

Preliminary Report

Accident on **24 March 2015**
at **Prads-Haute-Bléone**
(Alpes-de-Haute-Provence, France)
to the **Airbus A320-211**
registered **D-AIPX**
operated by **Germanwings**

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



Ministère de l'Ecologie, du Développement durable et de l'Energie

Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

Foreword

The BEA is the French Civil Aviation Safety Investigation Authority. Its investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liability.

BEA investigations are independent, separate and conducted without prejudice to any judicial or administrative action that may be taken to determine blame or liability.

This document is a Preliminary Report and has been prepared on the basis of the initial information gathered in the course of the investigation, without any analysis. Some of the points covered may evolve with time. Nothing in the presentation of this document or in any of the points raised therein should be interpreted as an indication of the conclusions of the investigation.

SPECIAL FOREWORD TO ENGLISH EDITION

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

Table of Contents

FOREWORD	2
GLOSSARY	4
ORGANISATION OF THE INVESTIGATION	5
1 - FACTUAL INFORMATION	7
1.1 History of Flight	7
1.2 Injuries to Persons	11
1.3 Damage to Aircraft	11
1.4 Personnel Information	11
1.4.1 Captain	11
1.4.2 Co-pilot	12
1.5 Aircraft Information	13
1.5.1 Airframe	13
1.5.2 Engines	14
1.5.3 Maintenance	14
1.5.4 Cockpit door locking system	15
1.5.5 Communication from the passenger cabin to the cockpit	18
1.5.6 OPEN DESCENT Mode	19
1.7 Telecommunications	20
1.8 Flight Recorders	20
1.8.1 Type of equipment	20
1.8.2 Opening and readout operations	21
1.8.3 Synchronization of recordings	22
1.8.4 Previous Flight	22
1.8.5 Work carried out on the Quick Access Recorder (QAR)	23
1.9 Wreckage and Impact Information	24
1.10 Survival Aspects	25
1.11 Organizational and Management Information	26
1.12 Additional Information	26
1.12.1 Testimony	26
1.12.2 Previous Events	26
1.12.3 EASA Safety Information Bulletin	27
2 - INITIAL FINDINGS	28
3 - THE ONGOING SAFETY INVESTIGATION	29

Glossary

ACP	Audio Control Panel
ACARS	Aircraft Communication Addressing and Reporting System
AME	Aero-Medical Examiner
ATC	Air Traffic Control
BFU	German Federal Bureau of Aircraft Accident (Bundesstelle für Flugunfalluntersuchung)
CIAIAC	Spanish safety investigation authority (<i>Comisión de Investigación de Accidentes e Incidentes de Aviación Civil</i>)
CVR	Cockpit Voice Recorder
DGAC	French general civil aviation directorate (Direction Générale de l'Aviation Civile)
EASA	European Aviation Safety Agency
FCU	Flight Control Unit
FDR	Flight Data Recorder
GPWS	Ground Proximity Warning System
ICAO	International Civil Aviation Organisation
LBA	German civil aviation authority (Luftfahrt-BundesAmt)
MEL	Minimum Equipment List
PF	Pilot Flying
PFD	Primary Flight Display
PM	Pilot Monitoring
QAR	Quick Access Recorder
REV	Medical certificate issued after review procedure

Controlled descent on autopilot, collision with terrain

Aircraft	Airbus A320-211 registered D-AIPX
Date and time	24 March 2015 at 09 h 41 ⁽¹⁾
Opertor	Germanwings
Place	Prads-Haute-Bléone (04)
Type of flight	Public transport
Persons on board	Captain (PM), co-pilot (PF), 4 cabin crew, 144 passengers
Consequences and damage	Crew and passengers fatally injured, aeroplane destroyed

⁽¹⁾Except where otherwise indicated, all times in this report are UTC. One hour should be added to obtain the legal time in metropolitan France on the day of the event.

ORGANISATION OF THE INVESTIGATION

On 24 March 2015, at around 10 h 15, the Marseille en-route control centre informed the BEA of the accident to an Airbus A320, registered D-AIPX that had occurred while overflying the French Alps. In accordance with the provisions of European regulation (EU) n°996/2010 of the European Parliament and Council of the 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a Safety Investigation was immediately initiated by the BEA.

A team of seven investigators from the BEA travelled to the accident site on the afternoon of 24 March. In coordination with the authorities in charge of the judicial investigation, and with helicopter transport provided by the Gendarmerie, the safety investigators were able to access the site the following day.

The CVR was found on the afternoon of 24 March 2015 and transferred the following day to the BEA for readout. After reading out the data, it appeared to the BEA that an act of unlawful interference was probably involved in the accident. European Regulation (EU) n°996/2010 and the advance arrangement "*relating to Safety Investigations between the French ministry of Justice and the BEA*" of 16 September 2014, specify that, in such a situation, the relevant elements gathered during the Safety Investigation must be communicated immediately to the judicial authorities, and the BEA can decide to continue the Safety Investigation, which it did.

The BEA associated the following foreign counterparts with the Safety Investigation, which then appointed Accredited Representatives:

- the BFU (Germany), the aeroplane being registered in Germany and operated by a German airline. This made it possible to obtain the assistance of technical advisers from Germanwings;
- the CIAIAC (Spain). This made it possible to obtain information relating to the aeroplane's stop at Barcelona and data from the Spanish ATC service.

The BEA also associated technical advisers from EASA, the DGAC, Snecma (on behalf of CFM) and Airbus.

The Safety Investigation is organised with three working groups in the following areas: aircraft, aeroplane systems and operations. The Accredited Representatives and the technical advisers were divided between the three groups.

At the time of the publication of this report, Australia, Israel and Japan appointed experts to follow the Safety Investigation, in accordance with standards and recommended practices in ICAO Annex 13, since some of the victims came from these countries.

The BEA's Safety Investigation, whose sole objective is to prevent accidents and incidents, will include the collection and analysis of data, a statement of conclusions, including the determination of the causes and/or contributing factors and, where appropriate, the issuing of Safety Recommendations.

1 - FACTUAL INFORMATION

1.1 History of Flight

Note: the following elements are based on the flight recorders, as well as on recordings of radio communications. The main points in the history of the flight below are referenced by the numbers on figure 1, page 10.

On Tuesday 24 March 2015, the Airbus A320-211 registered D-AIPX operated by Germanwings was programmed to undertake scheduled flight 4U9525 between Barcelona (Spain) and Düsseldorf (Germany), with the callsign "GWI18G". Six crew members (2 flight crew and 4 cabin crew) and 144 passengers were on board. The same crew had made the outbound flight, taking off from Düsseldorf at 6 h 01, and landing in Barcelona at 7 h 57.

The takeoff from Barcelona took place at 9 h 00 from runway 07R. The co-pilot was Pilot Flying (PF).

At 9 h 02 min 54, autopilot n°2 was engaged in "CLIMB" and "NAV" mode; autothrust had been engaged about a minute earlier.

At 9 h 12 min 15, during the climb, the buzzer to request access to the cockpit sounded for one second. Noises similar to the cockpit door opening and then closing were recorded, following which a flight attendant was present in the cockpit. The three crew members then started a conversation about how the stop at Barcelona had gone.

At 9 h 15 min 53, noises like those of the opening then the closing of the cockpit door were recorded.

The flight attendant left the cockpit. Following that, some discussions took place between the co-pilot and the Captain about managing the delay that resulted from late departure from Barcelona. At 9 h 27 min 20, the aeroplane levelled off at a cruise altitude of 38,000 ft (FL380) (point ① on figure 1). The flight crew was then in contact with the Marseille en-route control centre on the 133.330 MHz frequency.

At 9 h 29 min 40, the flight crew was transferred to the 127.180 MHz frequency of the Marseille control centre.

At 9 h 30 min 00 (point ②), the Captain read back the controller's clearance allowing him to fly direct to the IRMAR point: "*Direct IRMAR Merci Germanwings one eight Golf*". This was the last communication between the flight crew and ATC.

At 9 h 30 min 08, the Captain told the co-pilot that he was leaving the cockpit and asked him to take over radio communications, which the co-pilot read back.

At 9 h 30 min 11, the heading started to decrease and stabilised about a minute later around 23°, which is consistent with a route towards the IRMAR point.

At 9 h 30 min 13, noises of a pilot's seat movements were recorded.

At 9 h 30 min 24 (point ③), noises of the opening then, three seconds later, the closing of the cockpit door were recorded. The Captain was then out of the cockpit.

At 9 h 30 min 53 (point ④), the selected altitude on the FCU changed in one second from 38,000 ft to 100 ft⁽²⁾. One second later, the autopilot changed to "OPEN DES"⁽³⁾ mode and autothrust changed to "THR IDLE" mode. The aeroplane started to descend and both engines' rpm decreased.

At 9 h 31 min 37, noises of a pilot's seat movements were recorded.

At 9 h 33 min 12 (point ⑤), the speed management changed from "managed" mode to "selected"⁽⁴⁾ mode. A second later, the selected target speed became 308 kt while the aeroplane's speed was 273 kt. The aeroplane's speed started to increase along with the aeroplane's descent rate, which subsequently varied between 1,700 ft/min and 5,000 ft/min, then was on average about 3,500 ft/min.

At 9 h 33 min 35, the selected speed decreased to 288 kt. Then, over the following 13 seconds, the value of this target speed changed six times until it reached 302 kt.

At 9 h 33 min 47 (point ⑥), the controller asked the flight crew what cruise level they were cleared for. The aeroplane was then at an altitude of 30,000 ft in descent. There was no answer from the co-pilot. Over the following 30 seconds, the controller tried to contact the flight crew again on two occasions, without any answer.

At 9 h 34 min 23, the selected speed increased up to 323 kt. The aeroplane's speed was then 301 kt and started to increase towards the new target.

At 9 h 34 min 31 (point ⑦), the buzzer to request access to the cockpit was recorded for one second.

At 9 h 34 min 38, the controller again tried to contact the flight crew, without any answer.

At 9 h 34 min 47 then at 9 h 35 min 01, the Marseille control centre tried to contact the flight crew on 133.330 MHz, without any answer. The aeroplane was then at an altitude of 25,100 ft, in descent.

At 9 h 35 min 03 (point ⑧), the selected speed increased again to 350 kt⁽⁵⁾.

Subsequently, and until the end of the recording:

- the selected speed remained at 350 kt and the aeroplane's speed stabilised around 345 kt;
- the autopilot and autothrust remained engaged;
- the cockpit call signal from the cabin, known as the cabin call, from the cabin interphone, was recorded on four occasions between 9 h 35 min 04 and 9 h 39 min 27 for about three seconds;
- noises similar to a person knocking on the cockpit door were recorded on six occasions between 9 h 35 min 32 (point ⑨) and 9 h 39 min 02;
- muffled voices were heard several times between 9 h 37 min 11 and 9 h 40 min 48, and at 9 h 37 min 13 a muffled voice asks for the door to be opened;

⁽²⁾This is the minimum value that it is possible to select on A320.

⁽³⁾This mode is described in paragraph 1.5.6.

⁽⁴⁾When the speed is said to be "selected", the target speeds are chosen by the flight crew. When the speed is said to be "managed", it is the flight management system (FMS) that automatically determines the target speeds.

⁽⁵⁾This value is the maximum speed that the flight crew can select. It corresponds to VMO (maximum operating speed).

- between 9 h 35 min 07 and 9 h 37 min 54, the Marseille control centre tried to contact the flight crew on three occasions on 121.5 MHz, and on two occasions on 127.180 MHz, without any answer;
- between 9 h 38 min 38 (point 10) and 9 h 39 min 23, the French Air Defence system tried to contact the flight crew on three occasions on 121.5 MHz, without any answer;
- noises similar to violent blows on the cockpit door were recorded on five occasions between 9 h 39 min 30 (point 11) and 9 h 40 min 28;
- low amplitude inputs on the co-pilot's sidestick were recorded between 9 h 39 min 33 and 9 h 40 min 07⁽⁶⁾;
- the flight crew of another aeroplane tried to contact the flight crew of GWI18G at 9 h 39 min 54, without any answer.

At 9 h 40 min 41 (point 12), the "Terrain, Terrain, Pull Up, Pull Up" aural warning from the GPWS triggered and remained active until the end of the flight.

At 9 h 40 min 56, the Master Caution warning was recorded, then at 9 h 41 min 00 the Master Warning triggered and remained active until the end of the flight.

At 9 h 41 min 06, the CVR recording stopped at the moment of the collision with the terrain.

⁽⁶⁾Low amplitude inputs on the co-pilot's sidestick were recorded between 9 h 39 min 33 and 9 h 40 min 07.

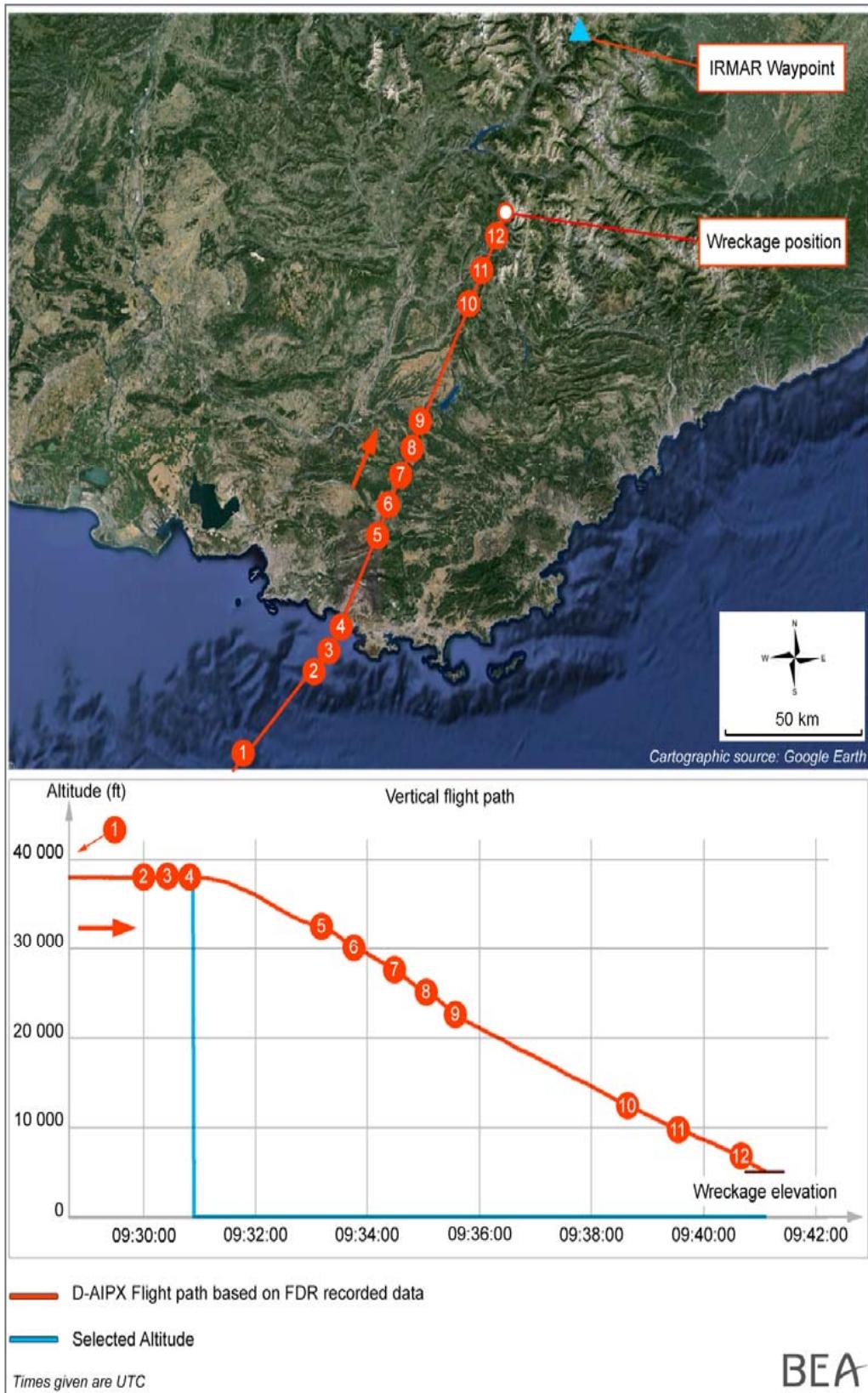


Figure 1 – accident flight trajectory

1.2 Injuries to Persons

	Injuries		
	Fatal	Serious	Minor/none
Crew members	6	-	-
Passengers	144	-	-
Others	-	-	-

1.3 Damage to Aircraft

The aeroplane was destroyed.

1.4 Personnel Information

1.4.1 Captain

Male, aged 34, German nationality.

- air transport pilot's licence ATPL(A) issued on 28 January 2014;
- A320 type rating revalidated on 9 July 2014;
- last class 1 medical check-up performed on 31 October 2014 and valid until 12 December 2015.
- Experience:
 - total: 6,763 flying hours;
 - on type: 3,811 flying hours, of which 259 as Captain;
 - in the previous 3 months: 108 hours;
 - in the previous month: 18 hours;
 - in the last 24 hours: 7 hours.
- Flying career:
 - from March 2001 to June 2003, he undertook Air Transport pilot training at the "Lufthansa Flight Training Pilot School" in Bremen (Germany) and the "Airline Training Center" in Phoenix (Arizona, USA)
 - in March 2005, he obtained his A320 type rating
 - from June 2005 to January 2010, he worked as a co-pilot on Airbus A320 for the Condor Berlin airline
 - in April 2010, he obtained his A340 type rating, and his type rating for the A330 in February 2011
 - from April 2010 to May 2014, he worked as a co-pilot on Airbus A330/A340 for Lufthansa
 - on 6 May 2014, he joined Germanwings as a Captain on A320.

After joining Germanwings, he followed the operator's conversion training course as a Captain from May to September 2014. During his training and recurrent checks his professional level was judged by his instructors and examiners to be above standard. He passed his line check on 20 September 2014.

The last Operator Proficiency Check (OPC) was performed on 14 January 2015.

His schedule shows that he had not flown between 14 and 22 March 2015. On 23 March 2015, the day before the accident, he flew two rotations from Düsseldorf to London-Heathrow: he took off from Düsseldorf at 6 h 09 for the first rotation and landed at Düsseldorf at 14 h 04 following the second rotation. On the day of the accident, he made the flight from Düsseldorf, taking off at 6 h 01, to Barcelona, landing there at 7 h 57.

1.4.2 Co-pilot

Male, aged 27, German nationality.

- private Pilot's Licence PPL(A) issued on 1 March 2011;
- multiple-crew Pilot's Licence MPL(A) issued on 11 February 2014;
- A320 type rating revalidated on 28 October 2014.
- Experience:
 - total : 919 flying hours;
 - on type : 540 flying hours;
 - in the previous 3 months : 107 hours;
 - in the previous month: 30 hours;
 - in the previous 24 hours : 3 hours.
- Flying career:
 - between January and April 2008, he took basic pilot's training entry selection courses with Lufthansa;
 - on 1 September 2008, he started his basic training at the "*Lufthansa Flight Training Pilot School*" in Bremen (Germany);
 - on 5 November 2008 he suspended his training for medical reasons;
 - on 26 August 2009 he restarted his training;
 - on 13 October 2010, he passed his ATPL written exam;
 - from 8 November 2010 to 2 March 2011, he continued his training at the "*Airline Training Center*" in Phoenix (Arizona, USA);
 - from 15 June 2011 to 31 December 2013, he was under contract as a flight attendant for Lufthansa while continuing his Air Transport pilot training;
 - on 2 September 2013, he joined Germanwings;
 - from 27 September to 23 December 2013, he took and passed his A320 type rating at Lufthansa in Munich (Germany);
 - from 27 January 2014 to 21 June 2014, he undertook his operator's conversion training including his line flying under supervision at Germanwings;
 - on 26 June 2014, he passed his proficiency check and was appointed as a co-pilot;
 - on 28 October 2014, he passed his Operator Proficiency Check.

During his training and recurrent checks, his professional level was judged to be above standard by his instructors and examiners.

On 9 April 2008, he obtained a class 1 medical certificate without restrictions and valid until 9 April 2009, issued by the Lufthansa aeromedical centre.

On 9 April 2009, his class 1 medical certificate was not revalidated by the Lufthansa aeromedical centre due to depression and the taking of medication to treat it.

On 14 July 2009, his request for renewal of his class 1 medical certificate was refused by the Lufthansa aeromedical centre. The latter informed the LBA of this.

On 28 July 2009, he obtained a new class 1 medical certificate valid until 9 April 2010, endorsed with the note "*Note the special conditions/restrictions of the waiver FRA 091/09 -REV-*". His pilot's licence then included the limitation "*****SIC**incl. PPL*****", which means "*Specific regular medical examinations – contact the licence issuing authority*". This limitation requires that the aeromedical examiner (AME) contact the licence issuing authority before proceeding with a medical evaluation relating to any extension or renewal of the medical certificate. It may relate to the medical history that the AME must be informed of before undertaking an assessment.

From July 2009, he obtained each year a class 1 medical certificate valid for one year that was endorsed with the note "*Note the special conditions/restrictions of the waiver FRA 091/09 -REV-*".

The last valid class 1 medical certificate had been issued on 28 July 2014 and was valid until 14 August 2015.

His schedule shows that he had not flown between 13 and 22 March 2015. On 23 March 2015, the day before the accident, he was in reserve from 03 h 00 and made a ferry flight from Düsseldorf to Berlin-Tegel between 04 h 57 and 05 h 56. He then returned to Düsseldorf at about 08 h 20 as a passenger. On the day of the accident, he made the flight from Düsseldorf, taking off at 6 h 01, to Barcelona, landing there at 7 h 57.

1.5 Aircraft Information

1.5.1 Airframe

Manufacturer	Airbus
Type	A320-211
Serial number	147
Registration	D-AIPX
Entry into service	05/02/1991
Airworthiness certificate	N°16332 of 13/01/2014 issued by the LBA
Airworthiness Review Certificate	T512ARC4034/2014 of 23/03/2015 valid until 11/03/2016
Utilisation since overhaul (72 h overhaul on 23/03/2015)	6 hours and 3 cycles.
Utilisation as of 24/03/2015	58,313 hours and 46,748 cycles.

1.5.2 Engines

Manufacturer: CFM

Type: CFM56-5A1

	Engine n° 1	Engine n° 2
Serial number	731923	731482
Date of installation	30/06/2012	12/04/2011
Total run time	42,466 hours and 31,836 cycles	50,720 hours and 41,961 cycles
Run time since previous overhaul	6,031 hours and 4 528 cycles since 02/04/2012	9,258 hours and 6,963 cycles since 05/04/2011

1.5.3 Maintenance

The aeroplane flew under the Lufthansa banner from its entry into service until January 2014, when it joined the fleet of Germanwings.

The aircraft was maintained by Germanwings and Lufthansa Technik in accordance with the Germanwings maintenance programme approved by the LBA. Its maintenance checks were up to date.

The last line maintenance performed on the aircraft took place on 23 March 2015 at Düsseldorf Airport. The operation involved checking the oil levels of and visually inspecting the wheels and landing gear.

During the event flight, some of the equipment was not in working order. The aeroplane could still fly with some acceptable deferred defects:

- the “Cabin ready” light had been absent since 6 March 2015, in accordance with the Minimum Equipment List (MEL);
- the lighting of the logo on the right side of the aeroplane had not been working since 18 March 2015, in accordance with MEL;
- play had been found at the level of the fasteners on the left-hand door of the nose gear since 23 March 2015;
- ignition B on the right engine on starting had not been working since 24 March 2015, in accordance with MEL.

On 24 March 2015, during the stop in Barcelona, before the accident flight, the Captain contacted the Germanwings maintenance service in Cologne about a problem concerning flushing of the front toilets on the aeroplane⁽⁷⁾. The correspondent on the telephone advised resetting the system circuit breaker located at the rear of the aeroplane. Since the disembarkation of the passengers had not finished, the Captain said he would carry out this operation as soon as possible and would contact the service again if the problem persisted. No other calls were recorded.

D check type scheduled maintenance was planned for April 2015.

⁽⁷⁾During the flight between Düsseldorf and Barcelona, the crew had already informed maintenance via an ACARS message.

1.5.4 Cockpit door locking system

Note: the following descriptions apply to D-AIPX and are based on information supplied by Airbus and Germanwings as of the date of the publication of this report.

A door separates the cockpit and passenger cabin. Its core consists of a composite "sandwich" type structure made of prepreg sheets covering a "honeycomb core". The outer prepreg sheets are designed to ensure bullet-proofing. A door escape hatch is pre-cut on its lower part. The latter can only be used from the cockpit. It is used in emergencies when the door is stuck. Unlike the cockpit door which opens towards the inside of the cockpit, the door escape hatch can only be opened in the opposite direction.

Three electrically-controlled locks are used to lock the door as soon as it is closed. A rotating handle system on the door is used to mechanically unlock it from the cockpit.

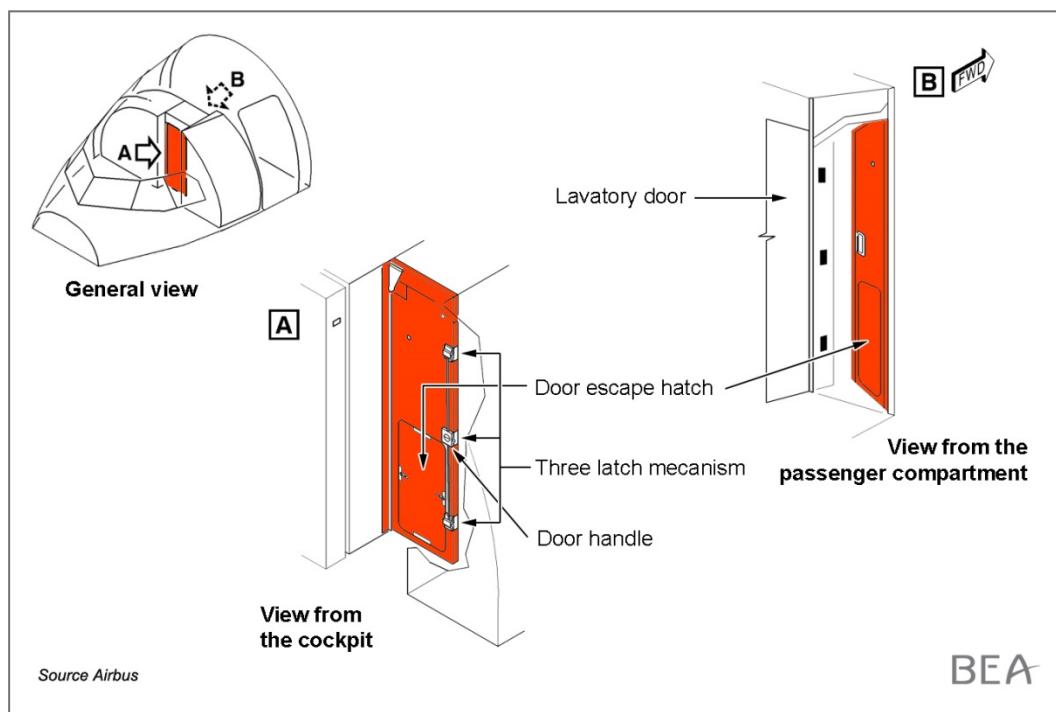


Figure 2 - cockpit access door

The cockpit door locking system (CDLS) is used to electrically control the locking and unlocking of the door.

Its main components are:

- A keypad with 12 keys (numbers 0 to 9, "*" and "#") located on the side wall of the control screen of the passenger compartment used by the cabin crew (the Forward Attendant Panel - FAP), in the passenger compartment. The keyboard also has two LEDs (green and red).
- A three-position switch, located in the cockpit on the centre pedestal (see figures 3 and 5). A return spring keeps the switch in the NORM position. Manual input is used to select the UNLOCK or LOCK position. There is also an indicator next to the switch, labelled OPEN and FAULT.

- A control unit (CKPT DOOR CONT) located on the top panel of the cockpit. Two pressure sensors are installed on this display to measure the pressure in the cockpit and monitor any sudden change. It also has LEDs that light up in case of malfunctions involving the three door locks or the system computer.
- A buzzer, located in the cockpit on the top panel, which sends an acoustic signal.

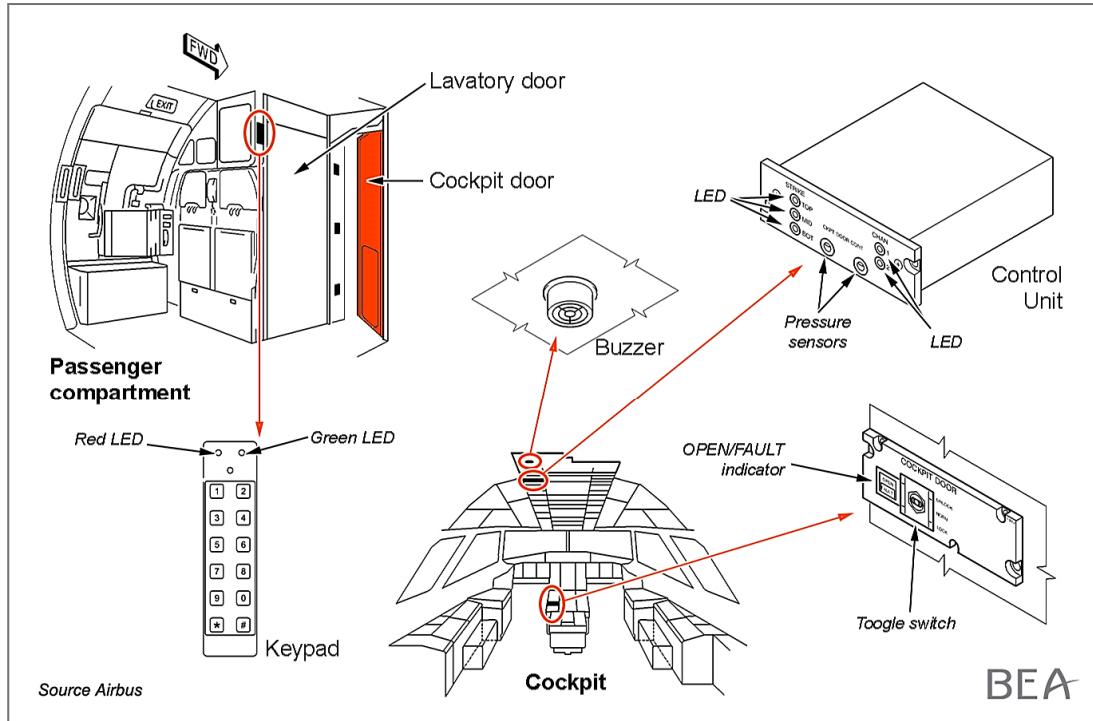


Figure 3 - cockpit door locking system

In the cockpit, the crew has two touchscreens located in front of the sidesticks. These screens retransmit the video from three cameras⁽⁸⁾ filming:

- the access door to the cockpit;
- the left front main door of the aeroplane;
- the right front main door of the aeroplane.

⁽⁸⁾Each crew member can select the camera they want to display on their screen.

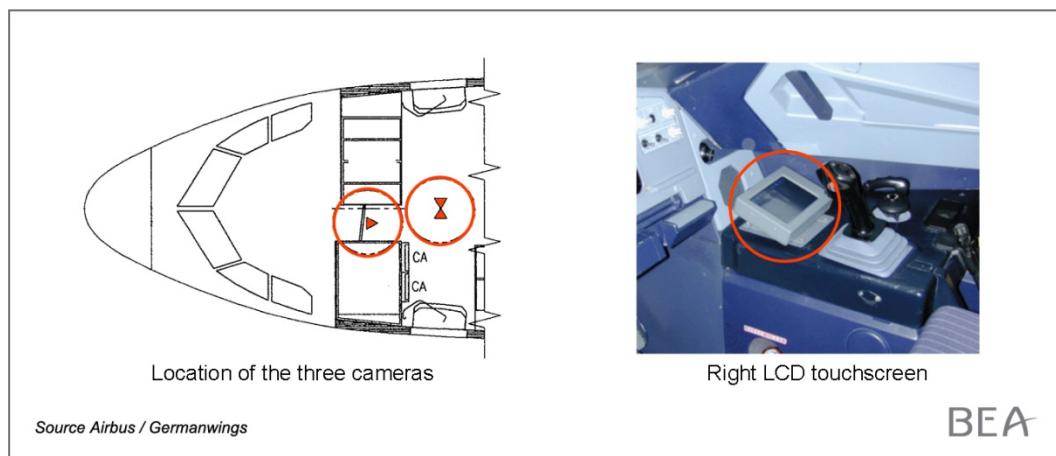


Figure 4 - surveillance cameras and monitor

The cockpit door locking system parameters can be set by each airline and for each aeroplane.

To request access to the cockpit from the passenger compartment, the normal one-digit access code followed by "#" must be entered on the keypad. A one-second acoustic signal from the buzzer sounds in the cockpit to warn the crew that someone wishes to enter. The pilots can then consult their monitoring screen.

The flight crew then moves the three-position switch:



Figure 5 - door control switch

- If they pull and maintain the switch in the UNLOCK position, the door unlocks. The acoustic signal stops. The green LED lights up continuously on the keypad to indicate the door has been unlocked. The door must then be pushed in order to open it. A magnet in the cockpit is used to keep the door in the open position.
- If the flight crew moves the switch to the LOCK position, the door is kept locked. The acoustic signal stops. The red LED lights up continuously on the keypad to indicate locking is voluntary. Any interaction with the keypad is then disabled for 5 minutes (until the extinction of the red LED)⁽⁹⁾. At any time, the crew in the cockpit may cancel this locking by placing the switch in the UNLOCK position. The door then immediately unlocks.
- In the absence of any input on the switch, the door remains locked. No LEDs light up on the keypad. The acoustic signal stops after one second.

⁽⁹⁾Any new selection of the LOCK position re-starts a 5-minute de-activation window.

In case of emergency (suspected flight crew incapacitation, for example), a three-digit code followed by "#" can be dialled on the digital keypad. The acoustic signal then sounds continuously in the cockpit for 15 seconds and the green LED on the keypad starts to flash.

If the flight crew does not respond during these 15 seconds, the door unlocks for 5 seconds. The green LED lights up continuously to indicate the door has been unlocked and the acoustic signal stops. The door only needs to be pushed in order to open it. After these five seconds have elapsed, the door locks again.

If the flight crew toggles the switch during those 15 seconds, the acoustic signal stops and the system reacts according to the command (UNLOCK/LOCK).

Note 1: Toggling the switch is not necessarily correlated with a request to access the cockpit. At any time, the crew can select the LOCK or UNLOCK position. The LOCK position overrides and resets any previous selection.

Note 2: In case of a power failure in this system, the access door to the cockpit is unlocked but remains closed.

When the door is open, the OPEN indicator lights up continuously. If an emergency procedure is initiated (three-digit code followed by "#"), the OPEN LED starts to flash.

1.5.5 Communication from the passenger cabin to the cockpit

Intercoms are present in the passenger compartment to allow the pilots and the flight attendants to communicate during the flight.

Each crew member can select the intercom they wish to contact. To get in touch with the cockpit, the "CAPT" key must be selected (figure 6).

When the "CAPT" key is selected:

- the ATT LED flashes on the three audio control panels (ACP) present in the cockpit;
- an acoustic signal, the "cabin call", lasting three seconds, sounds in the cockpit (it is inhibited during the take-off and landing phases);
- the message "CAPTAIN" is displayed on the monitor of the cabin crew (AIP – Attendant Indication Panel) when the "CAPT" key has been selected.

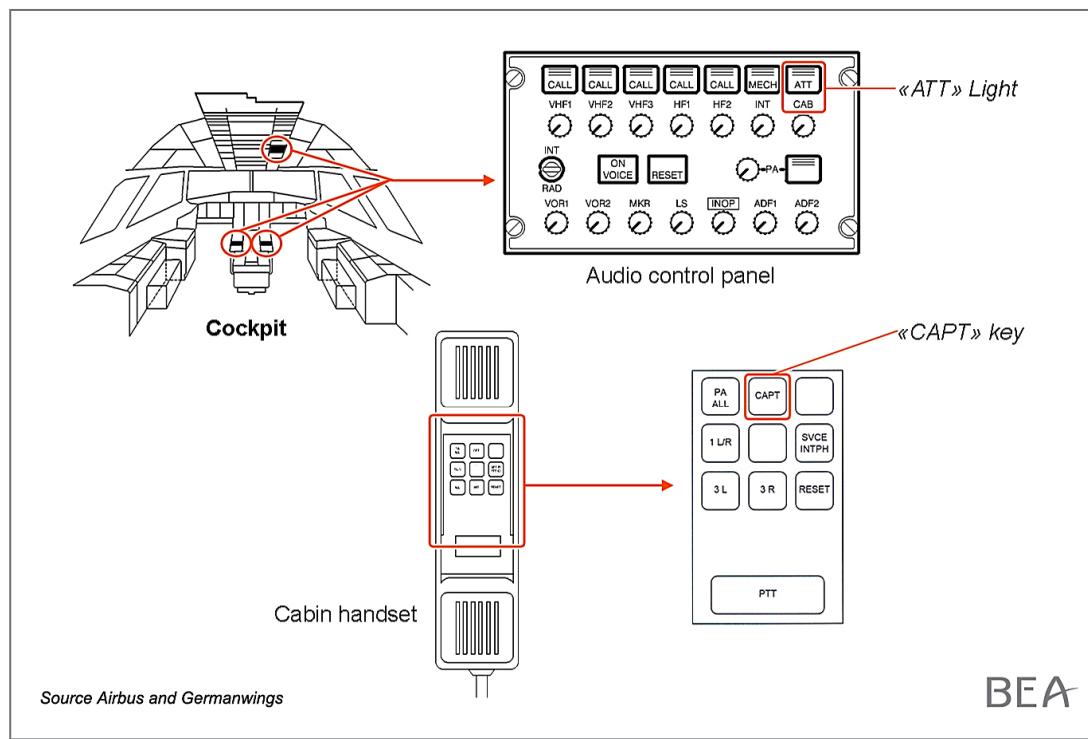


Figure 6 - intercom and communication system

1.5.6 OPEN DESCENT Mode

The automatic pilot on the Airbus A320 is equipped with a descent mode called "OPEN DESCENT". This mode ensures the aeroplane guidance in the vertical plane. When active, the autopilot acts on the attitude of the aircraft to reach and maintain the target speed while the auto thrust, if engaged, commands idle.

The target speed is said to be "*managed*" when calculated automatically by the flight management system or «selected» when selected manually by the crew via the dedicated selector knob located on the FCU control panel (figure 7).

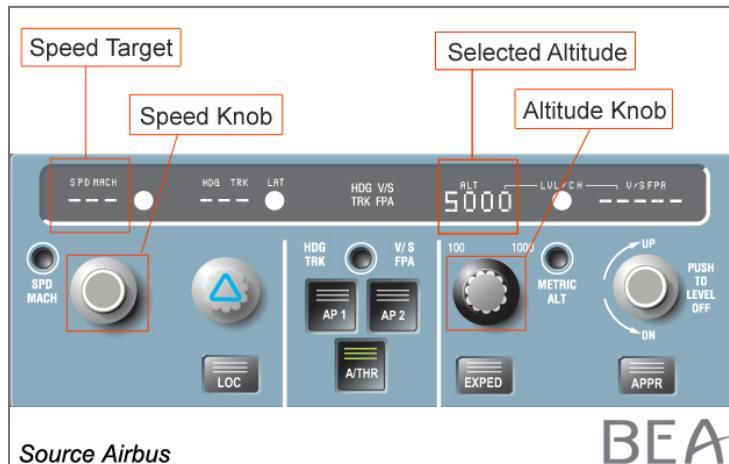


Figure 7 - FCU control panel

To engage this mode, the pilot must select an altitude below the current altitude and pull the altitude selector knob. During the descent, the modes displayed on the Flight Mode Annunciator (FMA) on the PFD screens were similar to the illustration below:



Figure 8 - FMA in OP DES mode

1.6 Meteorological Information

The information supplied by Météo France shows that in cruise at flight level FL380, the aeroplane was flying in clear skies above some scattered cirrus type clouds whose peaks were located at about 32,000 ft. The wind from the southwest was at about 40 kt.

At the site of the accident, a few altocumulus clouds were observed above the high terrain, which could locally cover the highest south-facing peaks. There was no convection phenomenon and the southeast wind was weak. The visibility was greater than 10 km. The ground was covered in snow above 2,000 m altitude on the south-facing slopes, and above 1,700 m on the north-facing slopes.

During the descent, the aircraft passed through a fine layer of scattered cirrus then some altocumulus whose base was at an altitude above 15,000 ft. The rest of the descent was performed outside of any clouds in visual flight conditions with visibility greater than 10 km.

1.7 Telecommunications

During the climb towards its cruise altitude, the flight crew was in contact with the Barcelona en-route control centre. It then contacted the F1 sector (West region) at Marseille en-route control centre on the 133.330 MHz frequency and continued its climb towards flight level FL380. After its transfer to sector B3 (East region) on 127.180 MHz, the flight crew read back the clearance from ATC by saying "*Direct IRMAR Merci Germanwings one eight Golf*". They did not re-contact ATC before the end of the flight.

The Marseille control centre tried on several occasions without success to establish contact with the aeroplane by using various frequencies: 127.180 MHz (sector B3 frequency and coupled with 132.490 MHz and 132.385 MHz) and the 121.500 MHz (emergency frequency) and by asking another aircraft to establish a radio relay on 127.180 MHz and 121.500 MHz.

Taking into account the loss of radio and radar contact, the DETRESFA emergency phase was triggered at 9 h 40.

1.8 Flight Recorders

1.8.1 Type of equipment

The aircraft was equipped with two flight recorders in accordance with the currently applicable regulations:

FDR

- manufacturer: Loral;
- model: F1000;
- type number: S800-3000-00 (Germanwings source: nameplate absent from the recorder);
- serial number: 246 (Germanwings source: nameplate absent from the recorder).

It is a data recorder with a memory card with a recording capacity of at least 25 hours. The decoding document supplied for this aircraft provides information on approximately 600 parameters.

CVR

- Manufacturer: L3COM;
- Model: FA2100;
- Type number: 2100-1020-02;
- Serial number: 00235;

This recorder is equipped with a memory card and has a recording capacity of at least 2 hours in standard quality and 30 minutes in high quality.

1.8.2 Opening and readout operations

CVR opening and readout

The CVR was sent to the BEA on 25 March 2015 under judicial seal.



Figure 9 - cockpit voice recorder (CVR) – D-AIPX

Given the significant damage to the CVR, the memory card was extracted from the protected module, visually inspected and tested electrically. Reading the data on the manufacturer's official equipment made it possible to obtain six audio tracks:

- four tracks lasting 31 minutes and 3 seconds:
 - 1 track including radio communications and the co-pilot's microphone signal;
 - 1 track including radio communications and the Captain's microphone signal;
 - 1 track including the radio communications and the signal from the headset microphone of the jump seat;
 - 1 track including the signal from the cockpit area microphone in high-quality.
- two tracks lasting 2 hours and 4 minutes:
 - 1 track including the first 3 mixed tracks;
 - 1 track including the signal from the cockpit area microphone in standard-quality.

Audio data contained in the recordings was from the event flight. Part of the previous flight is also recorded on the two-hour tracks.

A sound of breathing is recorded both on the co-pilot track and on that of the Captain throughout the accident flight. This breathing, though present on both tracks, corresponds to one person's breathing. It can be heard several times while the Captain was talking (he was not making any breathing sound then) and is no longer heard when the co-pilot⁽¹⁰⁾ was eating (which requires moving the microphone away or removing the headset). The sound of this breathing was therefore attributed to the co-pilot.

⁽¹⁰⁾The copilot had his meal during the climb around 9 h 15.

FDR opening and readout

The FDR was sent to the BEA on 2 April 2015 under judicial seal.

It showed significant mechanical and thermal damage. All of the equipment was covered in soot. After removing the protected module from the recorder casing, the memory card was removed from the protected module.



Figure 10 - Flight data recorder (FDR) - D-AIPX

Reading out the FDR with the manufacturer's official equipment resulted in a file with 39 Mb of flight data, including the event flight.

1.8.3 Synchronization of recordings

The CVR recordings were synchronized with the radio-communications from the Marseille control centre, the time at the control centre being used as a reference. The FDR recordings then were synchronized with those of the CVR using the radio communications with the control centre, the triggering of the GPWS alarms and the Master Warning parameter.

1.8.4 Previous Flight

All of the data from the previous flight, from Düsseldorf to Barcelona, was recorded on the FDR. The recordings from the CVR included the last 50 minutes of this flight. Synchronization of these recordings and the radio communications with the Bordeaux en-route control centre with which the crew was in contact, was performed based on the same principle as for the accident flight.

On the previous flight, the following facts can be noted:

- at 7 h 19 min 59, noises like those of the cockpit door opening then closing were recorded and corresponded to when the Captain left the cockpit; the aeroplane was then at cruise speed at flight level FL370 (37,000 ft);
- at 7 h 20 min 29, the flight was transferred to the Bordeaux en-route control centre and the crew was instructed to descend to flight level FL350 (35,000 ft), an instruction read back by the co-pilot;
- at 7 h 20 min 32, the aircraft was put into a descent to flight level FL350, selected a few seconds earlier;

- at 7 h 20 min 50, the selected altitude decreased to 100 ft for three seconds and then increased to the maximum value of 49,000 ft and stabilized again at 35,000 ft;
- at 7 h 21 min 10, the Bordeaux control centre gave the crew the instruction to continue the descent to flight level FL210;
- at 7 h 21 min 16, the selected altitude was 21,000 ft;
- from 7 h 22 min 27, the selected altitude was 100 feet most of the time and changed several times until it stabilized at 25,000 ft at 7 h 24 min 13;
- at 7 h 24 min 15, the buzzer to request access to the cockpit was recorded;
- at 7 h 24 min 29 noises like those of the unlocking of the cockpit door then its opening was recorded and corresponded to the Captain's return to the cockpit.

The following graphs were extracted from the FDR and illustrate the variations in selected altitude.

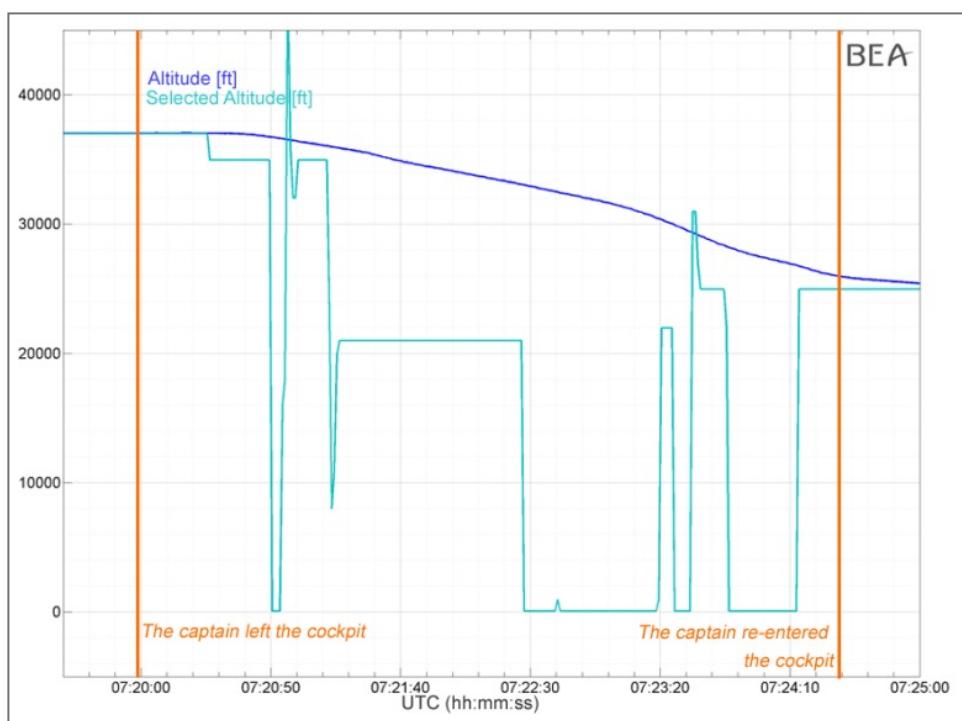


Figure 11 - descent during the previous flight

1.8.5 Work carried out on the Quick Access Recorder (QAR)

The aeroplane was equipped with the following QAR:

- manufacturer: Teledyne;
- model: WQAR;
- type number: 2243800-362;
- serial number: RA00815.

This equipment records the same data as the FDR on a Compact Flash card and on an SD card. The data is then used by the airline specifically for its flight analysis program.

The QAR was brought to the BEA on 29 March 2015 under judicial seal. It had suffered significant mechanical damage. The compact flash card and the SD card containing the flight data were extracted from the computer. X-ray analysis of the memory components from the two cards showed that their damaged condition made it impossible to retrieve recorded data.

The FDR was found and its data analysed four days later.

1.9 Wreckage and Impact Information

The accident site was located in mountainous terrain, in the municipality of Prads-Haute-Bléone (04) 1,550 m above sea level⁽¹¹⁾. The wreckage was fragmented with a large amount of debris spread over an area of 4 hectares in a sloping rocky ravine. The largest parts of the aeroplane were about 3 to 4 metres long.

On the lower part of the site, about 20 m above the ravine, is an area where the vegetation had been torn up, tree trunks were uprooted, tree branches were broken and the ground churned up. Parts from the aeroplane's wings and fuselage were found in this area. Apart from this area and the final debris field, no other contact with the environment was observed around the accident site.

On site, elements belonging to various parts of the aeroplane were identified. One of the engines was broken into many pieces in the main ravine. The debris of the other engine, concentrated in a small area, was found in the main west ravine.

The auxiliary power unit (APU) was located in the upper part of the site dozens of metres from the part of the rear fuselage to which the vertical stabilizer is attached. One of main landing gears was found near this part of the fuselage.

Parts from the cockpit (access door to the cockpit, sidestick, security camera) were also found in the upper part of the site.

The lower part of the site had a strong smell of kerosene.

The CVR, QAR and FDR were found respectively on 24/03/2015, 28/03/2015 and 02/04/2015 and were immediately transported to the BEA for readout.

Note: the front of the FDR was found separated from the rest of the recorder in which the crash module was located.

⁽¹¹⁾The geographical coordinates of the accident site are: 44°16'47.2"N / 006°26'19.1"E.

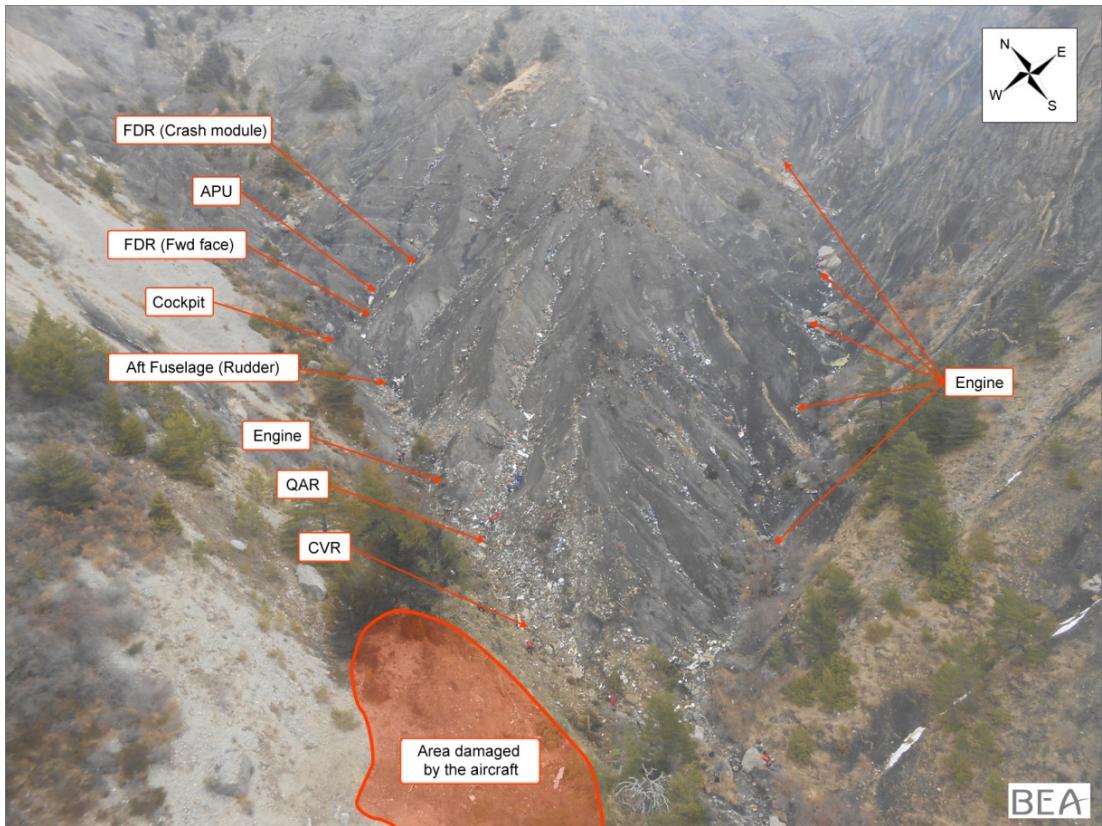


Figure 12 – general view of the accident site



Figure 13 - contact area with vegetation

1.10 Survival Aspects

The violence of the collision with the terrain caused the immediate death of all the aircraft's occupants.

1.11 Organizational and Management Information

Germanwings GmbH (GWI) was set up in 2002. It is a subsidiary of Lufthansa Group, which has owned 100% of its shares since January 2009. The Air Operator's Certificate (AOC) in its most recent revision was issued by the LBA on 20 October 2014. It is valid until 10 August 2015.

GWI operates 62 Airbus (43 A319 and 19 A320) and undertakes flights from Germany bound for many countries in Europe. Germanwings employs about 780 flight crew and 972 cabin crew.

Management of flight crew is undertaken by the Lufthansa Group management board. At the end of their training at Lufthansa (Lufthansa Flight Training School), the management board decides where to allocate the personnel, between the group's operators: Lufthansa, SWISS, Austrian Airlines, or Germanwings.

1.12 Additional Information

1.12.1 Testimony

All of the eyewitnesses who were close to the accident site stated that they had seen the aeroplane in continuous descent, in straight flight and with the wings horizontal.

1.12.2 Previous Events

A search undertaken in the ICAO and BEA databases since 1980 brought to light the existence of six public transport accidents whose conclusions show that they were caused by intentional manœuvres by one of the flight crew members, or mean that it is not possible to rule out the hypothesis of intentional manœuvres by one of the crew members that was intended to lead to the loss of the aircraft and its occupants.

Date	Aircraft	Operator	State of Occurrence	Fatalities	Circumstances
29/11/2013	ERJ 190	LAM	Namibia	33	The aeroplane was in cruise at flight level FL380 when the co-pilot left the cockpit to go to the toilet, leaving the Captain alone. On three occasions, different altitudes were selected to order a descent to the ground with autopilot. The CVR showed several aural warnings, as well as noises of repeated knocking and calls, corresponding to attempts to get into the cockpit.
31/10/1999	B767	EgyptAir	North Atlantic Ocean	217	The aeroplane was in cruise at flight level FL330 with a flight crew consisting of a Captain, a duty co-pilot and a relief co-pilot. The duty co-pilot left the cockpit, and the relief co-pilot took his place in the right seat. Eight minutes later, the Captain left the cockpit in turn, leaving the relief co-pilot alone. The autopilot was then disengaged and nose-down inputs were recorded on the FDR. The aeroplane descended. The engines were shut down. The Captain returned to the cockpit and tried to take back control of the aeroplane. The Captain repeatedly asked the co-pilot to help him to pitch up the aeroplane ('pull with me') but the latter continued to command the elevator to pitch nose down. The aeroplane regained altitude before descending again. It collided with the surface of the ocean. The reasons that led the co-pilot to take these actions could not be determined.
11/10/1999	ATR-42	Air Botswana	Botswana	1	The pilot, the only person on board, deliberately flew the aeroplane into the ground by crashing at Gaborone airport. The validity of his licence had been revoked for medical reasons.
19/12/1997	B737	Silk Air	Indonesia	104	While the aircraft was in cruise at 35,000 ft, the flight recorders stopped recording one after the other. The aeroplane suddenly started to descend. No Mayday message was transmitted before or during the descent. The aircraft crashed into a river. The safety investigation was not able to identify any technical problem that would make it possible to explain the accident.
21/08/1994	ATR42	Royal Air Maroc	Morocco	44	The Captain disengaged the autopilot and deliberately directed the aircraft towards the ground. The co-pilot was in the cockpit but was not able to counter the Captain's actions.
09/02/1982	DC-8	Japan Airlines	Japan	24	After having disengaged the autopilot on final approach at a height of 164 ft, the pilot pushed the control column forward and set the thrust levers on idle. He then moved the thrust levers of engines 2 and 3 to the reverse idle position. While the aircraft's attitude decreased, the co-pilot tried to pull on the control column. The co-pilot was unable to raise the nose of the aeroplane because the Captain was pushing forward on the control column with both hands. The aircraft crashed into the sea 510 m short of the runway. The investigation showed that the pilot's actions resulted from a mental problem. He was suffering from schizophrenia.

1.12.3 EASA Safety Information Bulletin

EASA issued, on 27 March 2015, a Safety Information Bulletin (SIB n°2015-04⁽¹²⁾) relating to authorised persons in the cockpit. This bulletin recommends operators to re-assess the safety and security risks associated with flight crew members leaving the flight crew compartment due to operational or physiological needs during non-critical phases of flight. Based on this assessment, operators are recommended to implement procedures requiring at least two authorised persons to be in the flight crew compartment at all times, or other equivalent mitigating measures to address risks identified by the operator's revised assessment.

⁽¹²⁾See <http://ad.easa.europa.eu/ad/2015-04>

2 - INITIAL FINDINGS

On the basis of the initial facts gathered during the investigation, the following findings have been made:

- The aeroplane had a valid Certificate of Airworthiness.
- The aeroplane's maintenance documentation did not mention any system failures that were incompatible with the flight as planned.
- The flight crew possessed the licences and ratings required to perform the flight.
- The co-pilot obtained his class 1 medical certificate without restrictions in April 2008, valid for one year.
- An episode of depression and the taking of medication to treat it delayed the renewal of the copilot's class 1 medical certificate between April and July 2009.
- From July 2009, the co-pilot's medical certificate was endorsed with the note "*Note the special conditions/restrictions of the waiver FRA 091/09 -REV-*". His pilot's licence had been endorsed with the note "****SIC**incl. PPL ****".
- The Captain's and co-pilot's training files show that their professional level was above standard.
- The aeroplane took off from Barcelona bound for Düsseldorf on 24 March 2015 at 9 h 00, with flight number 4U9525, and callsign GWI18G.
- The autopilot and autothrust were engaged during the climb.
- The Captain left the cockpit at the beginning of the cruise at FL380.
- The selected altitude changed from 38,000 ft to 100 ft while the co-pilot was alone in the cockpit. The aeroplane then started a continuous and controlled descent on autopilot.
- Several altitude selections towards 100 ft were recorded during descent on the flight that preceded the accident flight, while the co-pilot was alone in the cockpit.
- During the descent of the accident flight, the Marseille control centre called the flight crew on eleven occasions on three different frequencies, without any answer being transmitted.
- The French military defence system tried to contact flight GWI18G on three occasions during the descent, without any answer.
- The buzzer to request access to the cockpit sounded once during the descent, 4 min 7 s after the Captain had left.
- The interphone sounded in the cockpit, 4 min 40 s after the Captain had left.
- Three other calls on the interphone sounded in the cockpit.
- None of the calls using the interphone elicited any answer.
- An input on the right sidestick was recorded for about 30 seconds on the FDR 1 min 33 s before the impact, not enough to disengage the autopilot.
- The autopilot and autothrust remained engaged until the end of the CVR and the FDR recordings.
- The sound of breathing was recorded on the CVR until a few seconds before the end of the flight.
- Before the collision with the terrain, warnings from the GPWS, Master Caution and Master Warning sounded.
- The aeroplane collided with the terrain at 9 h 41 min 06.

3 - THE ONGOING SAFETY INVESTIGATION

The initial information from the investigation shows that, during the cruise phase, the co-pilot was alone in the cockpit. He then intentionally modified the autopilot instructions to order the aeroplane to descend until it collided with the terrain. He did not open the cockpit door during the descent, despite requests for access made via the keypad, the cabin interphone and knocks on the door.

The Safety Investigation is ongoing, based in particular on a detailed analysis of information on the flight crew, as well as on information from the flight recorders and radio communications.

The investigation will also study the systemic failings that may have led to this accident or to similar events, with two main investigative orientations:

- Medical aspects: the investigation will seek to understand the current balance between medical confidentiality and flight safety. It will specifically aim to explain how and why pilots can be in a cockpit with the intention of causing the loss of the aircraft and its occupants, despite the existence of:
 - regulations setting mandatory medical criteria for flight crews, especially in the areas of psychiatry, psychology and behavioural problems;
 - recruitment policies, as well as the initial and recurrent training processes within airlines.
- Cockpit security: the investigation will seek to understand the compromises that were made between the requirements of security, specifically those that followed the attacks on 11 September 2001, and the requirements of flight safety. In this context, the investigation will include a focus on cockpit door locking systems and cockpit access and exit procedures.

BEA

Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

10 rue de Paris
Zone Sud - Bâtiment 153
Aéroport du Bourget
93352 Le Bourget Cedex - France
T : +33 1 49 92 72 00 - F : +33 1 49 92 72 03
www.bea.aero

