid currents are calculated by the CCOMFRE module, which has two microcontrollers (MCU68332). The front and rear gear wheels are segregated when calculating the currents that actuate the servo valves, such that one microcontroller controls the four front wheels and another controls the four rear wheels. This module thus controls the front and rear landing gear wheels independently.

Similar

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

2.1 Progression of the flight, approach and landing

Flight EXS917 to Tenerife South departed Manchester at 08:37 UTC, and was uneventful for its approximate four-hour duration.

Based on the information obtained from the flight recorders, the aircraft leveled out at FL400 and a speed of 245 kt until 12:08:43 UTC, when it began its descent to the destination airport. Approximately 6 minutes before starting the descent, the crew set the autobrake system to LOW.

The crew made a stabilized approach at a speed of 135 kt, which resulted in the aircraft being established on the glide slope and configured for landing. At 12:39:13 UTC, the autopilot was disengaged at about 420 ft, after which the captain completed the approach to runway 07. The main landing gear wheels touched down at 12:39:40 UTC. The landing was smooth, with a vertical acceleration value of 1.16 g.

2.2 Activation of the braking system

The graph in Figure 4 shows how when the gear touched down, without any input by the crew, the brake pressure in the four rear main gear wheels (5, 6, 7 and 8) rose to values close to 2500 psi, which initially locked all four wheels. Within a few seconds, the brake pressure decreased in wheels 5 and 6, which again began to turn until the aircraft came to a stop. Figure 4 shows how the rotational speed for these wheels increased again and then gradually decreased until the aircraft stopped on the runway. This was likely due to the damage caused to the hydraulic lines on these wheels as the wheels were dragging on the pavement, which released the brake pressure in the lines, unlocking the wheels. Figure 6 shows the damage along the entire circumference of both rims.

As for wheels 7 and 8, they remained completely locked during the entire time the aircraft was decelerating. Figure 7 shows how only part of the circumference of the rims was damaged.

This behavior of the brake system was caused by a command generated by the braking and steering control unit, which applied maximum braking power to the rear wheels after landing, even though the autobrake was set to LOW.

2.3 Tests conducted by the manufacturers involved

The incident was caused by the abnormal operation of the braking system. Because of this, the manufacturers of the various components that comprise the system, namely the tachometers, servo valves and BSCU, analyzed and tested said components.

The BSCU is the common element of the braking system that separately controls the forward and aft gear wheels, and which could give rise to the abnormal behavior in question, specifically through the anti-skid system.

Nothing unusual was detected during the analysis and tests of the tachometers and servo valves on the four affected wheels.

The tests performed on the unit, which consisted of visual inspections with lenses and X-rays of the circuits that make it up, also revealed no faults in the unit.

Successive temperature, vibration and other tests were conducted on an avionics test bench while monitoring the operation of the unit under said conditions. These tests were unable to reproduce the incident or determine its cause.

The manufacturer of the unit noted the possibility that the incident may have been caused by a fault in the BSCU operating algorithm that could have resulted in the temporary corruption of some of the variables used by the unit.

3. CONCLUSIONS

3.1. Findings

- The crew had valid licenses and medical certificates at the time of the incident.
- The documentation of aircraft G-VYGL was also valid.
- The aircraft had been maintained in accordance with its approved maintenance program.
- The flight from Manchester to Tenerife South lasted about 4 hours, and according to the crew, was uneventful.
- The aircraft landed on runway 07 at the Tenerife South airport at 12:40 UTC. It was a smooth landing at 1.16 g. The crew had set the autobrake system to LOW.
- After the landing, without the pilot taking any action to cause it, the four rear main landing gear wheels suddenly locked. The aircraft traveled approximately 986 m before coming to a stop.
- These four tires blew out and the rims and landing gear were damaged.
- There were no injuries as a result of the incident.
- After disembarking the passengers and cargo, the aircraft was raised using cranes and wheels 5 and 7 were replaced in order to tow the aircraft to parking.
- The runway was reopened and operations resumed some 5.5 hours after the incident.
- The information taken from the QAR did not show any abnormal flight parameters during the approach.
- The maximum brake pressure reached in the aft gear wheels was about 2500 psi.
- The checks and tests of the tachometers, servo valves and braking and steering control unit conducted by the manufacturers involved did not reveal any faults or problems with any of those components.
- The tests carried out were unable to reproduce the incident.

3.2. Causes

The likely cause of the incident was the abnormal behavior of the anti-skid system.

4. SAFETY RECOMMENDATIONS

None.