Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

Air Accident Investigation Unit (Belgium)
City Atrium
Rue du Progrès 56 Vooruitgangstraat
B1210 Brussels

Safety Investigation Report

ACCIDENT TO A BOEING B747-228F OPERATED BY CARGO B IN BRUSSELS ON 27 OCTOBER 2008

Ref. AAIU-2008-18- EBBR
Issue date: 26 January 2015
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Federal Public Service
Mobility and Transport
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AAIU-2009-18

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FOREWORD

This report is a technical document that reflects the views of the investigation team on the circumstances that led to the accident.

In accordance with Annex 13 of the Convention on International Civil Aviation, it is not the purpose of the aircraft accident investigation to apportion blame or liability. The sole objective of the investigation and the Final Report is the determination of the causes, and define recommendations in order to prevent future accidents and incidents.

In particular, Art. 17.3 of EU Regulation 996/2010 stipulates that a safety recommendation shall in no case create a presumption of blame or liability for an accident, serious incident or incident.

Safety recommendations and Safety messages
When AAIU(Be) issues a **safety recommendation** to a person, organization, agency or Regulatory Authority, the concerned person, organization, agency or Regulatory Authority must provide a written response within 90 days.
That response must indicate whether the recommendation is accepted, or must state any reasons for not accepting part or all of the recommendation, and must detail any proposed safety action to give effect to the recommendation.

AAIU(Be) can also issue a **safety message** to a community (of pilots, instructors, examiners, ATC controllers), an organization or an industry sector for it to consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to a safety message, although AAIU(Be) will publish any response it receives.

The investigation was conducted by L. Blendeman, with the support of the US NTSB and the Bureau d'Enquête et Analyse of France.
The report was compiled by L. Blendeman

NOTE:

1. For the purpose of this report, time will be indicated in UTC, unless otherwise specified.
2. ICAO doc. 9859 was used for the identification of the hazard and the consequence.

SYMBOLS AND ABBREVIATIONS

EU	European Union
‘	Minutes
°	degree
°C	Degree Centigrade
‘	Feet
“	Inch
AAIU(Be)	Air Accident Investigation Unit (Belgium)
AC	Aircraft
AMSL	Above Mean Seal Level
ANT VOR	Antwerp VHF omnidirectional range
APU	Auxiliary Power Unit
AR/KB	Arrêté Royal / Koninklijk Besluit
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATPL (A)	Airline Transport Pilot Licence (Airplane)
ATSB	Australian Transport Safety Board
BCAA	Belgian Civil Aviation Authority
BEA	Bureau d'Enquête et Analyse
CAA	Civil Aviaiton Authority
CB/CBB	Cargo B Airlines
CAS	Corrected Air Speed
CIV 1C SID	Chievres 1C Standard Instrument Departure
CPL(A)	Commercial Pilot Licence (Airplane)
CVR	Cockpit Voice Recorder
deg	degrees
DGAC	Direction Générale de l'Aviation Civile
EBBR	Brussels Airport
EC	European Commission
FCM	Flight Crew Member
FDR	Flight Data Recorder
FE	Flight Engineer
FH	Flight Hour
FMS	Flight Management System
g	gravitational acceleration
GSM	Cellular phone
GWT	Gross Weight

h	hour
ICAO	International Civil Aviation Organisation
Km	Kilometer
kt(s)	knots
LH	Left Hand
LPC	Licence Proficiency Check
mbar	millibar
N	North
N1	Low Pressure Compressor rotational speed
NAV	Navigation
NE	North East
OM	Operator's Manual
OPC	Operators Proficiency Check
OPS	Operations
para	paragraph
PIC	Pilot In Command
PNF	Pilot Not Flying
QRH	Quick Reference Handbook
RJ	Regional Jet
RPM	Revolutions per Minute
RTTO	Real Time Take-Off
SOP	Standard Operating Procedure
Tcu	Towering Cumulus
TO	Take-Off
TORA	Takeoff Run Available
TOW	Take Off Weight
US NTSB	United States - National Transport Safety Board
UTC	Coordinated Universal Time
V1	Critical Engine Failure Recognition Speed
V2	Takeoff Safety speed
VHF	Very High Frequency
Vr	Rotation Speed
ZFW	Zero Fuel Weight

Synopsis.

Date and hour of the accident:	27 October 2008 at 15:20 UTC
Aircraft:	Boeing B747-228F (SCD) msn: 24158
Accident location:	On the Brussels airport - EBBR
Aircraft operator:	Cargo B Airlines (ICAO code: CBB)
Type of flight:	Commercial Air Transport – International - Cargo
Persons on board:	6 persons

Abstract.
The aircraft took off from Brussels airport at 15:00 UTC. Upon rotation, the crew heard an abnormal noise, and had difficulties to get the aircraft in the air. After adjusting the engine power, the aircraft took off.
Observers on the ground saw two white clouds appearing successively under the tail of the aircraft upon rotation, followed by flames.
The inspection of the runway revealed that parts separated from the aircraft, amongst which the APU access door.
The aircraft dumped the excess of fuel and landed back in Brussels at 16.20 UTC.
Inspection on the ground revealed that large portions of the underside skin of the tail section were missing.

Cause(s).
The accident was caused by an inadequate take-off performance calculation, due to wrong gross weight data input error in the software used for the computation of the take-off performance parameters and the failure to comply with the operator's SOP for checking the validity of the data.

Contributing factor(s)

- Inadequate pairing of crew members with low experience.
- Lack of distraction management.

Hazards[1] identified during the investigation.
Entry of inadequate values for the take-off weight in the Flight Management System (FMS)

Consequences[2].
Abnormal runway contact (ARC) - tail strike
Runway excursion (RE)

[1] Hazard – Condition or object with the potential of causing injuries to personnel, damage to equipment or structures, loss of material, or reduction of ability to perform a prescribed function.

[2] Consequence – Potential outcome(s) of the hazard

1. Factual Information

1.1. History of flight.

The flight BB3101 of Cargo B was scheduled to fly from Brussels (EBBR) to Campinas, Sao Paulo, Brazil (SBKP) via Dakar, Senegal (GOOY)

The crew consisted of 6 persons; three pilots, 2 flight engineers and a load master (passenger). The third pilot was intended as relief pilot, needed for the long flight. The additional flight engineer was an examiner, needed for a routine check of the first flight engineer.

The relief pilot was not planned to fly that day; he was shopping when called on the morning to fly on the afternoon. He had just the time to get home and to drive from Ostend to Brussels.

The co-pilot and the relief pilot were the first in the crew room, where the briefing took place. The commander arrived one hour before planned departure and got the envelope with the documents the flight planning prepared for the flight.

The relief pilot, having just completed the B747-400 conversion course, requested the commander to fly on the second leg of the flight (Dakar – Viracopos) in order for him, during the first leg (Brussels – Dakar), to refresh his memory on the B747-200.

The crew agreed that the co-pilot would be the pilot flying for the first leg.

During the briefing, the three pilots and the dispatcher discussed the flight route and the alternate destinations; GBYD (Banjul, Gambia) and GUCY (Conakry, Guinea). The flight engineers arrived later, and did not participate in the briefing.

The flight engineers arrived 20 to 30 minutes before the departure time.

Realizing the time left to prepare for the flight was insufficient, the commander requested to postpone the flight for 30 minutes; this was granted and the crew went to the aircraft.

They were met by the maintenance team, who reported the aircraft was technically in order. A mechanic was called later to handle a concern with one of the altimeters.

The pilots went in the cockpit, at their respective seats, and began the flight preparation. There was no apparent stress.

The co-pilot set the route into the FMS, while the commander checked the ATIS information.

In the cockpit, the relief pilot asked the commander to do the performance computation with the real time take-off software (RTTO). The commander agreed and requested to make the computation for dry and wet runway; in the event the runway's conditions would change. The relief pilot took one of the two portable computers on-board, and performed the computation. The relief pilot took the following into consideration:

- Wet runway.
- Starting from B1 intersection of Runway 25R.
- Disregard the head wind value

The cargo loading was reported on the load sheet produced by a local handling agency. The commander and the relief pilot discussed about the opportunity to use either the figures of the load sheet, or use a specific module of the performance computer in order to enter the weight of the individual pallets, as it is done in outstation. They agreed to use the load sheet, as they were in Brussels.

```
PASSENGER/CABIN BAG            0      0/0/0/0        TTL   0
                                      PAX Y    0
**********************************************************************
TOTAL TRAFFIC LOAD        107765
DRY OPERATING WEIGHT      157856
ZERO FUEL WEIGHT ACTUAL   265621  MAX 281680       ADJ
TAKE OFF FUEL              98100
TAKE OFF WEIGHT  ACTUAL   363721  MAX 377842       ADJ
TRIP FUEL                  69300
LANDING WEIGHT   ACTUAL   294421  MAX 299370  L    ADJ

                                  ************************************
BALANCE AND SEATING CONDITIONS    *          LAST MINUTE CHANGES
DOI      69.15   LIZFW    65.01   * DEST  SPEC     CL/CPT     + - WEIGHT
LITOW    55.60   LILAW    65.76   *
MACZFW    25.2   MACTOW   21.4    *
MACLAW    24.9                    *
                                  *
CABIN AREA TRIM                   *
                                  *
UNDERLOAD BEFORE LMC       4949   *              LMC TOTAL
**********************************************************************
CAPTAINS INFORMATION AND LOADMESSAGE BEFORE LMC

CG LIMIT TOW   FWD    19.39   AFT   66.97
         LAW   FWD    30.44   AFT   88.64
         ZFW   FWD    40.81   AFT   84.58

TAXI FUEL   800    TAXI WEIGHT ACTUAL 364521  MAX 379202
FUEL DENSITY  0.800kg/ltr

PANTRY CODE  S  STANDARD
PAXWEIGHTS USED    Y   M 84 F 84 C 35 I 0
ACTUAL BAGWEIGHTS USED
```

Figure 1: Extract of the load sheet showing the actual ZFW, TOFW and taxiweight (TW)

While doing it, the relief pilot entered a wrong figure for the loading. The value of 265 T (zero fuel weight) was entered instead of the take-off weight (TOW) (normally 364 T).

The relief pilot handed over the computer to the commander who checked the performance figures, in re-starting the computation (without checking the load sheet and re-introducing the value of TOW, as per SOP). The commander

checked that the outcome was identical to the figures written on the TO performance card the relief pilot had filled in.
The commander then determined the trim value, based on the value of 264000 kg for Total TOW with the Quick Reference Handbook (QRH).

The crew performed the pre-flight check, as per procedure. The operation was somewhat disrupted by a concern regarding the feeding of dogs carried on board and an intervention of the ground crew.

Up to that point, the Zero Fuel weight (ZFW) was not indicated on the TO performance card, and the TOW indicated on the card was the value of the ZFW, the performance figures were consistent with the computation done with the zero fuel weight (101 ton less than the actual weight).

During pre-flight check, after calling for zero fuel weight, the co-pilot noticed the discrepancy on the TO performance card, and drew the attention of the commander. The card was subsequently corrected –the indicated value of 264 was changed to 364 T; the correct value of the TOW. There were no changes brought the performance figures (speeds).

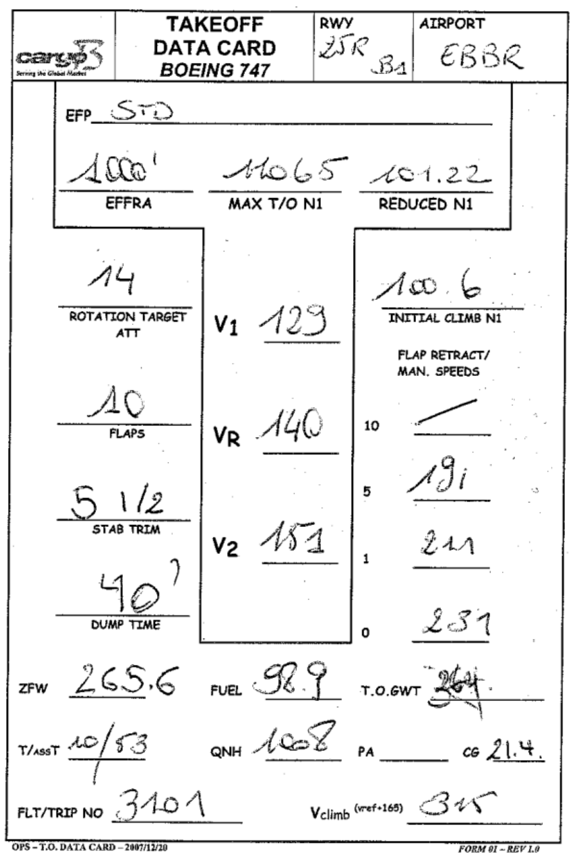
TAKEOFF DATA CARD BOEING 747
RWY 25R B1
AIRPORT EBBR
EFP STD
1000' EFFRA
1106.5 MAX T/O N1
101.22 REDUCED N1
14 ROTATION TARGET ATT
V1 129
100.6 INITIAL CLIMB N1
FLAP RETRACT/ MAN. SPEEDS
10 FLAPS
VR 140
10 —
5 1/2 STAB TRIM
5 191
V2 151
1 211
40' DUMP TIME
0 231
ZFW 265.6
FUEL 98.9
T.O.GWT 364
T/ASST 10/53
QNH 1008
PA
CG 21.4
FLT/TRIP NO 3101
Vclimb (vref+165) 315
OPS – T.O. DATA CARD – 2007/12/20
FORM 01 – REV 1.0

Figure 2: TO performance card after modification of the TOW from 264 to 364 and filling in the ZFW.

The card was handed over to the flight engineer, who checked that the speed value were reflected on the bugs and dials.

Having completed the Before Start Check List, the crew requested push-back which was granted at 14:37:19.

The airplane taxied towards runway 25R, intersection B1. The commander decided to use the full runway length instead of the take-off from the B1 intersection as originally planned. The clearance for take-off was given at 14.59.30. before the airplane reached runway 25R.

The airplane stopped a few seconds at the threshold, and the take-off procedure was performed as prescribed, with the call-ups at the pre-defined values. At rotation, the airplane did not react as usual. The pilot flying felt the controls were sluggish and the airplane was not climbing. He pulled the control wheel further, without noticeable results. At that moment, the tail section contacted the runway. The sound was not noticed by the pilots (the commander stated he heard a ‘tik’), having the headphones on.

When the aircraft was between A3 and A5 in the take-off roll, the Tower (Air) controller observed the aircraft rotate. Till then the take-off roll seemed normal to them. At first nose-up attitude was normal but was then increased. The aircraft did not get airborne and a tail strike, accompanied by sparks, flames and smoke or dust was observed.

The pilot noticed the stick shaker being activated 2 times during the take-off roll. He ordered full thrust, followed by the flight engineer. The throttles were advanced up to the forward stop. At that point, the airplane had accelerated sufficiently to get airborne.

The aircraft became airborne between A6 and A7, leaving approximately 600 m take-off run available (TORA). At the time the Tower controller was accompanied by a second controller sitting next to him. Both observed the tail strike.

The two controllers called out “tail strike, tail strike”, alarming other controllers in the room. One controller observed that the initial flight attitude seemed to be more nose-up than normal, but that it was corrected soon and the aircraft appeared to be flying the expected pattern (CIV 1C SID).

In the meantime, the alerting actions had begun. One controller called the fire brigade to report a possible emergency situation. Because the severity of the event could not be immediately assessed only the telephone was used for this purpose at this stage. Approach was informed of the tail strike, the arrivals approaching for 25R were re-directed and the departures on 25R were interrupted awaiting an inspection of the runway.

The events were also observed by a ground crew and a Brussels Airport support vehicle, one of which reported to have seen parts detach from the fuselage. The report triggered the “local standby” alert, which was later upgraded to “urgency”.

Once airborne, the Tower controller tried to contact the airplane, but it had left the frequency. The airplane called on Ground frequency. The trainee ground controller instructed the airplane to contact the Tower frequency, but instead the airplane called the Approach frequency when passing 3500’ AMSL. ATC requested the airplane about the intentions.
The approach controller, who had in the meantime received a report from the Tower of a possible tail damage, informed the crew. The crew was instructed to hold at ANT VOR, first at FL060, then later at FL080. The crew then reported they needed to dump fuel before returning to land in EBBR.

After about 1 hour and 20 minutes flight, the aircraft landed on 25R, which had in the meantime been swept and brought back into operation. At 16:20 the aircraft landed at the touch down aiming point and used the full runway length for deceleration. The fire brigade was in the meantime also deployed along the runway and followed the aircraft after landing. The airplane taxied on own power to stand 906.

After all traffic had vacated the runway, it was swept again.

The tail section of the aircraft showed severe scraping damages

Figure 3: Start of rotation

Figure 4: The airplane tail hit the runway.

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Figure 5: The airplane continues the take-Off, scraping the tail on the runway

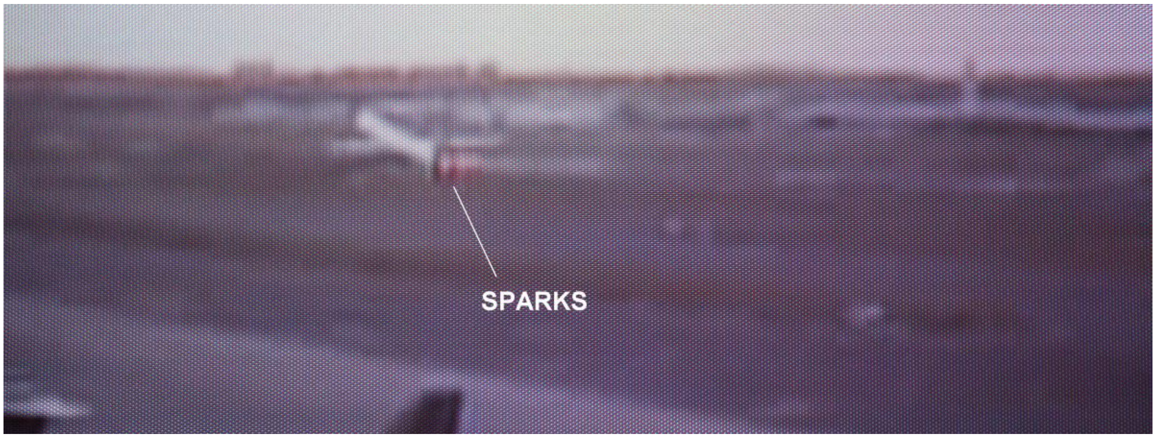


Figure 6: Sparks are visible

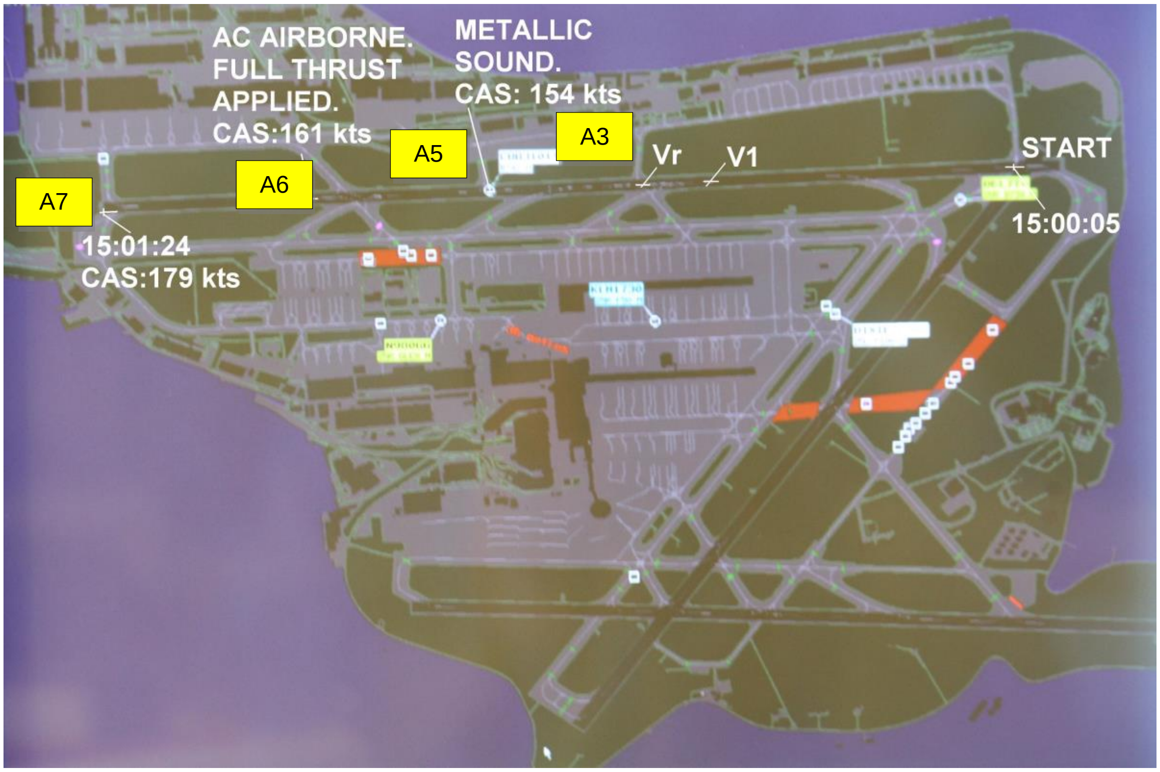


Figure 7: Ground radar image of the event

1.2. Injuries to persons.

Injuries	Crew	Passenger	Others	Total
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	0
None	5	1	0	6
Total	5	1	0	6

1.3. Damage to aircraft.

The B747 tail suffered significant damage.

The sections 46 and 48 were damaged. In detail;

Section 46

The following structural items were damaged by the tail strike:

- All the frames from Body Station (BS) 2080 on.
- The lower half stringers on BS 1961 – 2181.
- LH outflow door.
- Skin panels

Section 48

The following structural items were damaged by the tail strike:

- Light damage on the pressure dome.
- All the frames from BS 2460 on,
- Lower skin panels,
- Firewall BS 2658.

The APU doors were damaged, and there were damages on the APU tubing and wiring.

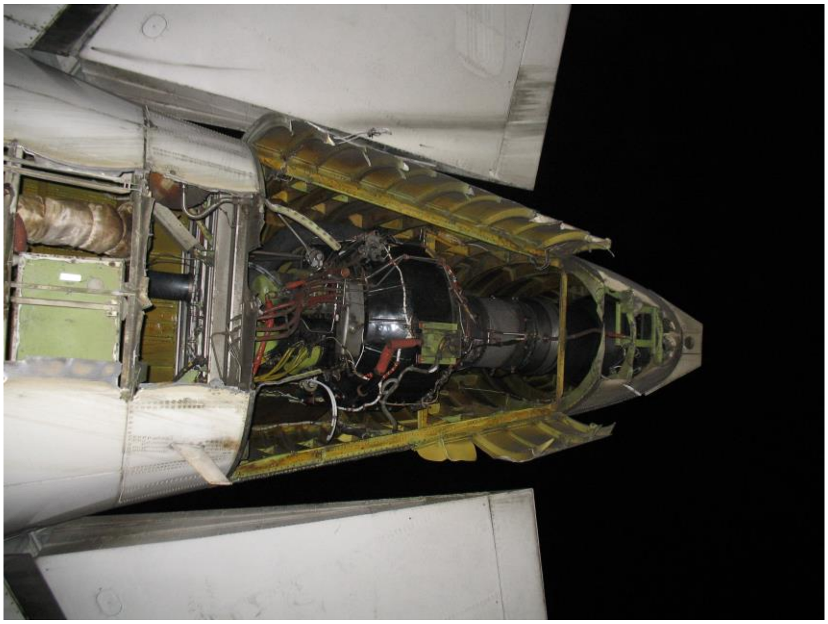


Figure 8: Tail end damage

Figure 9: damage forward of the APU compartment.

1.4. Other damage.

Slight scraping damages on the runway 25R of Brussels Airport.

1.5. Personnel information.

Commander.

Sex:	Male
Age:	43
Nationality:	Belgian
Licence:	ATPL(A) first issued on 29 October 1999, last issued on 11 March 2008, valid until 01 February 2013.
Rating:	A320, B747-100/-300.
Type qualified:	on B747 since March 2008. Commander on B747 since June 2008.
Medical:	Medical certificate first class, issued on 21July 2008, valid until 9 February 2009.

Employed by the airline since December 2007.

Flight time history:
The pilot has:

- not flown for the last 24 h
- not flown for the last 7 days
- flown a total of 43:37 FH for the last 30 days
- flown a total of 67:57 FH for the last 90 days

The commander complied with all relevant requirements as laid down by the BCAA and Cargo B Airlines. This includes B747 initial, recurrent training (last followed in March 2008), proficiency check (last OPC in August 2008, LPC in March 2008) and line check (last in June 2008)

Flight time experience:
Total Flight time: 11360FH
Total time as Pilot in command (PIC): 6800 FH

Experience on type:
B737: 1800FH (qualified in 1992)
DC10: 1400FH (qualification as F/O in 1995 - last flight on 17/04/1997)
A330/340: 1400FH
A320: 6500FH
B747: 260FH

Experience as Flight Engineer on DC10, between 1989 and 1992, more than 1500 FH

Co-pilot (Pilot Flying).

Sex:	Male
Age:	29
Nationality:	Belgian
Licence:	CPL(A) first issued on 29 May 2000, last issued on 30 November 2007, valid until 30 November 2012.
Rating:	Avro RJ/Bae 146, B747-100/-300 (since 30 November 2007).
Medical:	Medical certificate first class, issued on 16 January 2008, valid until 16 January 2009

Flight time history:
The pilot has:

- not flown for the last 24 h
- not flown for the last 7 days
- flown a total of 51:05 FH for the last 30 days
- flown a total of 94:30 FH for the last 90 days.

The pilot complied with all relevant requirements as laid down by the BCAA and Cargo B Airlines. This includes B747 initial, recurrent training (last followed in May 2008), proficiency check (last OPC in May 2008, LPC in November 2007), and line check (last in April 2008).

Flight time experience:
Total Flight time: 3536FH
Total time as PIC: 1100 FH

Experience on type:
BAe146: 1630FH
B747: 570FH

Relief Pilot.

Sex:	Male
Age:	31
Nationality:	Belgian
Licence:	ATPL(A) first issued on 29 January 2006, last issued on 23 October 2008, valid until 27 April 2012.
Rating:	B747-100-300 (since 6 September 2007), BAe146
Medical:	Medical certificate first class, issued on 22 July 2008, valid until 22 July 2009

Flight time history:
The pilot has:

- not flown for the last 24 h
- not flown for the last 7 days
- flown a total of 8:07 FH for the last 30 days
- flown a total of 51:22 FH for the last 90 days.

The pilot complied with all relevant requirements (first officer) as laid down by the BCAA and Cargo B Airlines. This includes B747-100/-300 initial, recurrent training (last followed in May 2008), proficiency check (last OPC in May 2008, LPC in November 2007), and line check (last in April 2008).

Flight time experience:
Total Flight time: 3483FH

Experience on type:
BAe146: 2704FH
B747: 568FH

The relief pilot had just completed a type qualification for B747-400.

Flight Engineer.

Sex:	Male
Age:	47
Nationality:	Dutch
Licence:	Flight Engineer licence issued by the Dutch CAA, first issued in June 1987, last issued in March 2008, validated by BCAA in June 2008, valid until March 2009.
Rating:	B747 100-300
Medical:	Medical certificate first class, issued on 23 June 2008, valid until 26 June 2009

The flight engineer has:

- not flown for the last 24 h
- not flown for the last 7 days
- flown a total of 44.15 FH during the last month
- flown a total of 114:36 FH during the last 3 months.

The flight engineer complied with the qualification requirements including B747 initial and recurrent training (last followed in February 2008), Line Proficiency Check (last performed in February 2008), Line Check (last in March 2008).
The Operational Proficiency Check (OPC) was last performed in February 2008 and the recurrent check was performed during the accident flight (overdue by two months - frequency is one per 6 months).

Flight time experience:
Total Flight time: more than 11600FH (mostly on B747)

Instructor Flight Engineer.

Sex:	Male
Age:	54
Nationality:	Belgian
Licence:	Flight Engineer licence issued by the Dutch CAA, first issued in August 1979, last issued in August 2008, validated by BCAA in September 2008, valid until February 2009.
Rating:	B747 100-300. Instructor Flight Engineer, valid until 01 May 2010
Medical:	Medical certificate first class, issued on 6 March 2008, valid until 24 February 2009

The instructor flight engineer has:

- not flown for the last 24 h
- not flown for the last 7 days
- flown a total of 44.49 FH during the last month
- flown a total of 130.58 FH during the last 3 months.

The flight engineer complied with all relevant requirements as laid down by the BCAA and Cargo B Airlines. This includes B747-100-300 initial, recurrent training (last followed in January 2008), proficiency check (last OPC in July 2008, LPC in July 2008), and line check (last in October 2007).

Flight time experience:
Total Flight time: more than 11000FH

Note: the load master present on board was not supposed to play any role in the flight and is considered in this report as a passenger.

1.6. Aircraft information.

The B747 is a 4-jet engine wide body airliner. It first flew on 9 February 1969. A total of 1405 units were produced until now.
The B747 exists in several versions, for the transport of passenger and freight.

The 747-200F is the freighter version of the B747-200 model. It can be fitted with a side cargo door and a nose cargo door. The nose swings up so that pallets or container, in length of 12m can be loaded straight in on motor-driven rollers. It has a freight capacity of 110 tons, a basic operating weight of 340661 lb (154661 kg), a maximum fuel capacity of 161819 kg and a maximum take-off weight of 820000 lb (371945 kg). It entered first service in 1972 with Lufthansa.

A total of 393 of the -200 versions had been built when production ended in 1991. Of these, 225 were 747-200s, 73 were 747-200F, 13 were 747-200C, 78 were 747-200M, and 4 were military.

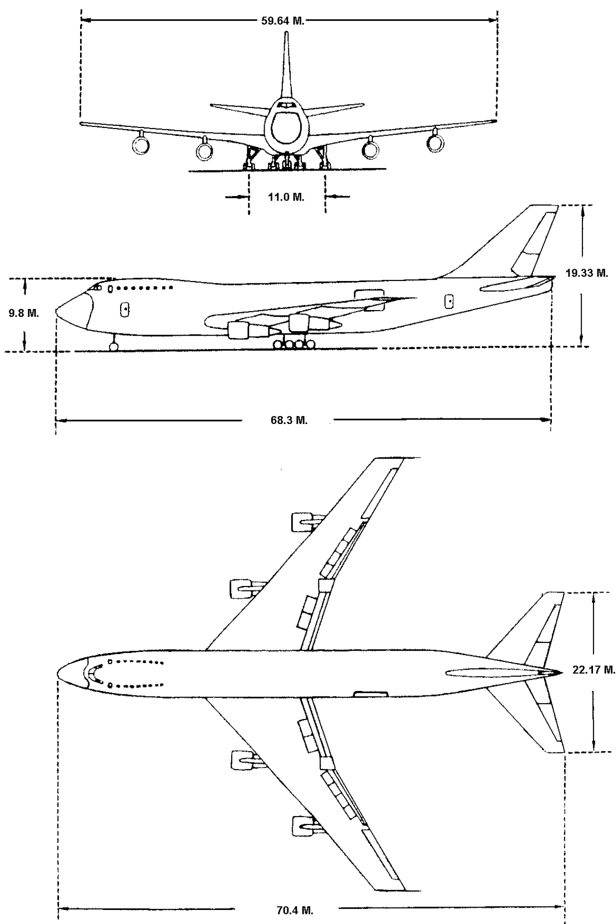


Figure 10: B747-200F

Airframe

Manufacturer:	Boeing
Type:	B747-228F
Serial Number:	24158
Built year:	1988
Certificate of Registration:	N° 10172, issued in September 2007
Certificate of Airworthiness:	Issued in September 2007, Airworthiness Review Certificate issued on 25 September 2008, valid until 11 March 2009.
Total Flight Hours:	82357.49 FH
Total Flight Cycles:	15773 FC

Engines

Manufacturer:	General Electric
Type:	High-bypass turbofan jet engine
Model:	CF6-50C2
Engine 1 Serial:	517329
Engine 2 Serial:	517989
Engine 3 Serial:	517419
Engine 4 Serial:	517313

Maintenance

The maintenance is performed by a Part-145 approved Maintenance Organisation.
The aircraft is maintained in accordance with a Maintenance Schedule (MS) issued in November 2007

The last maintenance check – S-Check and 1A-Check - was performed on 14 October 2008, at AC time 82312 FH

Aircraft loading

The loading of the aircraft was performed in accordance with the Operator's B-747 Weight and Balance Manual.
After the flight, the loading was removed from aircraft and weighed at the facility of Flight Care in Brussels Airport. No significant deviation was observed with respect to the Load Sheet.

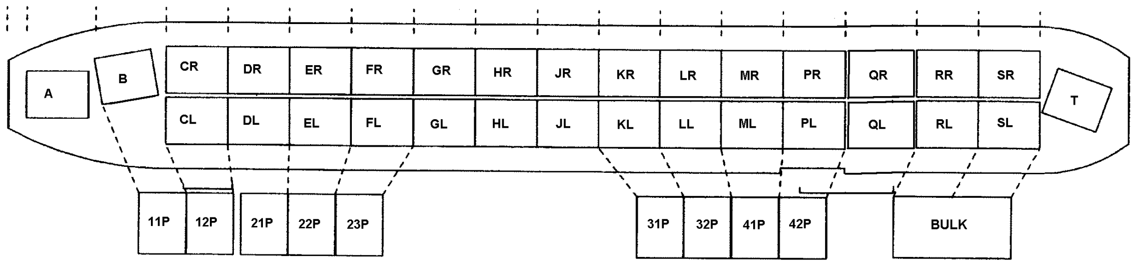


Figure 11: Cargo position identification

Location	Weight (kg – load sheet)	Weight (kg – measured)	Difference
A	1090	1090	0
B	2770	2770	0
CL	2855	2855	0
CR	615	615	0
DL	2550	2550	0
DR	2460	2460	0
EL	5675	5670	- 5
ER	635	635	0
FL	3880	3880	0
FR	4370	4375	5
GL	3865	3860	- 5
GR	4785	4785	0
HL	3905	3900	- 5
HR	6755	6750	- 5
JL	3905	3900	- 5
JR	6540	6535	- 5
KL	3905	3905	0
KR	1570	3130 :2 = 1565	- 5
LL	2095	2150	55
LR	1570	3130 :2 = 1565	- 5
ML	3900	3895	- 5
MR	3905	3900	- 5
PL	3865	3865	0
PR	3550	3550	0
QL	0	0	0
QR	0	0	
RL	3365	3360	- 5
RR	1620	3530 :2 = 1765	145
SL	3905	3900	- 5
SR	1620	3530 :2 = 1765	145
T	985	1005	20
11P	1375	1375	0

12P	530	555	25
21P	535	555	20
22P	1340	1335	- 5
23P	2630	2630	0
31P	4560	4680	120
32P	1270	1270	0
41P	1340	1340	0
42P	1675	1675	0
Bulk	0	0	0
Total	107765	108235	460

Procedures

Hereunder a selection of extracts from the Operator's Operations Manuals, partaining to the topics discussed in Chapter 2. Analysis.

Operator's Operations Manual Part A.

4.1.2.3 CREWING OF INEXPERIENCED FLIGHT CREW MEMBERS

The Director Operations will ensure through the Flight Crew Scheduling department that special procedures are in place to prevent inexperienced flight crew being scheduled to fly together.

A flight crewmember is inexperienced, following completion of a type rating or command course, and the associated line flying under supervision, until either he has achieved:

- 100 flying hours and flown 10 sectors within a consolidation of 120 days;
- 150 flying hours and flown 20 sectors (no time limit) on the type.

A reduced number of flying hours or sectors may be approved, subject to any other condition which the BCAA may impose, when:

- a flight crew member has previously completed a type conversion course with the Company he may, with the approval of the Training Manager, be considered experienced following the completion of the command course and associated line training;
- When introducing a new airplane type.

Flight Crew scheduling department is responsible for the supervision of the required flying hours and sectors. When the above requirements are met the restriction for the flight crewmember will be removed by the Director of Operations.

5.2.4 FCM RECENCY

A pilot shall not operate an aircraft as

1. pilot-in-command unless he has carried out at least 3 takeoffs and 3 landings in the preceding 90 days, as a pilot flying in an aircraft (or an approved flight simulator) of the type to be used.
2. co-pilot unless he has carried out at least 1 takeoffs and 1 landings in the preceding 90 days, as a pilot flying in an aircraft (or an approved flight simulator) of the type to be used.

The recency of experience can be regained in the period between 90 and 120 days during normal line flights, if these flights are conducted under surveillance of a LTC or TRI.

When more than 120 days have passed, the recency of experience can be regained only after receiving training and checking as specified in OM D.

REMARK

The flight simulator shall be acceptable to the BCAA.

5.2.6 OPERATION ON MORE THAN ONE TYPE OR VARIANT

Not applicable

Operator's Manual Part D

2.2.2 CONVERSION TRAINING AND CHECKING

(…)

Once a FCM has commenced a conversion course, he shall not undertake flying duties on another type of aircraft until the course is completed or terminated (abandoned).

The Operator's Standard Operating Procedures (**OM-B bulletins**) describes how to compute the take off performance data and how to validate them.

1. INTRODUCTION

The CBA Standard Operating Procedures (SOP) outline the duties and responsibilities along with task sharing details of the B747 operating **Flight Crew Members (FCM)**.

The CBA SOP must be regarded as working instructions that are supplemental to the Boeing procedures. Where required, more information is provided on exact sequence of actions, on task responsibility and on crew coordination. All exact call outs are described. On occasions, the Boeing procedures were slightly altered in order to adapt to the safety standards as applied throughout the entire aviation industry of today or to the actual systems onboard of the aircraft.

The Standard Operating Procedure shall be adhered to under all normal circumstances in order to enhance safety standards. Deviations from SOP are allowed if, in the opinion of the commander, this will result in a safer and/or more efficient flight operation. All deviations shall be properly briefed and understood by all Flight Crew Members.

Each Flight Crew Member must be aware of his own duties and responsibilities and must know the duties and responsibilities of the other FCM as well. When a Flight Crew Member's workload becomes excessive, the concerned FCM shall verbally state this and he may ask another Crew Member to temporarily share his duties, i.e. making a T/O calculation, verifying the loadsheet, etc.

3.2 COCKPIT PREPARATION

Utilizing the scan flow described in the OM B, all crewmembers check the correct position of all switches, circuit breakers and selectors. When required, they perform appropriate system tests.

FMS preparation and NAV setup is done by the PF.

The Take-Off performance calculations shall be done via the RTTO (Real Time Take Off) performance program on the laptop computer by both pilots individually. The PNF shall fill in the TO data card. The TO data card will then be handed over to the FE for verification.

Until further notice, an EDP (Electronic Data Processing) loadsheet will be presented to the Captain by the ground handling agent.

One FCM, preferably the PNF, will crosscheck the loadsheet by input of all data in RTTO and will verify that presented loadsheet is within limits.

In case of LMC higher than the limits given in OM A chapter 8.1, a new loadsheet must be requested.

In case an EDP loadsheet is impossible to obtain, it is permitted to perform the Weight & Balance calculation through the RTTO (Real Time Take Off) program on the onboard laptop. Both pilots will perform the calculation individually. The FE will crosscheck final data. ZFW, TOW and indexes shall then be noted on the copy of the loading plan that shall be signed by the Captain and given to the ground handling agent.

Figure 12: Operator's SOP (OM-B Bulletin B-O-2008-07 of 30/07/2008)

2. RTTO PERFORMANCE CALCULATION SOFTWARE

2.1 GENERAL

Each pilot should independently follow the 'Input' process detailed below. However, operational use of the laptop computerized takeoff performance calculator requires a minimum of one serviceable laptop.

In the event of only one serviceable laptop being available, the takeoff performance program should be closed after the first calculation. The pilot completing the crosscheck should re-start the takeoff performance program and follow the 'Input' process.

If no serviceable laptop is available, Cargo B dispatch should be contacted by GSM or by any other available communication channel.

Figure 13: Operator's SOP (OM-B Bulletin B-O-2007-01 of 01 Sep 2007 – RTTO Application)

1.7. Meteorological conditions

Observed at Brussels Airport

Wind:	Direction:	280 degrees
	Speed:	9 Knots

Visibility:	10 Km
Clouds:	Towering Cumulus 2600 feet 5000 feet
Pressure:	1008 mbar
Temperature	10°C
Dew point:	5°C
Runway:	Damp.

The meteorological conditions played no significant role in the accident.

1.8. Aids to Navigation

Not applicable.

1.9. Communication

Radio.

As per procedure, the airplane was communicating with Brussels ATC (Ground and Tower frequency). The communication was recorded. For the take-off sequence and the minutes after the take-off, the CVR transcript (Chapter 1.11) includes the radio communication with ATC.

Immediately after the take-off, a Brussels Airport support vehicle contacted the Tower to report seeing parts falling from the airplane on the grass next to the runway.

At 15:02:29; the runway 25R was closed by ATC.

At 15:07:09, a vehicle from Airport inspection started to screen the runway for debris.

At 15:07:45, a 1m-metallic part was removed from the runway.

At 15:15:00, the inspection of the runway for debris was completed.

At 16:17:21, the airplane called Brussels ATC requesting the landing clearance.

The airplane landed at 16:20:47. It was followed on the runway by vehicles from the fire brigade and airport inspection.

Radar trace (see Fig.6)
The path followed by the airplane has been recorded from the ground radar data of Brussels airport. The radar image results from the integration of the data of 4 radars located at various places on Brussels Airport (Cardion, North, South, Tower).

1.10. Aerodrome information

The Brussels airport is located at 6.5 Nautical Miles (12km) NE of the city of Brussels, on the coordinates 50°54'05''N 004°29'04''E. The elevation is 56m asl.
The airport is certified (Interim certificate N° A-POR\2008\Annex14_001) to be compliant with the requirements of ICAO Annex 14 and the Belgian Law (AR/KB 15 March 1954).

The airport has three bi-directional runways with hardened asphalt and anti-slip layer (type Possehl). All three runways are certified to ICAO reference code "4E" (this code interrelates the numerous specifications concerning the characteristics of aerodromes, including the length of runways and the size of aircraft it can accommodate).
The B747-200F requires a code "4E" airport.

Runway 25R was in use for take-offs and runway 25L was in use for landings. Some parts of the taxiways were undergoing repairs, and therefore unavailable.

The main characteristics of the runways are:

	07 L / 25 R	07 R / 25 L
Actual bearing	65.38° / 245.38°	69.89° / 249.89°
Available distance for take-off	3638m	2891m / 3211m
Width	45m	45m
Slope	- 0.21% / + 0.21%	-0.15% / +0.15%

The airport is equipped with surveillance cameras that were able to record images from the airplane taking off. On the pictures, the effects of the tail strike are clearly visible (see Fig.2 – 5).

The take-off run available on RWY 25R (TORA) from the B1 entry point is 3267m.

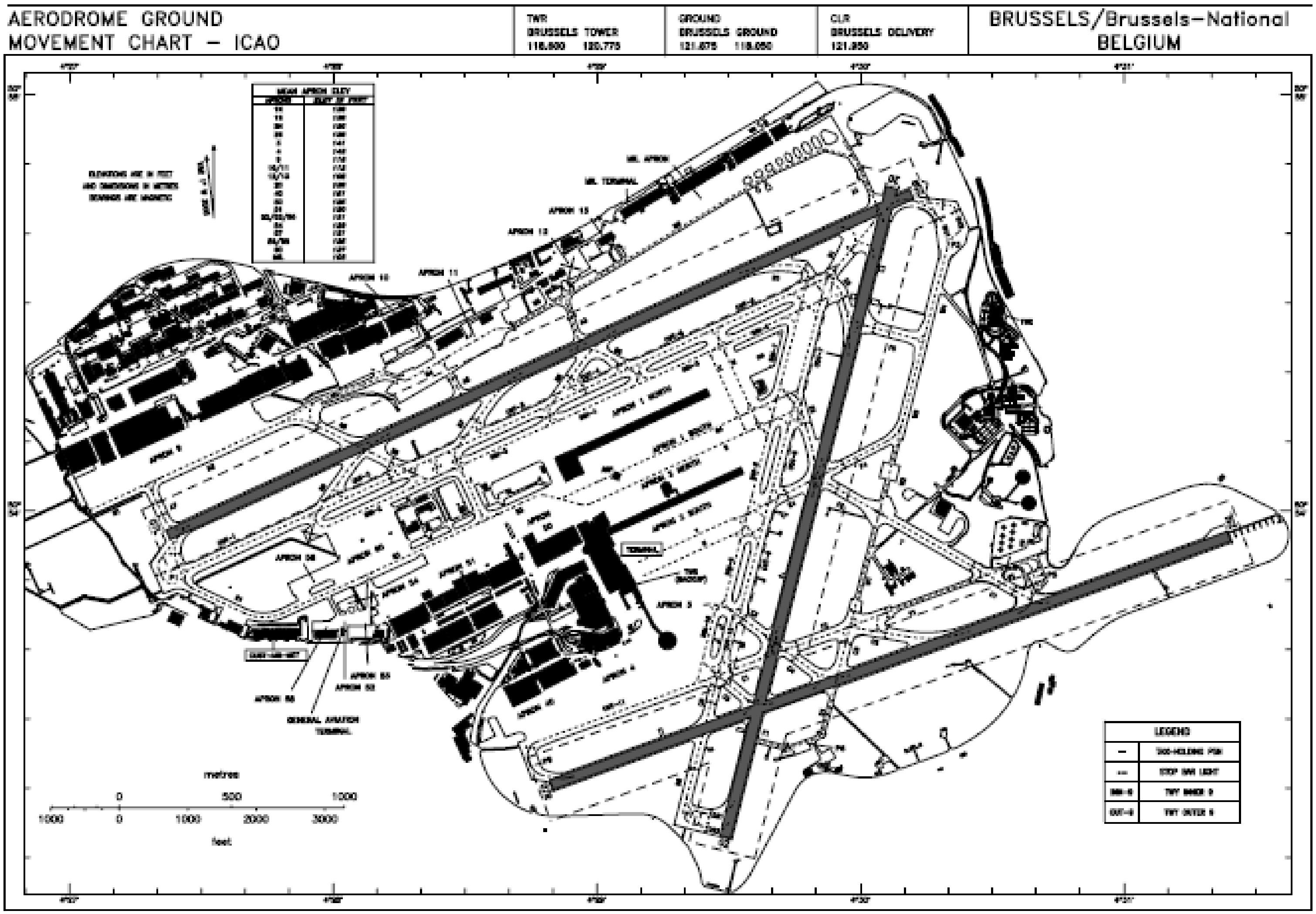


Figure 14: EBBR airport chart

1.11. Flight Recorders

The airplane was equipped with:

- A Cockpit Voice Recorder
  - Manufacturer: Honeywell
  - Part Number: 980-6022-001
  - Serial Number: 120-06-005

- A Flight Data Recorder.
  - Manufacturer: Honeywell
  - Part Number: 980-4700-042
  - Serial Number: 09450

The two recorders were retrieved from aircraft on 30 October 2008 and sent for read-out to the BEA-France on the 31 October 2008.

CVR Cockpit Voice Recorder
The tape cockpit voice recorder was sent to the BEA-France's Audio Laboratory for read-out.

This model of CVR is a solid-state recorder that records 120 minutes of audio in a four channel format:

- One channel for each flight crew member (captain, FO and FE) and
- One channel for the cockpit area microphone.

The timing of the CVR was correlated to the flight data recorder (FDR), and both recordings were correlated to the UTC time recorded on the ATC communication system.

The excellent quality recording contains events from approximately 1 hour before the take-off through the accident sequence and ends with the landing. The recording starts at 13:56 and ends at 15:56.

The sequence related to the computation of the take-off performance data is not recorded on the CVR because it took place earlier, outside the cockpit.

A selection of the transcript is given hereunder;

Cockpit Briefing

A cockpit briefing started at 14:22:41. It covered the following subjects:

- engine starting sequence,
- push-back,
- taxi route (Alpha 6, Bravo 8, Outers, Whisky 4, Whisky 41, full runway 25R), flaps setting (flaps 10), and
- the review of the emergency procedures (if anything before 80kts, abort, calling ‘reject’, after 80 kt, abort only for engine fire, engine failure, or aircraft unable to fly; after V1, continuation of the flight, etc..)

Before Start Check List

The “Before Start Check List” was initiated at 14:26:15, with the commander, the co-pilot and one flight engineer present in the cockpit.

It was interrupted (14:27:15) at the “Fuel” sequence; During the interruption, ground mechanics made tests (elevator movement – completed at 14:31:44) and the commander enquired on the radio about the available food for the 20 dogs carried on board.

The “Before Start Check List” was resumed at 14:34:59 up to the “Gross weight” sequence. The communication transcript is hereunder:

Time (counter)	Transcript	Person (comments)
14:35:11	Weight and Balance?	
14:35:12	Observable	
14:35:13	Gross Weight. We gaan eerst.	
14:35:15	Zero fuel weight is ??	Flight engineer
14:35:17	Two sixty five six, I think	Commander
14:35:18	Sixty five six ?	Flight engineer
14:35:19	Ja	Commander
14:35:31	Drie zes vier vijf ?	Flight engineer
14:35:37	Ja	Commander
14:35:43	He, boys the lower door is not yet completely closed	(Outside disturbance)
14:35:51	(the other Flight engineer) is downstairs with, by the dogs, I’ll go down	Flight engineer (leaving the cockpit)
14:36:00	Het gaat niet, (something wrong)…264 TO gross weight …	The co-pilot (noticing a discrepancy on the TO performance card, ZFW left blank)

Time (counter)	Transcript	Person (comments)
14:36:07	Three six four , three six four	commander (correction of the TO performance card – changing the 2 into a 3 for the TO gross weight)
14:36:11	OK, door is closed	Flight engineer (coming back in the cockpit).
14:36:12	Thank you	commander
14:36:22	Gross weight ?	
14:36:24	heu.. Drie zes vier vijf (three six four five)	Flight Engineer
14:36:25	three six four five, set	commander

This sequence resulted in a manual correction of the takeoff data chart, but not in a re-evaluation of the thrust settings or the take-off speeds. This happened 24 minutes before the take-off.

The “Before Start Check List” was completed at 14:36:47.

The request for push back and start was made at 14:37:11

Engine N°4 was started at 14:37:35.

Brakes were released at 14:39:42.

The 3 other engines were started from 14.42.47 to 14.45.51.

The “After Start Check List” was initiated at 14:46:11

During the taxi, there was no unnecessary chat noticed (silent cockpit) between the crew members.

The crew initiated a “small summary of the departure” when taxying at 14:53:11. The value of reduced N, V1, Vr, V2 were read as indicated on the Take-off performance data card.

The “Before Takeoff Check List” was initiated at 14:54:4 and completed “to the line” at 14:55:14.

The take-off sequence (the transcript includes the radio communication with ATC):

Time	Transcript	Communication
14:57:25	Cargo B 3101, contact tower on 120.775, bye-bye	Ground ATC
14:57:29	120.775, Cargo B 3101, bye	Commander
14:57:41	Tower, Cargo B 3101 again, we'll be ready upon reaching.	Commander
14:57:47	Cargo B, tower, Roger, you can line up and wait, Runway 25R.	Tower
14:57:51	We'll line up and wait , runway 25R, Cargo B 3101	Commander
14:59:20	Cargo B3101, wind 290 degrees, 7 knots, Runway 25R, clear for take-off.	Tower
14:59:25	Cleared to take-off, runway 25R, Cargo B 3101.	Commander
	.... (running the check list)...	Flight engineer
15:00:00	Before take-off check list completed	Flight engineer
15:00:01	Ready guys ?	Commander
15:00:02	Ready	
15:00:02	You have controls ?	Commander
15:00:03	I have controls	Co-Pilot
15:00:05	Take-off	Commander
	(sound of engine increasing)	
15:00:13	Set Thrust	F/Eng
15:00:38	Eighty	Commander
	Check	Co-Pilot
15:00:54	V One	Commander
15:00:58	Rotate	Commander
15:01:05	(metallic scraping sound)	
	oef !	
15:01:09	Tire, tire, tire (in French: pull, pull, pull)	Commander
15:01:11	Power ?	Flight engineer
15.01.13	Tire (in French: pull)	Commander ?
	Set full thrust	Co-Pilot
15:01:15	Full thrust – Full thrust	Commander – F/O / Flight engineer
15:01:16	Gear up – Gear up	Co-Pilot - Commander
15:01:26	Autothrottle.	Co-Pilot

The stick shaker is audible twice from 15:01:12 to 15:01:15.

After take-off, the crew realized the problem

Time	Transcript	Communication
15:02:22	That was a weird sound.	
15:02:23	What was it ?	
15:02:25	It shook me seriously	
15:02:29	(to ATC) Brussels, allo, Cargo B3101,	Commander
15:02:33	…. Not pressurized.. (referring to the tail strike on take-off emergency abnormal checklist)	Flight Engineer
15:02:34	(to the Flight Engineer) I do not know what the ‘bang’ was …I heard a weird bang..	Commander
15:02:36	Cargo B 3101 ?	Ground ATC
15:02:38	Checking in, Hallo	Commander
15:02:41	Cargo B 3101, contact Tower, 120.775	Ground ATC
15:02:46	I was nearly full rudder. Is the rudder ?…	? co-pilot
15:02:53	Tail strike, not pressurized	Flight Engineer.
15:02:55	(To ATC) Brussels, Cargo B3101, OK Sir at 3000ft, climbing	Commander
15:03:30	Tail strike, not pressurizing	Flight Engineer
15:03:35	Report intentions, Cargo B3101	Tower
15:03:38	(to ATC) Our intentions, tell us the problem ?	Commander
15:03:42	It seems you had a tail strike	Tower
15:05:22	I think the speed was too low	Flight Engineer
15:07:26	We had a tail strike, and we need to return to Brussels	Commander

FDR Digital Flight Data Recorder

The Honeywell Flight Data Recorder (FDR) is a solid state device that records airplane flight information in a binary format, using analog signals.

The time range of the recorded data is 383 953 seconds (100 hours).
The decoding was done using the Air France documentation, which is known to be the former operator of the airplane. According to this documentation, 97 parameters are recorded on the FDR.

The accident flight was the last flight of the recording

The following parameters were found to be invalid:

- Normal acceleration (g)
- Flaps position (deg)
- Pitch control position (deg).

No information related to the airplane weight is recorded.

The European Regulation EC 8/2008 requires that Commercial Air Transport aircraft are equipped with a Flight Data Recorder. Specifically, the accident aircraft, was operating such that it was required to be equipped with an FDR that recorded 16 parameters, as cited in EU OPS 1.725. The accident aircraft was not in compliance with the carriage requirements because the sampling interval of the engine power parameters recorded to satisfy the requirements – laid down in the document Eurocae ED55 - for parameter 9, Thrust/power on each engine, was 4 seconds not the required 1 second interval.

The following relevant parameters were read:

Parameter Name	Plot/Tabular Label	Units	Record rate
Computed Airspeed Airspeed	Comp	knots	1 per second
Radio Altitude	Altitude radio	feet	
Control Column Position	Ctrl Col Pos	degrees	2 per second
Engine 1 N1 rpm	Eng1 N1		1 per 4 seconds
Engine 2 N1 rpm	Eng2 N1		1 per 4 seconds
Engine 3 N1 rpm	Eng3 N1		1 per 4 seconds
Engine 4 N1	Eng4 N1		1 per 4 seconds
Pitch Attitude	Pitch	degrees	1 per second

The parameter evolution curve is given in appendix.The following elements can be noted :

- Before take-off, neither flaps nor slats are retracted (however the precise aircraft configuration cannot be deduced from the parameters).
- The engine power (N1) starts increasing from 31% at 15 h 00 min 08 s.
- The Auto-throttle is engaged at 15 h 00 min 13s.
- The CAS starts increasing from its floor value of 50 kt at 15 h 00 min 28 s.
- All four N1 parameters reach a value of about 101% at 15 h 00 min 30 s.
- The Pitch attitude starts increasing at 15 h 01 min 01 s. At this time the CAS is 147 kt.
- The Pitch attitude reaches 12.3 degrees at 15 h 01 min 06 s and stays with this value until 15h 01 min 10 s.
- The Air/Ground switch commutes to “Flight” at 15 h 01 min 11 s. It is once again “Ground” at 15 h 01 min 12 s, then it commutes back to “Flight” at 15 h 01 min 13s and keeps this status for the rest of the flight

The time sequence of the take-off is as follows:

Action	Time	Remark
Throttle moving towards TO setting	15:00:09	
CAS reaching 129 kts	15:00:53	Computed V1
CAS reaching 140 kts	15:00:57	Computed Vr
Air / Ground switch => Air	15:01:13	
CAS reaching 163 kts	15:01:15	Actual V1
Throttle moving towards Full power	15:01:17	
Altitude starts climbing	15:01:18	
CAS reaching 174 kts	15:01:19	Actual Vr

Note:

When the airplane lifted off at 15:01:18, the remaining TORA measured based on the radar trace was around 600 m.

1.12. Wreckage and Impact information

The airplane tail hit the concreted runway at high speed. The shock liberated parts that fell on the runway.

1.13. Medical and Pathological information

Not applicable.

1.14. Fire

There was no fire.

1.15. Test and Research

1.15.1 Re-enactment.

The airplane crew was invited in AAIU's offices for a re-enactment of the flight, from the flight preparation to the take-off.

During this simulation, besides the sequence of events (described in para 1.1), some topics became apparent:

- The crew members did not know each other, and came from various companies, before joining the airline.
- The work sphere inside the cockpit was relaxed, and the crew stated there was no excessive time pressure.
- The crew did not follow the prescribed procedure of the airline for verifying the TO performance data.
- The thinking pattern of the crew member was still influenced by their experience of the former airline they work for and airplane they flew.

1.15.2. Publications.

Safety Bulletin and Investigation Reports.

There were a number of similar accidents in the past. The investigation reports constitute a solid base for safety awareness programs in airlines.

The safety management of the operator had published, a couple of months before the event, an article in the company's news bulletin about an accident that occurred in Halifax, Canada with a Boeing B747-244SF (a type of aircraft and operation similar to the operator's).

This accident resulted in the destruction of the aircraft and the dead of all seven crew members. It was due to the incorrect entry of the Take-Off weight for the computation of the takeoff data.

The Halifax accident investigation report is available on the Transport Safety Board of Canada (TSB) website:

http://www.tsb.gc.ca/eng/rapports-reports/aviation/2004/a04h0004/a04h0004.asp (Aviation Investigation Report A04H0004 - Reduced Power at Take-off and Collision with Terrain).

The investigation report identified the following contributing factor to the accident, strikingly applicable to this case:

- *It was likely that an independent check of the take-off data card was not performed by the crew as required by the standard operating procedures (SOPs)*

Studies.

Owing to a series of very similar cases, a number of studies were launched by Investigation Authorities:

1. Use of Erroneous Parameters at Take-Off (May 2008)

A working group was established in France to study the processes specifically relating to the use of erroneous take-off performance parameters, and to analyse why skilled and highly trained crews were unable to detect these errors. The working group consisted of representatives from the French BEA, DGAC and the Laboratory of Applied Anthropology (specialists in human factors).

The document (DOC AA 556/2008 – May 2008) is available on the BEA website on the following addresses:

http://www.bea.aero/en/publications/etudes/analyses.php (use of erroneous parameters at take-off – in French and English.

Several conclusions of this report are remarkably applicable to this case; e.g.:

- *In several cases, the ZFW was entered instead of the TOW into the performance calculator,*
- *Checks on the "take-off parameter calculation" function can be shown to be ineffective because they consist of verifying the input of the value but not the accuracy of the value itself,*
- *In the same way, the check of data featuring on several media often proves to be ineffective. It's often limited to item by item comparisons. If the item is wrong, the check is correct but inadequate because it doesn't cover overall consistency. In particular, there is no comparison between values for takeoff weight given in the final loadsheet, on the takeoff paper or electronic "card" and in the FMS,*
- *In several cases, crews perceived abnormal airplane behaviour during takeoff. Some took off “normally”. Others were able to adopt different strategies: stopping takeoff, increasing thrust, delayed rotation.*

2. Take-off performance calculation and entry errors: A global perspective (January 2011)

In 2009, the ATSB started a research study to further explore why the events related to entry errors in take-off performance calculation occurred. The study went through the identification and analysis of contributing safety factors based on the chain-of-events theory of accident causation concept from Reason (1990).

One objective of the report was to explore the nature of the associated human errors and identify the higher-level safety factors that contributed to these occurrences.

The document (AR-2009-052 published January 2011 – ISBN 978-1-74251-097-2) is available on the ATSB website on the following address:

> http://www.atsb.gov.au/publications/2009/ar2009052.aspx (Take-off performance calculation and entry errors: A global perspective – in English)

Extracted from the conclusions of the report:

Due to the immense variation in the mechanisms involved in making take-off parameter calculation and entry errors, there is no single solution to ensure that such errors are always prevented or captured. This report has discussed several error capture systems that airlines and aircraft manufacturers can explore. These include: appropriate crew procedures, especially those involving cross-checking; aircraft automation systems and software design involving the entering and checking of data; the provision of, and design of flight documentation and performance charts; and adequate crew pairing that accounts for aircraft-type experience for all crew operating the aircraft. At the same time, pilots need to ensure procedures are followed even when faced with time pressures or distractions.

3. Other publications

Airbus has published a Flight Operation Briefing Note on “Preventing Tailstrikes at Takeoff”. Boeing has also published articles on this subject (Aero QTR_01 07) available at: http://www.boeing.com/commercial/aeromagazine/articles/qtr_1_07/article_02_1.html)

and studies (A human factors approach to prevent tailstrikes – Cpt Vern Jeremica, May 2004)

1.15.3. Similar events.

The Belgian aviation incident database was researched for events bearing some similarities with this accident. The aim is to bring this accident into perspective.

There were no incidents reported in relation to an inadvertent entry of an inadequate value of TO weight for the computation of the TO performance data while the load sheet gave the correct value.

For the period 2011-2014, there were however a series of events related to errors on the load sheet that could, if not detected by the crew, have resulted in inadequate value of TO weight for the computation of the TO performance data and /or inadequate setting of the elevator trim.

48% of the cases were detected by the crew before the flight.

On the remaining 52 % of the events that were not detected by the crew, only a fraction (28% - 11 cases) resulted in the crew experiencing an abnormal behavior of the airplane upon take-off. The occurrence ratio is one such significant event per 114000 flight hours.

The abnormal behavior was:

- Nose heavy at rotation, or (when the weight is overestimated)
- Nose wheel starts to lift off before reaching the rotation speed.

The causes identified for the phenomenon were:

- Load not reported on the load sheet (wrong number of passengers, wrong number of luggage in cargo holds for passenger airplane, and wrong loading figure for cargo airplane).
- Wrong distribution of the load (passenger distribution, or load distribution in the cargo holds).

There were only 2 cases related to cargo flights, but they showed the largest variation in weight (29 tons reported instead of 36 tons for one case, 4 tons not taken into account for the other).

The amplitude of the error and its effect seems to be more limited for passenger carrying airplane. However, the most critical events (5 cases) resulted in a shift of 2 units for the trim value on A320-type airplane, it remained in the normal operating band.

A similar event, however with a more critical outcome involving an Airbus A320 taking off from Bastia, France was investigated by the BEA France.

The report (in French) is available at:

http://www.bea.aero/docspa/1998/f-sh980918/htm/f-sh980918.html

2. Analysis.

2.1. The take-off sequence

The sequence of events, starting from the taxying is as follows:

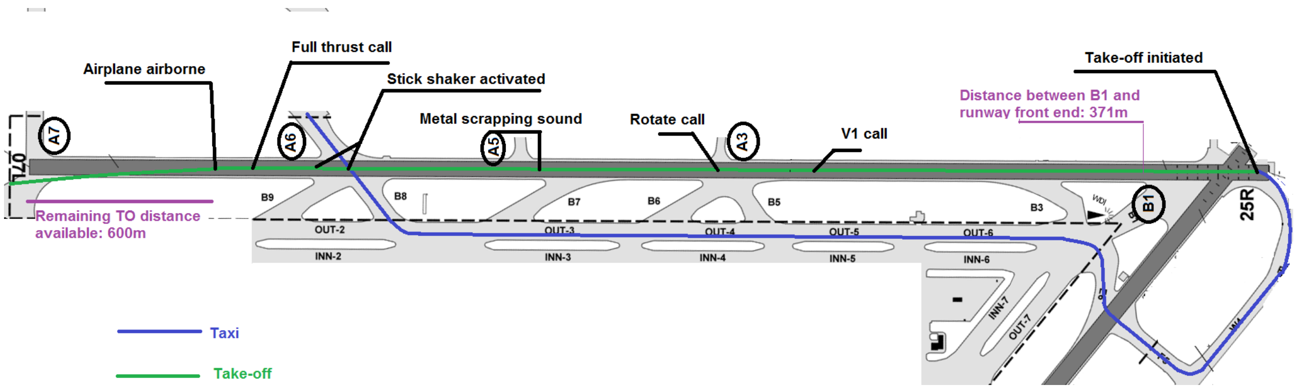


Figure 15: Take-off sequence

After the flight preparation, the commander decided to take-off from the front end of the runway, instead of the B1 position, in order to get some extra safety margin. This meant an extra 371 m available take-off distance.

The airplane taxied as instructed up to Runway 25R and stopped for a few seconds before the engine were set to take-off power (101.6% N1 as set on the dial bugs and the take-off performance data card).

The crew called out '80 (kts)', 'V1', 'rotate' when the airplane reached the indicated speed value.

The pilot pulled the control wheel, but the airplane did not lift off. The reflex of the pilot was to pull more on the control wheel (up to 12°).

A metallic sound occurred when the tail scraped the ground. The commander told the pilot to "pull, pull, pull". The pilot realized he could not pull more.
The airplane moved up somewhat, and the air/ground switch was activated, having for result the activation of the stall warning (stick shaker).
The flight engineer voiced his concern, and suggested to increase power. The pilot ordered "set full thrust", immediately responded by the flight engineer.

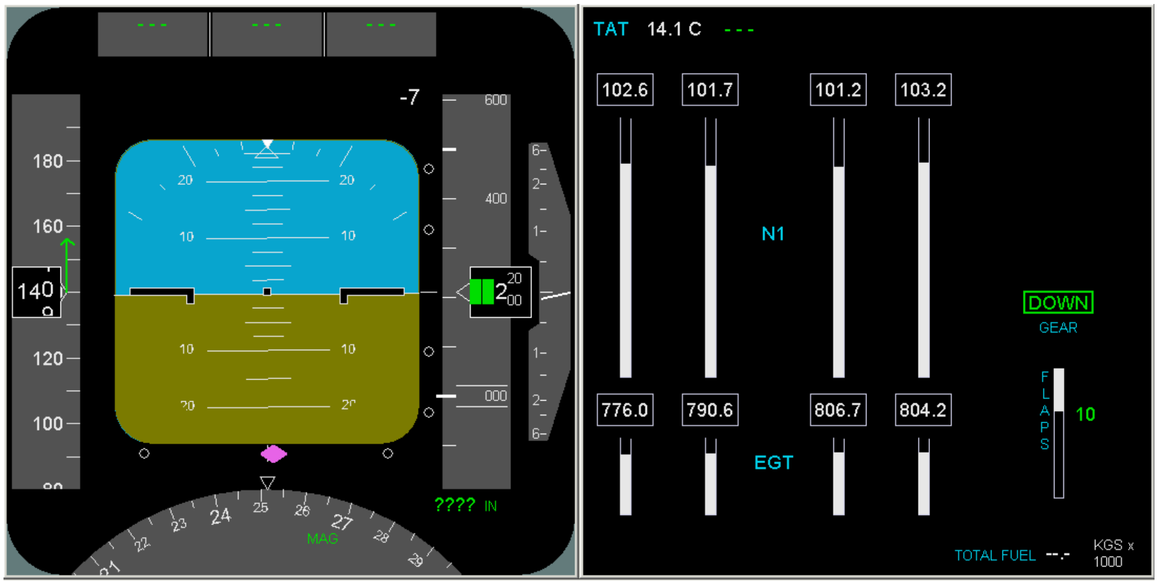


Figure 16: flight deck simulation screenshot: Start of rotation

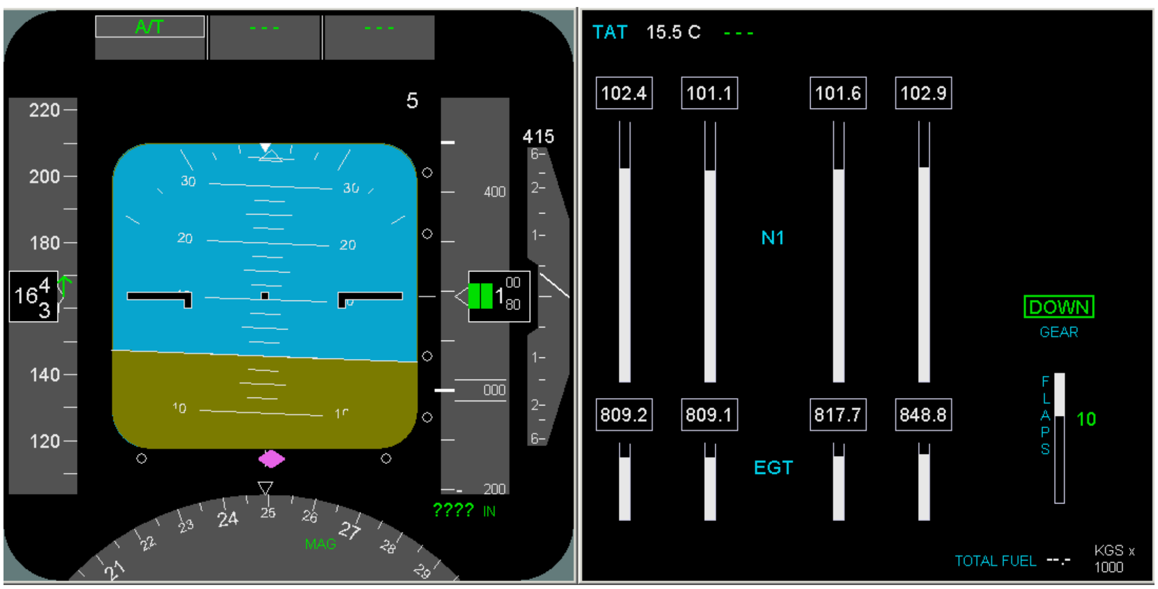


Figure 17: flight deck simulation screenshot: moment of rotation

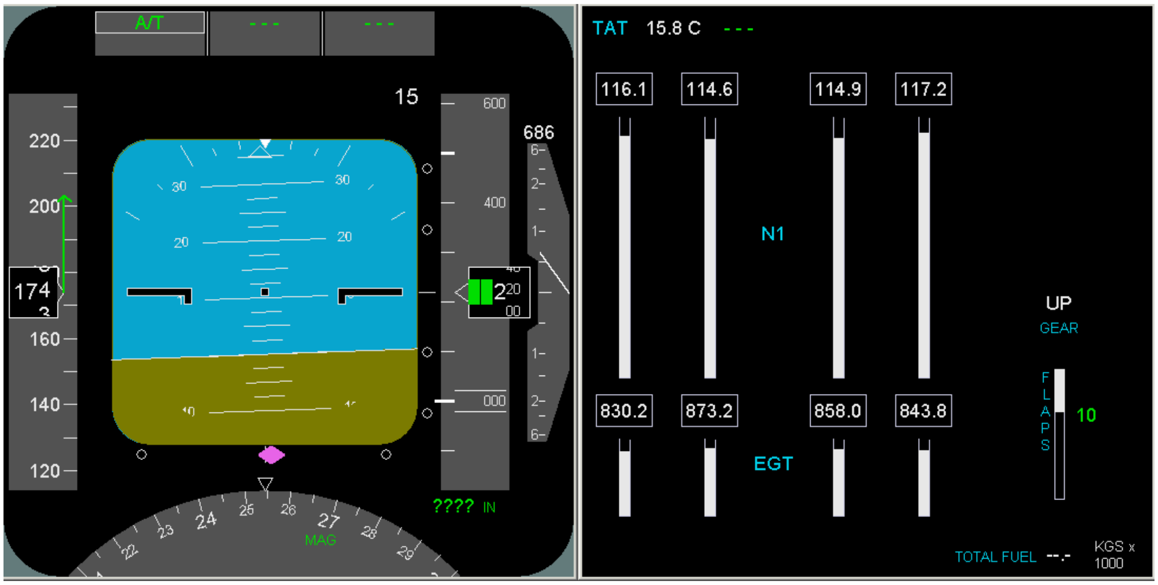


Figure 18: flight deck simulation screenshot: moment of lift-off

By that time, the airplane reached 170kts; sufficient for lift-off.

After the tail strike, the crew performed well in containing and managing the abnormal situation. The Commander was able to let the crew work as a team and together they completed decision making, communication to external bodies and execution of abnormal checklists according the Operator’s standards. Dumping, preparation for approach and approach procedures were adequately executed.

2.2. Take-off Power parameters.

The take-off power settings used during the take-off corresponded to the entry of 264 tons (ZFW) as TO gross weight in the RTTO (Real Time Take Off) software instead of the actual 365 tons reported on the load sheet.
During the investigation, the correct take-off performance data were computed and showed large differences.

	Speeds and thrust set for TOW 264 Tons – flaps 10	Speeds and thrust set for TOW 365 Tons – flaps 10
Engine setting N1 (%)	101.6 %	109.8 %
V1	129 kts	163 kts
Vr	140 kts	174 kts
V2	151kts	183 kts

The aircraft was rotated for take-off at a speed that was more than 30 kts lower than the required speed in the given conditions. At this low speed the aircraft was aerodynamically unable to fly and the risk of tail strike very high.

2.3. The crew

The crew members did not know each other prior to the flight, at the exception of the flight engineers.

The captain, the second and third pilot reported the atmosphere in the cockpit was relaxed. They chatted in order to get to know each other. One of the conversation item was the company they were originating from. As they were all coming from reputable companies, the captain stated it gave a good feeling as of the ability of the crew.

All crew members were trained in the aircraft type, company procedures and all other required matters.

For the pilots however, their experience flying cargo operations and "old-type" aircraft types with 3-men crew such as the B747-200 were limited.

Only the commander had prior experience with a 3-men cockpit crew on DC-10, flying as Flight Engineer, then as co-pilot. But this experience was gained 10 years earlier.

The recent experience of the commander, co-pilot and relief pilots was essentially flying for passenger-carrying airlines with airplanes of a more modern generation than the B747-200 (A320, Avro RJ85/100).

The crew (lack of) experience is reflected in the actions of the crew during the incident, as the pilots seem to initially react with their experience with 2-men crew narrow body aircraft.

The flight engineers, by contrast, are very experienced on B747-200. They are the first to suggest to increase power, and to identify the tail strike (the transcript of the communication shows the flight engineer already consulting the QRH for the procedure on tail strikes ('not pressurize', repeated) while the pilots do not seem to realize what happened.

Note:

The relief pilot had just completed an important part of the B747-400 conversion course. As per regulation, and Operator's procedure manual, he was not supposed to undertake flying duties on another type of aircraft until the course was fully completed, including line checks. However, he was selected for this flight (he was within the conditions of recency as per OM Part A Chapter 5.2.4), and he accepted. (The consequence being that he had to re-do the B747-400 conversion course).

However, more important, the Operator's procedure did not specifically address this issue, as it would have been appropriate to incorporate some kind of training or checks before he would be allowed to flight duties on the B747-200.

2.4. The company

Cargo B was founded in 2007, the company was new. The crews were coming from various horizons, various companies according to the individual qualifications.

The company was small but was adequately organized and had a set of procedures aimed to comply with relevant regulatory requirements, but did not go beyond the requirements. As an example, the set of procedures did not incorporate a check aimed to detect gross errors in the introduction of data in the RTTO system, although the safety department was aware of the specific dangers of wrong data entry in the RTTO.

Nevertheless, the procedure relative to the take-off parameters seems adequate. However, this procedure is split into 2 different documents (bulletin 2008-7 and 2007-1), making it more difficult to apply (than if all requirements were integrated in a single procedure) and remains vague for some key elements; as an example:

> "the take-off data card will be presented to the FE for verification"
>
> (what verification ? verification that the bugs on the speed indicators are correctly placed, or verification that the computation and data are correct ?)

The manual incorporates a procedure on 'crewing of inexperienced flight crew'. But, according to this procedure, the crew was considered 'experienced', as it covers the obvious case of crew with very little flight experience on type.

The scheduling of the crew, in particular the late calling of the relief pilot, shows the little margin of crew available and the priority to cope with the immediate commercial operational pressure.

The flight safety officer was trying to create a company-wide culture, by training sessions and publication of safety booklets including articles on relevant aircraft accident investigations, such as Halifax MK Airlines flight 1602 included in the Jan-Mar 2008 edition of SAFE.

The same booklet included on article on "Cockpit interruptions and distractions" with a selection of examples, but the article does not suggest to re-do a briefing for the beginning in the event it was interrupted.

The Company went bankrupt on 7 July 2009.

2.5. Human Factors

Errors and opportunities

The two safety studies in chapter 1.15. analyze in depth the relevant human factors leading to the use of inadequate engine settings and the non-recognition by the crew of this situation.

In this case, the initial error was made at the computation of the take-off parameters, using the RTTO (Real Time Take Off) software by entering a TOW that was much lower than the actual. As human errors may occur, the procedure was designed to detect such errors by requiring an independent verification.

The procedure was adequate, but was not followed.

- The procedure requires both commander and co-pilot to compute individually and independently the take-off parameters – using each a different laptop, or sequentially using the same laptop, making sure it was reset in the process.
- The initial computation was made by the relief pilot, who asked to observe the first flight, as he came back from a B747-400 conversion course and needed to 'refresh' his memory on the 'old' type. The verification was made by the commander, who did not re-set the computer, but pushed the 'compute' command instead. The computer gave the same (erroneous) results.
- The results were transcribed manually on the take-off performance data card, but two new errors occurred:
    - The value (264) of the ZFW was entered in the T.O. GWT block.
    - The block ZFW was left blank.

- The TO performance card was handed over to the flight engineer, for (per procedure) verification and the setting of the speed bugs. With no correct indication of the take-off weight, even with a wider experience of the B747, the flight engineer could not detect that the speeds were incorrect. However, the flight engineer did not object to the ZFW block remaining blank.

During the performance of the "Before Start" check list, the crew was interrupted – at the crucial point of verifying the Gross weight - by a technical intervention (checking the movement of the elevator) and by a recurring problem of ensuring food for 20 dogs being carried on board. The disturbance itself may have had an influence on the needed concentration of the crew. The "dog problematic" even led the flight engineer to leave the cockpit while the crew was performing the check list.

During his absence, the co-pilot (who was not present during the computation of the take-off parameters) noticed the discrepancy on the take-off parameters data card, and he notified the commander.

The last opportunity to detect the inadequate settings was missed, as the discrepancy on the card was handled as a clerical error (the digit ‘2’ was changed into a ‘3’). This was made possible because the figures of ZFW and TO GWT were ‘similar’ (ZFW = 264 tons, and TO GWT was 365 tons). The CVR shows the TO GWT was called “three six four” and “three six five” by the commander.

The CVR read-out showed that the flight engineer was not aware of the weights being carried at that time. His concentration, and therefore capacity to detect the wrong settings was influenced by the ‘dog food’ problem and the further performance of the check list.

The second (instructor-) flight engineer present for the flight was to perform a routine check of the flight engineer. This may have potentially provided an additional pair of eyes. However, he did not get involved in the flight preparation, and did not identify the wrong setting either.

Situational awareness

The work sphere in the cockpit was relaxed with the occasional joke; the crew stated they did not feel a particular time pressure. However, the succession of events during the flight preparation showed the traditional symptoms of time pressure:

- Use of the relief pilot for the computation of the take-off parameters normally dedicated to the co-pilot.
- Procedure not followed.
- Interruptions during the performance of the check list, with the FE leaving the cockpit.
- The various interruptions (ground mechanic, the dog food problem).
- The dismissal of the errors on the take-off performance card as ‘clerical’, without considering the possible potential consequences.

The commander was confident in the flight abilities of the crew, largely based on the statement of the pilots they were originating from large, reputable Belgian airlines. The crew itself was reinforced; there were three pilots and two flight engineers.

The commander was evidently aware of the fact that the airplane was carrying a heavy load; he asked to use the whole runway length.

The low engine power and speed setting would normally “tell” the commander and pilots there was something wrong, but it did not happen.

The low engine power would also have for effect that the acceleration during the take-off would be lower than normal, however, this (small) effect would be difficult to feel and identify, in particular for the pilots, not having an wide experience on the type.

2.6. Weight

For cargo flights, the nature of the cargo being carried may vary greatly (feathers or anvils?), more so than passenger flights, where the crew physically sees the passengers in number and distribution in the cabin, and may apprehend the load more easily. The awareness of the weight carried on cargo flights rests with the load sheet.

2.7. Engine RPM and take-off speeds

The overall experience on B747 of the crew was low; the commander had 260 FH, and co-pilot 570 FH, but for an average flight duration of 9 hours, this would mean an experience of 30 or 60 take-offs, compared to their more vast experience on other aircraft type such as the A320 (the commander) and Avro /BAe146 (co-pilot and relief pilot).

On these aircraft, a setting of 101.6% N1 (as set for take-off) would be indicative of a ‘high power’ take-off setting (in Belgium, standard conditions). Therefore the value of the N1 setting would not ‘ring a bell’ in the pilot’s brain.

The same would apply to the take-off speeds; the typical values for BAe 146(RJ) and A320 for a take-off in more or less the same conditions would give the following:

	V1	Vr	V2
A320	154kts	154kts	155kts
BAe146	133kts	137kts	142kts

Nevertheless, this reasoning would not be valid for the flight engineers, directly involved in the power setting and having a vast experience on B747. For the flight engineer in charge, the disturbances during the pre-flight briefing, the business at hand prevented him to realize on time that there was something wrong. He was the first crew member to question the speed values as the cause of the problem, after the take-off.

3. Causes

3.1. Findings:

- The ZFW was used instead of GWT to generate the take-off performance data, which resulted in incorrect V speeds and thrust setting being transcribed to the take-off performance data card.
- The incorrect V speeds and thrust setting were too low to enable the aircraft to take off safely for the actual weight of the aircraft.
- The flight crew using the RTTO software on the on-board laptop computer did not adhere to the operator's procedures for an independent check of the generation of take-off performance data.

3.2. Cause and contributing factor

Cause(s).
The accident was caused by an inadequate take-off performance calculation, due to a wrong gross weight data input error in the software used for the computation of the take-off performance parameters and the failure to comply with the operator's SOP for checking the validity of the data.

Contributing factor(s)

- Inadequate pairing of crew members with low experience
- Lack of distraction management

4. Safety recommendations.

There were a series of similar accidents in the past, for which Safety recommendations were made. All these recommendations were reviewed and were found sufficient and adequate. As a consequence, no additional recommendation was made.

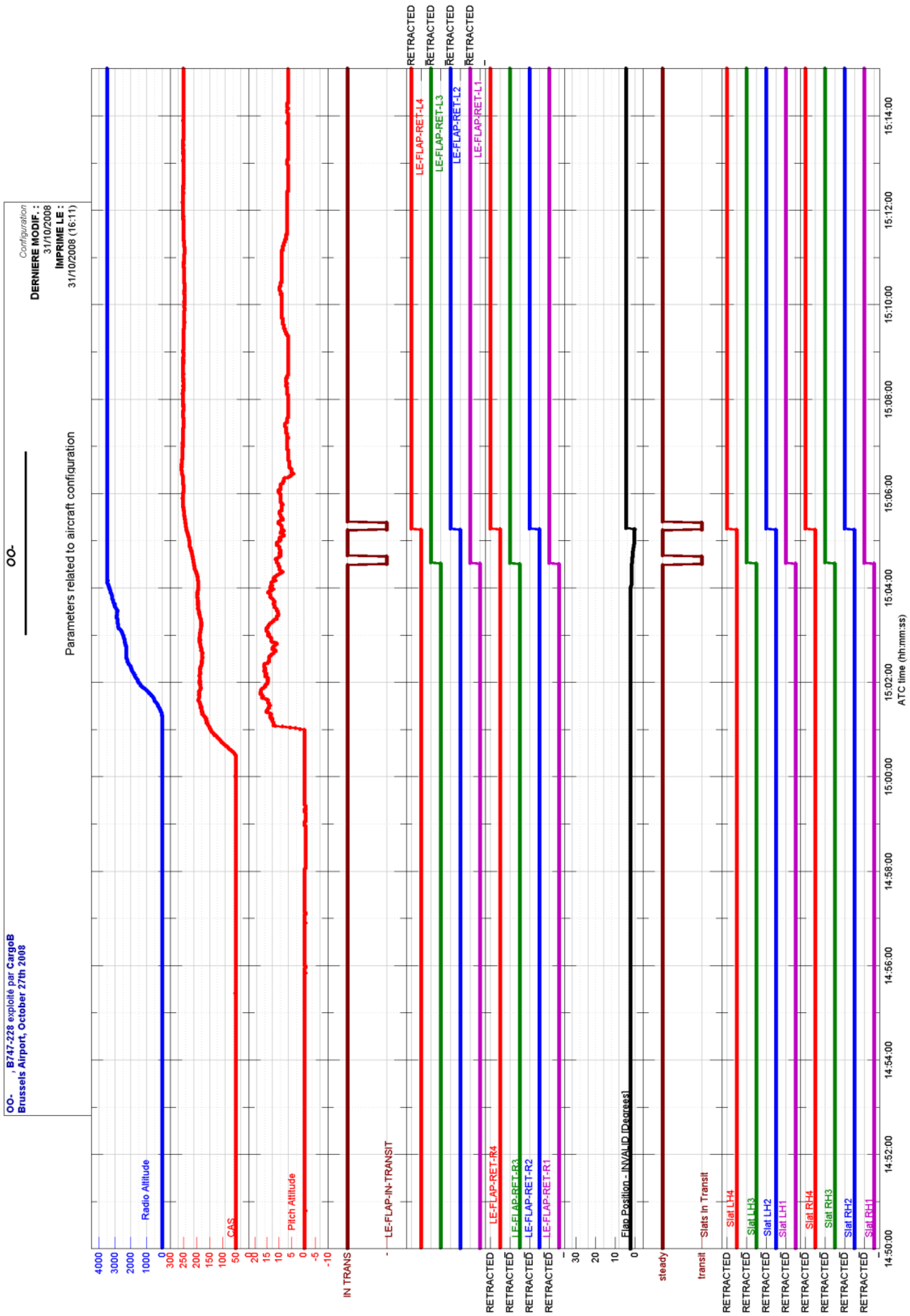
Corrective actions by the operator.
The accident was discussed with the company and the procedures for computation of the weight and balance were improved and enforced through training.

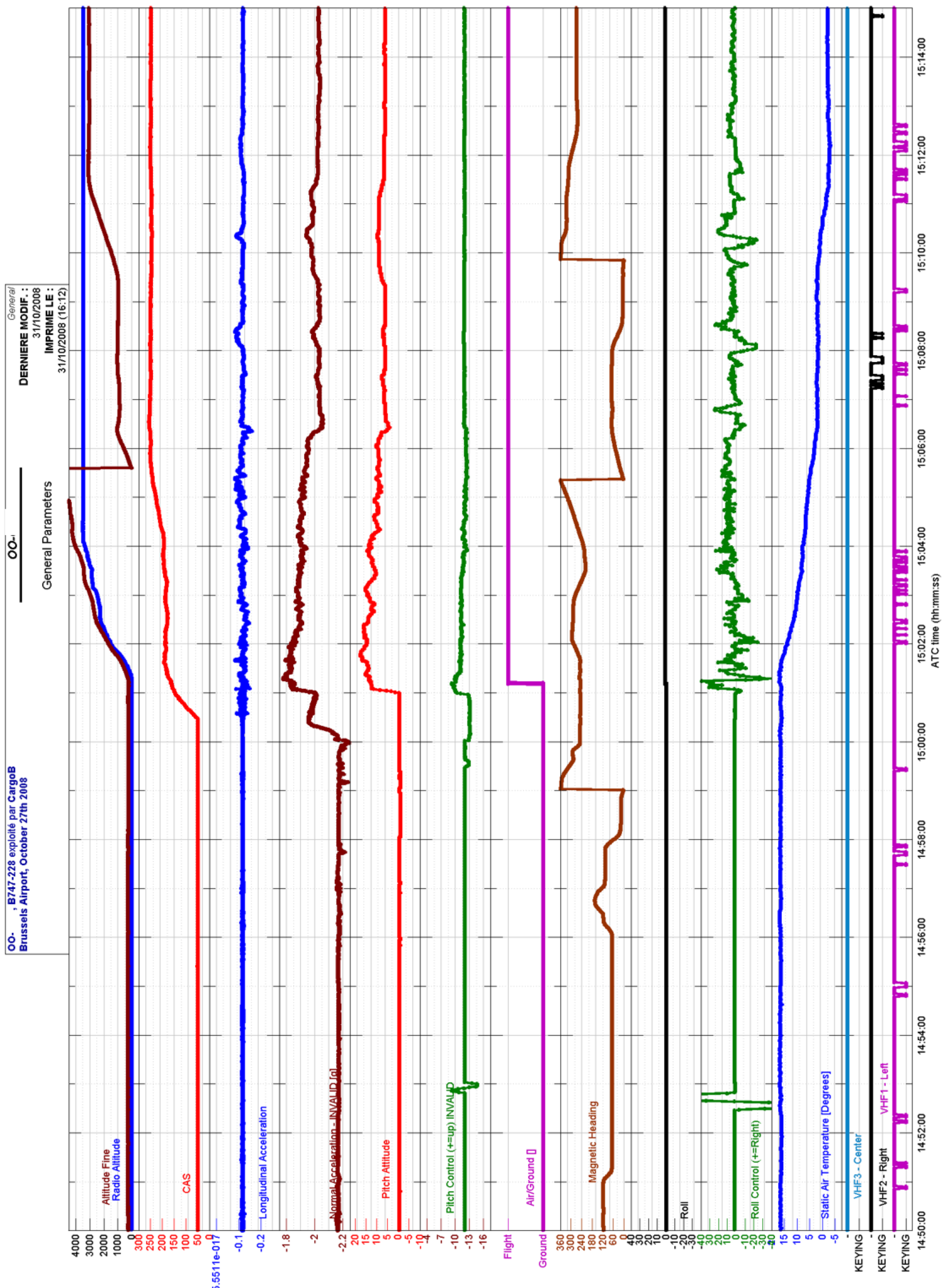
The Flight Ops and Training department took the following measures:

- Rephrasing of the normal SOP's
- Recommended flap setting for take-off: 20 (flaps 10 only to be used in exceptional cases)
- Store the calculations of the load sheet and take off data on **both** laptops
- Reviewing the role (input) of the relief crew
  (B-O-2008-08 was revised : Supernumerary crews are not allowed to perform duties of the active crew (PF-PNF-FE) unless they relieve an active crew member. Only fuelling, catering and security checks can be delegated to supernumerary crew members)

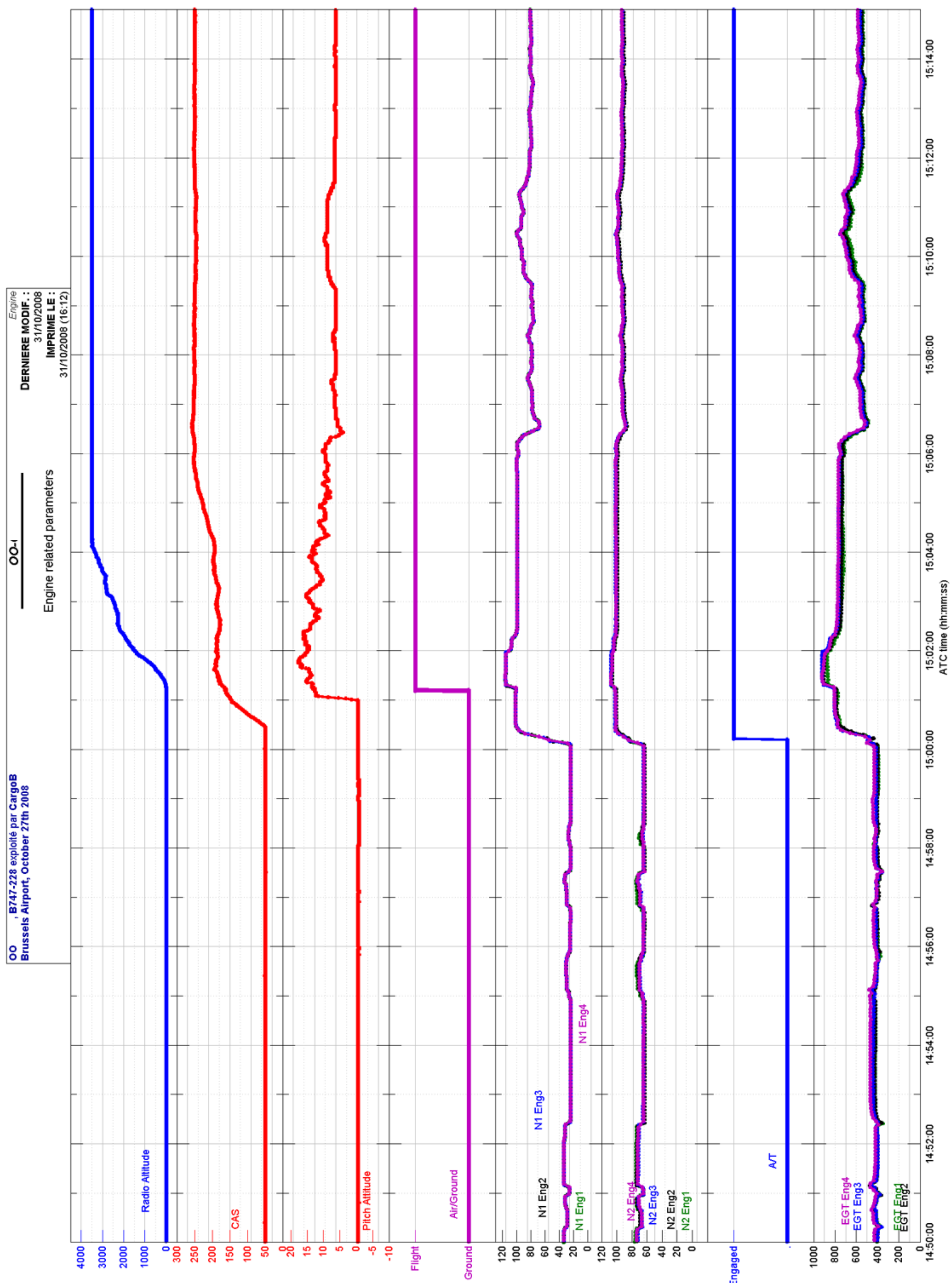
In order to explain the findings and recommendations and to promote and re-enforce the measures taken, a kick-off meeting was organized with the instructors on 17 November 2008. A series of meetings were organized with all flight crew.

APPENDICES: FLIGHT DATA RECORDER

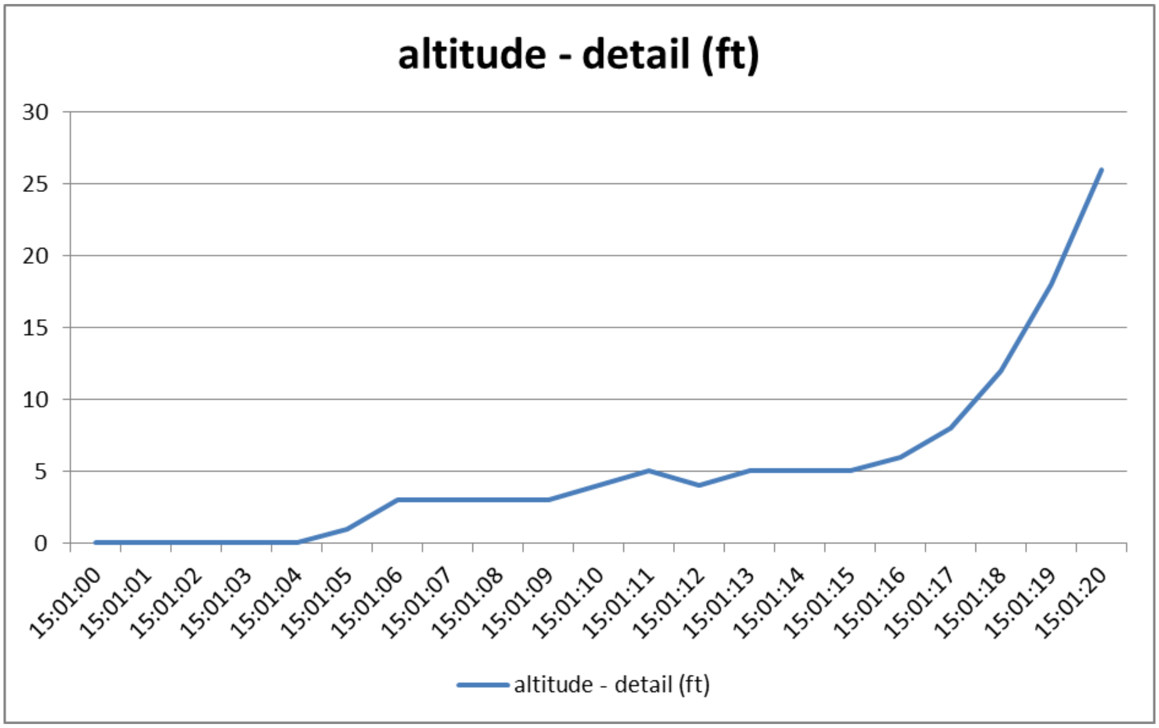


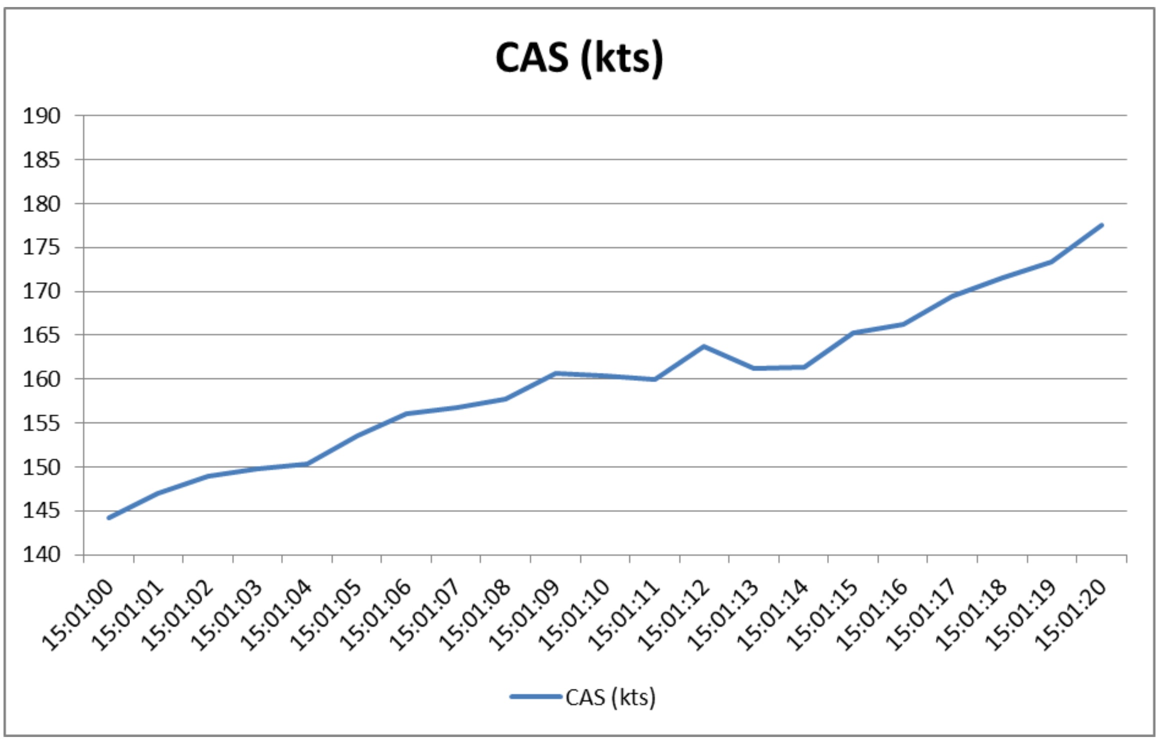

OO- , B747-228 exploité par CargoB
Brussels Airport, October 27th 2008
OO-
General Parameters
General
DERNIERE MODIF. :
31/10/2008
IMPRIME LE :
31/10/2008 (16:12)
Altitude Fine
Radio Altitude
CAS
Longitudinal Acceleration
Normal Acceleration - INVALID [g]
Pitch Attitude
Pitch Control (+=up) INVALID
Air/Ground []
Magnetic Heading
Roll
Roll Control (+=Right)
Static Air Temperature [Degrees]
VHF3 - Center
VHF2 - Right
VHF1 - Left
Flight
Ground
KEYING
ATC time (hh:mm:ss)

-


OO , B747-228 exploité par CargoB
Brussels Airport, October 27th 2008
OO-I
Engine related parameters
Engine
DERNIERE MODIF. :
31/10/2008
IMPRIME LE :
31/10/2008 (16:12)
Radio Altitude
CAS
Pitch Attitude
Air/Ground
Flight
Ground
N1 Eng1
N1 Eng2
N1 Eng3
N1 Eng4
N2 Eng1
N2 Eng2
N2 Eng3
N2 Eng4
A/T
Engaged
EGT Eng1
EGT Eng2
EGT Eng3
EGT Eng4
ATC time (hh:mm:ss)
14:50:00
14:52:00
14:54:00
14:56:00
14:58:00
15:00:00
15:02:00
15:04:00
15:06:00
15:08:00
15:10:00
15:12:00
15:14:00

\-


altitude - detail (ft)
30
25
20
15
10
5
0
15:01:00
15:01:01
15:01:02
15:01:03
15:01:04
15:01:05
15:01:06
15:01:07
15:01:08
15:01:09
15:01:10
15:01:11
15:01:12
15:01:13
15:01:14
15:01:15
15:01:16
15:01:17
15:01:18
15:01:19
15:01:20
altitude - detail (ft)


CAS (kts)
190
185
180
175
170
165
160
155
150
145
140
15:01:00
15:01:01
15:01:02
15:01:03
15:01:04
15:01:05
15:01:06
15:01:07
15:01:08
15:01:09
15:01:10
15:01:11
15:01:12
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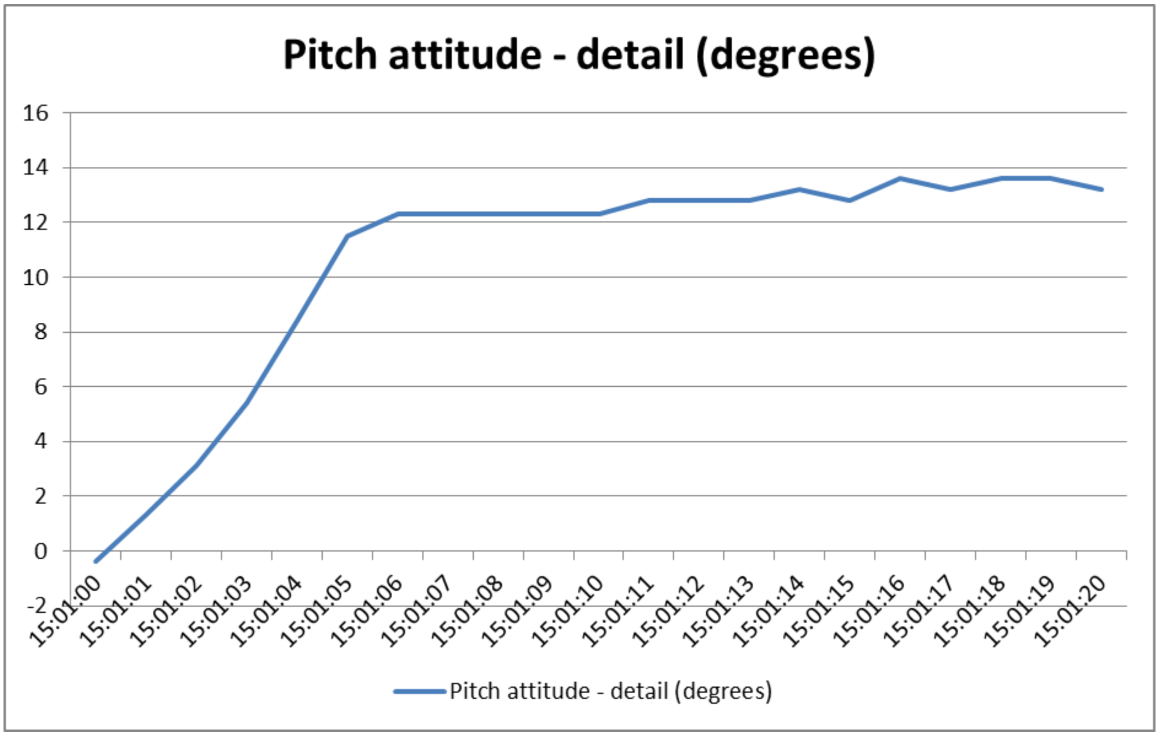
15:01:20
CAS (kts)


Pitch attitude - detail (degrees)
16
14
12
10
8
6
4
2
0
-2
15:01:00
15:01:01
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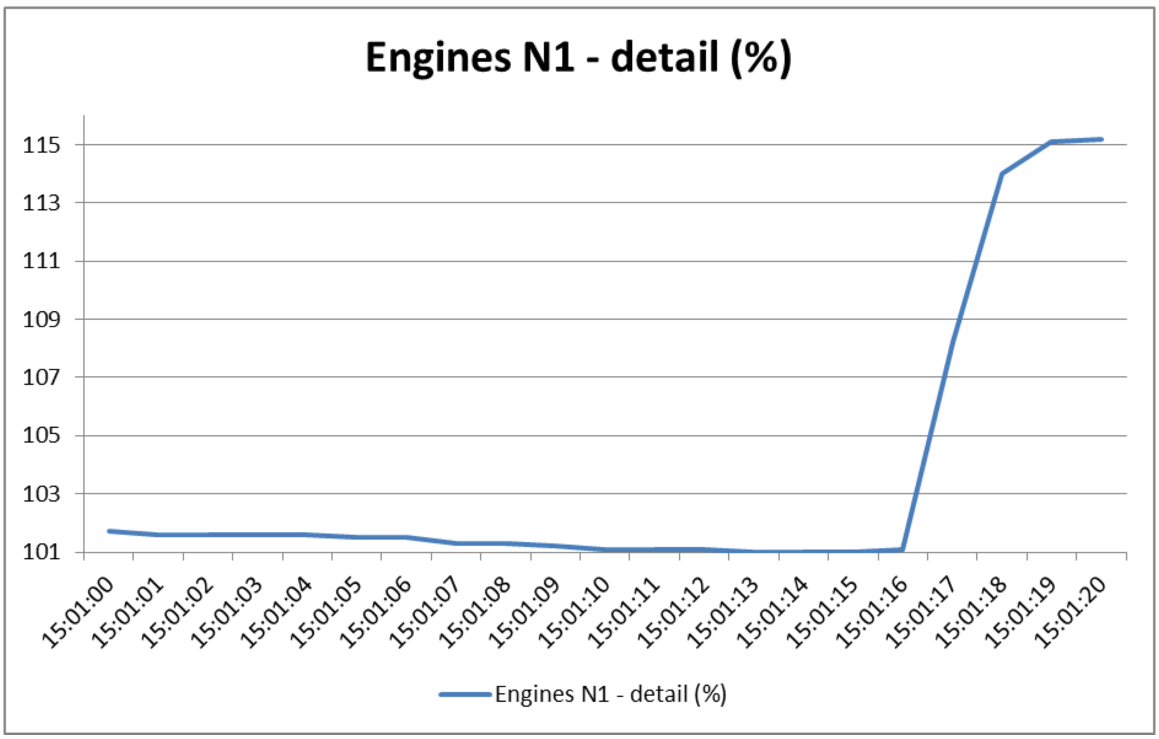
15:01:03
15:01:04
15:01:05
15:01:06
15:01:07
15:01:08
15:01:09
15:01:10
15:01:11
15:01:12
15:01:13
15:01:14
15:01:15
15:01:16
15:01:17
15:01:18
15:01:19
15:01:20
Pitch attitude - detail (degrees)


Engines N1 - detail (%)
115
113
111
109
107
105
103
101
15:01:00
15:01:01
15:01:02
15:01:03
15:01:04
15:01:05
15:01:06
15:01:07
15:01:08
15:01:09
15:01:10
15:01:11
15:01:12
15:01:13
15:01:14
15:01:15
15:01:16
15:01:17
15:01:18
15:01:19
15:01:20
Engines N1 - detail (%)

Federal Public Service
Mobility and Transport
Air Accident Investigation Unit
Air Accident Investigation Unit - (Belgium)
CCN
Rue du Progrès 56 Vooruitgangstraat
B1210 Brussels

Phone: +32 2 277 44 33
Fax: +32 2 277 42 60

air-acc-investigation@mobilit.fgov.be
www.mobilit.fgov.be