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Report

Serious incident on **29 June 2010**
near Basel-Mulhouse (68) airport
between the **Airbus A319** registered **HB-JZQ**
operated by **easyJet Switzerland**
and the **Airbus A319** registered **F-GRHA**
operated by **Air France**

BEA

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

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

Safety Investigations

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SPECIAL FOREWORD TO ENGLISH EDITION

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

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Glossary

ACAS	Airborne Collision Avoidance System
ACC	Area Control Centre (DSNA)
ANS	Air Navigation Service
AP	Automatic Pilot Autopilot
ATHR	Auto Thrust
CTR	Control zone
CVR	Cockpit Voice Recorder
DAR	Direct Access Recorder
DME	Distance Measuring Equipment
DO	Operations Division (DSNA)
DSAC	Civil Aviation Safety Directorate
DSNA	Air Navigation Services Directorate
DTI	Technology and Innovation Directorate (DSNA)
EPISTIL	Preliminary Assessment of Impact on Technical Computing and Software Safety
FCOM	Flight Crew Operating Manual
FCU	Flight Control Unit
FD	Flight Director
FDR	Flight Data Recorder
FL	Flight Level
FO	First Officer
Ft	Feet
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
Kt	Knots
LOFT	Line-Oriented Flight Training
ND	Navigation Display
NM	Nautical Mile
NOTAM	Notice to Airmen
PF	Pilot Flying
PFD	Primary Flight Display
PNC	Cabin crew
PNF	Pilot Non Flying
QFU	Magnetic bearing Magnetic orientation of the runway (in tens of degrees)
RA	Resolution Advisory
FIS	Flight Information Service
SOP	Standard Operating Procedures
STCA	Short Term Conflict Alert
TA	Traffic Advisory

TCAS	Traffic alert and Collision Avoidance System
TMA	Terminal Control Area
TRI	Type Rating Instructor
VFR	Visual Flight Rules
V/S	Vertical Speed
VSI	Vertical Speed Indicator
WCS	Worst-Case Scenario

Synopsis

Aircraft	(1) A319 registered HB-JZQ (2) A319 registered F-GRHA
Date and time	29 June 2010 at around 17 h 30 UTC[(1)]
Operators	(1) Easy Jet Switzerland (2) Air France
Place	13 NM southwest of Basel Mulhouse airport
Type of flights	Scheduled public transport of passengers
Persons on board	(1) Instructor (PF), right seat; Trainee Captain (PNF), left seat (2) Captain (PNF); Co-pilot (PF)
Consequences and damage	Minor injuries

[(1)]Except where otherwise stated, the times shown in this report are expressed in Universal Time Coordinated (UTC).

SUMMARY

The crew of flight AF7343 took off from Basel Mulhouse runway 15 bound for Paris Orly. Soon after, they were cleared to climb to FL110 by the approach controller. Approximately one minute later, the controller cleared the crew of flight DS1058 from Palma during its approach to runway 15 to descend to the same altitude. A traffic advisory was triggered on board the two aeroplanes followed by a series of resolution advisories including a procedure reversal. During these manoeuvres, the vertical load factor recorded on flight DS1058 oscillated between - 0.19g and 2.04g. A cabin crew member was slightly injured.

This loss of separation was a serious incident. The investigation showed that it was caused by an error in speech by a trainee controller who assigned the same flight level to both aeroplanes, one climbing and the other descending, without the instructor controller detecting the error.

The following may have contributed to the error and to the fact it was not detected:

- on the basis of an inadequate safety study, CPUs with insufficient capacity were installed, causing a failure that had not been resolved at the time of the serious incident;
- an unusual situation of conventional procedural control for both controllers, against a background of weather avoidance requests;
- the inadequate combination of conventional procedural control and the use of a radar system declared inoperative;
- the role of contact exerted by the instructor controller between the trainee controller and the coordinator controller was not conducive to the supervision of the trainee controller.

It is possible that the vertical speed of AF7343 may have played a role in the sequence in which the TA and then the RA occurred.

The loss of separation was worsened as evidenced by the reversal of the TCAS RAs, due to the conjunction of:

- the tendency of AF7343 to decrease its rate of climb further to an instruction from the trainee controller asking the crew to maintain FL100, given prior to the triggering of the TCAS RA "maintain vertical speed, crossing maintain", inviting the crew on the contrary to maintain a constant rate of climb;
- a brief nose-up input by the PF of flight DS1058, when the AP was disengaged after the TCAS RA "monitor vertical speed" inviting the crew not to climb was issued.

The minor injury to a flight DS1058 cabin crew member of was due to the abrupt manoeuvres by the PF, at the time subject to increasing levels of stress in response to the successive TCAS RAs.

The radar display system malfunctions were due to the mismatch between the equipment as it was configured and the traffic liable to be taken into account. Inadequate coordination between the services and time constraints did not facilitate the detection of the anomaly during the safety studies carried out prior to the incident.

The BEA has issued four recommendations concerning:

- the automation of ACAS resolutions;
- preventive Resolution Advisories;
- the use of radar images during procedural control;
- smoothing the vertical flight path when approaching a flight level.

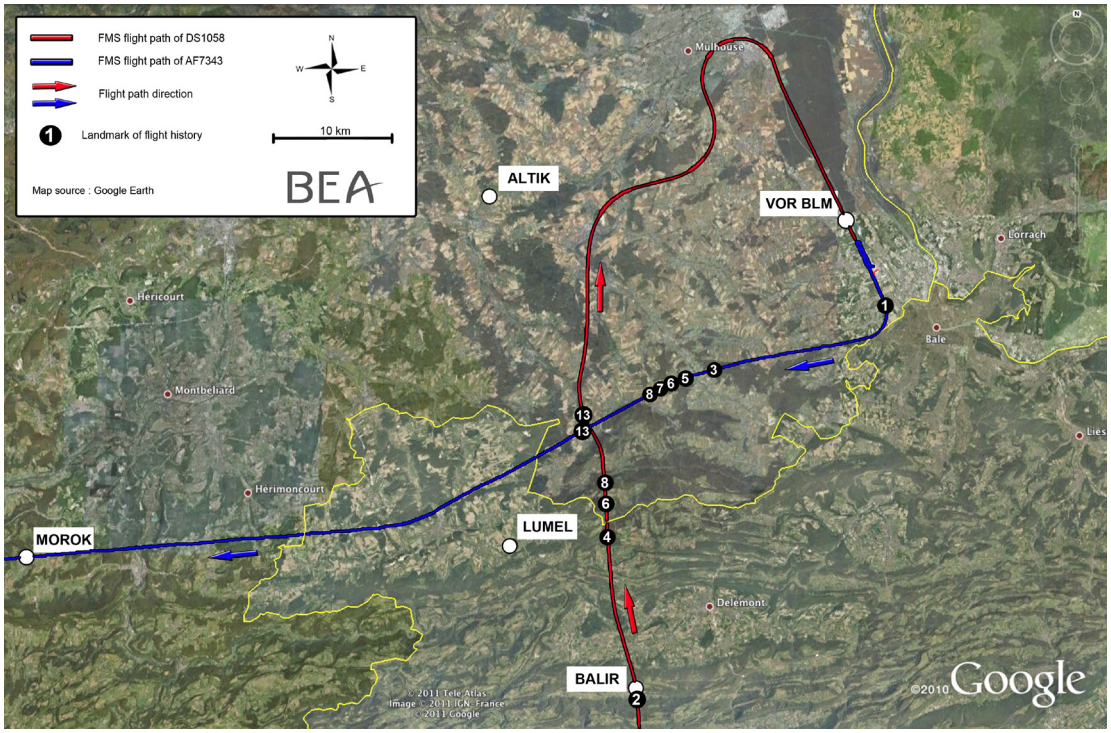
1 - FACTUAL INFORMATION

1.1 History of the Flight[2]

At 17 h 24 min 24, the crew of flight DS1058 from Palma contacted the Basel Mulhouse approach controller on descent to FL120. An instructor (TRI) was the pilot flying (PF) in the right seat. The controller requested the crew to continue via waypoints BALIR and then ALTIK and to prepare for an ILS 15 approach after a DME arc (12 NM from BLM).

For three days, air traffic control at Basel Mulhouse had been based on "procedures" because of uncertainty about the reliability of the radar display. The precision approach radar scope, however, was on. A trainee controller was at this position; the instructor was positioned at the adjacent station.

At 17 h 26, AF7343 took off from Basel Mulhouse runway 15 to follow a departure via waypoint LUMEL 5T bound for Paris Orly. The Captain was the PNF. At 17 h 27 min 40 (1), the approach controller requested a climb to FL110. The crew read back and selected FL110 on the control panel (FCU)[3].



At 17 h 28 min 46 (2), the crew of DS1058 called out they were above waypoint BALIR and requested a visual approach. The controller requested they descend to FL110, refused the visual approach and asked if they could reach waypoint ALTIK. The crew indicated they needed to alter their heading 10° to the right to avoid a thunderstorm cell. The controller cleared them to do so and requested that they call back when they could fly direct to waypoint ALTIK.

At 17 h 30 min 01 (3), the crew of AF7343 requested permission to set their heading to 230° to the left to avoid a thunderstorm cell. The controller cleared them to do so and requested that they call back when they could fly direct to waypoint MOROK.

At 17 h 30 min 10 (4) DS1058 was at FL110. At 17 h 30 min 18 (5), AF7343 passed FL100 in a climb. Its vertical speed was greater than 3,000 ft/min[4].

[2] Chronology based on the synchronisation of data by the data recorders of AF7343 and DS1058, the cockpit voice recorder of AF7343, as well as the radar and telecommunications data from air traffic control.

[3] Communications were in French between the trainee controller and the crew of F-GRHA (flight AF7343), and in English between the trainee controller and the crew of HB-JZQ (flight DS1058).

[4] Parameter calculated from the altitude recorded in the FDR.

The controller informed the crew of DS1058 that a visual approach was not possible due to a departure. At 17 h 30 min 27 (6), a reciprocal traffic advisory was displayed on the TCAS of AF7343 and of DS1058. Aboard AF7343, the PNF called out "TCAS you fly, FD OFF"; both flight directors (FD) were disabled.

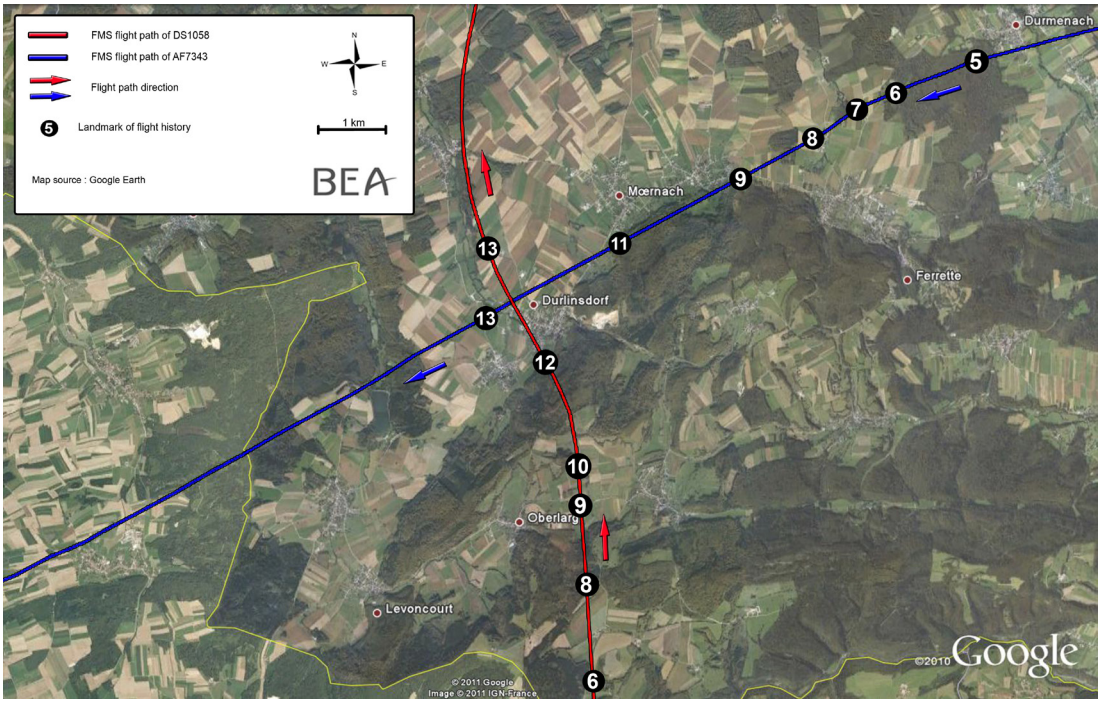
At 17 h 30 min 30, the Short Term Conflict Alert (STCA) was triggered on the precision approach radar scope.

At 17 h 30 min 31, the controller requested the crew of AF7343, then at 10,600 ft[5] to stop climbing at FL100 (7). The crew read back the request and stated they were descending to FL100. The autopilot (AP) of AF7343 was disengaged at 17 h 30 min 35 s. The PF applied a nose-down input. The attitude decreased from 4.6° to 2.1°.

[5]Altitudes are shown in relation to the reference pressure 1013 hPa.

At 17 h 30 min 37 (8), whereas AF7343 reached a flight level of approximately 10,750 ft in a climb, a corrective resolution advisory (RA) *"maintain vertical speed, crossing maintain"* was triggered, inviting the crew to maintain a minimum vertical speed evaluated to be 1,500 ft/min. The PF applied a nose-up input, changing the attitude from 2.1° to 6.7°. The PNF called out *"TCAS climb"* to the controller.

At the same time, aboard DS1058, the preventive RA *"monitor vertical speed"* was triggered, prompting the crew not to climb. The PF briefly applied a nose-up input while the AP was disengaged; the attitude changed from 2.8° to 5.3°. The FDs were kept triggered, the auto-thrust (ATHR) was disengaged and the thrust levers were moved forward. Approximately two seconds after the first action, the PF applied a nose-down input; the attitude changed from 5.3 to -5.6° and the vertical load factor reached -0.19 g.



At 17 h 30 min 45 (9), the altitude of DS1058 reaches a maximum of approximately 11,050 ft. The thrust levers were moved to the IDLE detent. The ATHR was disengaged. A corrective RA *"descend, crossing descend"* was temporarily recorded for 1 to 2 seconds, then the corrective RA *"climb climb now"* was triggered. The PF applied a nose-up input and started a turn to the left at a bank angle of about 30°.

The attitude increased from -5.6° to 13.8° and the heading decreased from 355° to 329°. Simultaneously, the corrective RA *"descend descend now"* was triggered aboard AF7343. The PF applied a nose-down input, the attitude changed from 6.7° to -5.3°.

Three seconds later (10), AF7343 reached a maximum altitude of approximately 11,040 ft. The PNF called out *"TCAS descend"* to the controller. Aboard DS1058, as it reached a minimum altitude of approximately 10,870 ft, the corrective RA *"increase climb"* was triggered, inviting the crew to apply a vertical speed of about 2,500 ft/min. The thrust levers were moved forward to the TOGA detent. The vertical load factor reached 2.04 g. The PNF called out the triggering of a TCAS RA to the controller.

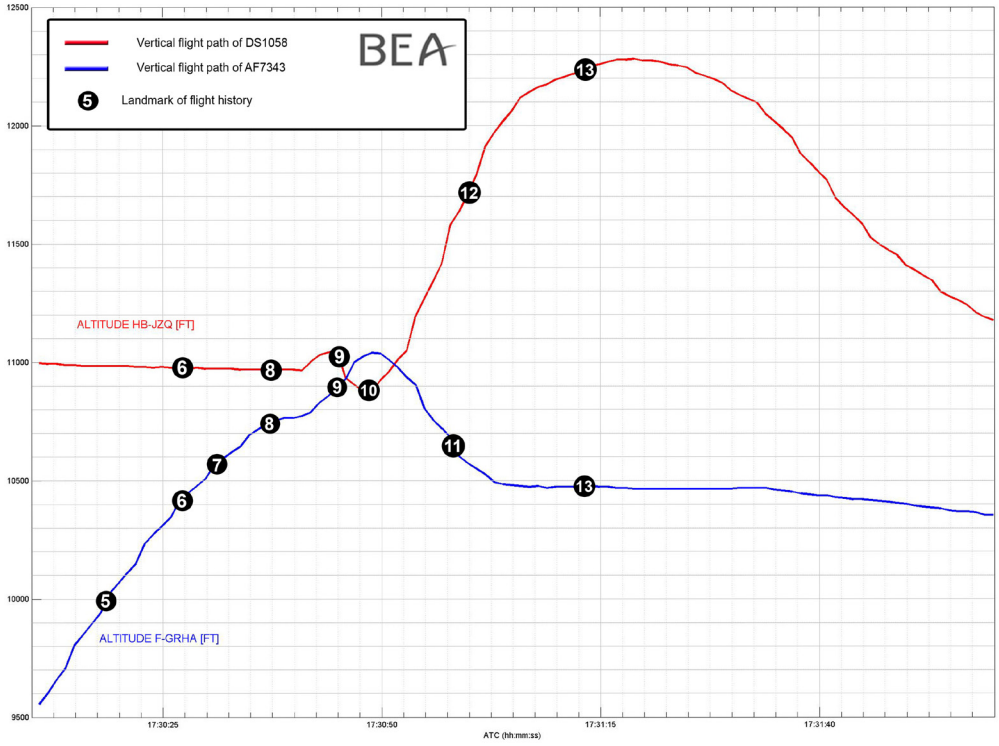
At 17 h 30 min 58 (11) and then 17 h 31 min 00 (12), the corrective RA *"adjust vertical speed"* was triggered respectively aboard AF7343 and DS1058.

The minimum angular separation in the sequence was recorded at 17 h 31 min 08 and corresponded to a separation of 0.29 NM in the horizontal plane and 1,760 ft in the vertical plane. At 17 h 31 min 13 (13), the *"clear of conflict"* messages were triggered on both aeroplanes. The altitude of AF7343 was approximately 10,480 ft. Four seconds later, DS1058 reached a maximum altitude of approximately 12,280 ft.

During the incident, AF7343 on a standard departure via waypoint LUMEL and DS1058 arriving via waypoint BALIR were at the same flight level for the second time at a horizontal distance of 2.2 NM, i.e. a flight time of about 16 seconds with a closing speed of approximately 500 kt.

The operational instructions in the case of procedural control indicate: *"the departure for waypoint LUMEL is separate from all the holding areas EXCEPT WAYPOINT BALIR."* Therefore there was loss of separation.

The risk of a mid-air collision is characterized by the dual triggering of the TCAS and of the STCA.



DS1058 landed at Basel Mulhouse to 17 h 39. At 18 h 14, AF7343 landed at Paris Orly.

1.2 Injuries to Persons

A member of the cabin crew of flight DS1058 was slightly injured during the series of evasive manoeuvres.

1.3 Damage to Aircraft

Not applicable.

1.4 Other Damage

Not applicable.

1.5 Personnel information

1.5.1 Flight Crew of flight DS1058

1.5.1.1 Instructor PF

- ❒ Airline Transport Pilot License issued on 19 November 1998.
- ❒ A320 type rating obtained on 16 December 2003.
- ❒ Command course taken in October 2005.
- ❒ Instructor course taken in May 2008, right-seat familiarization and qualification course in June 2008.
- ❒ Medical fitness certificate issued on 6 May 2010, valid until 19 May 2011.
- ❒ Last proficiency check carried out on 21 April 2010. During the check, the instructor had to carry out a TCAS exercise as PNF. It was simply suggested that he review the phraseology to be used with air traffic control.
- ❒ In general, the reports from the last checks of the PF show a good level of competence. Positive comments were made about his behaviour, especially in emergency situations.
- ❒ Experience:
  - ■ Total: 9,418 flying hours, including 5,000 as captain;
  - ■ On type: 4,374 flying hours;
  - ■ in the previous three months: 139 hours;
  - ■ in the previous 24 hours: 5 hours.

1.5.1.2 Trainee Captain

- ❒ Airline Transport Pilot License issued on 1 December 2003.
- ❒ A320 qualification valid.
- ❒ Previous type qualifications: ERJ145.
- ❒ Flying hours:
  - ■ Total: 7,090 flying hours, including 221 as captain;
  - ■ On type: 3,350 flying hours, including 10 as trainee captain.

1.5.2 Flight Crew of Flight AF7343

1.5.2.1 Captain PNF

- Airline Transport Pilot License issued on 18 May 1992.
- A320 type rating obtained on 15 May 1999.
- Command course taken in 1999.
- Medical fitness certificate issued on 4 December 2009, valid until 31 December 2010.
- Last proficiency check carried out on 17 March 2010.
- Experience:
  - Total: 6,667 flying hours, including 3,519 as captain;
  - On type: 2,289 flying hours;
  - in the previous three months: 97 hours;
  - in the previous 24 hours: 3.5 hours.

1.5.2.2 Co-pilot PF

- Airline Transport Pilot License issued on 11 May 2008.
- A320 type rating obtained on 7 October 2003.
- Medical fitness certificate issued on 16 December 2009, valid until 31 December 2010.
- Last proficiency check carried out on 4 March 2010.
- Experience:
  - Total: 3,643 flying hours;
  - On type: 3,481 flying hours;
  - in the previous three months: 74 hours;
  - in the previous 24 hours: 3.5 hours.

1.5.3 Basel-Mulhouse Air Traffic Control Services Personnel

1.5.3.1 Instructor Controller

- Unit endorsement obtained on 22 January 2001, valid until 18 January 2011.
- Valid instructor endorsement.
- *"Radar display failure"* simulation exercises carried out on 7 October 2009 and 4 February 2010.

1.5.3.2 Trainee Controller

- Assigned to Basel Mulhouse as of 31 December 2007.
- Controller LOC Proficiency Certificate obtained on 5 September 2009.
- In training for first controller qualification (phase 5 out of 7 in coordination and phase 7 out of 9 on radar).

1.6 Aircraft Information

1.6.1 Principles of operation of TCAS II

The TCAS II system is the only one to meet the ACAS standards set by ICAO. The specifications for TCAS II version 7.0 are set out in document ref. RTCA DO-185A.

The system is designed to issue a traffic advisory (TA) to warn the crew of possible threats and a resolution advisory (RA) to ensure adequate separation from the threats. The triggering criteria are set so that those applicable to the TA are satisfied before those of the RA[6].

There are two types of RA: preventive and corrective. A preventive advisory does not require that the flight path be modified by the crew. A corrective advisory requires that the flight path be corrected.

In particular, RTCA DO-185A defines the various RAs and the formulation of the voice announcements:

Advisory	Type	Voice announcement
List of TCAS RAs issued[7] aboard DS1058		
Limit Climb (Do Not Climb)	Preventive	Monitor Vertical Speed
Altitude Crossing Descend	Corrective	Descend, Crossing Descend -- Descend, Crossing Descend
RA Reversal (Descend to Climb)	Corrective	Climb, Climb NOW -- Climb, Climb NOW
Increase Climb	Corrective	Increase Climb, increase Climb
Weakening of Positive RAs (After Up Sense RA)	Corrective	Adjust Vertical Speed, Adjust
Clear of conflict		Clear of conflict
List of TCAS RAs issued aboard AF7343		
Altitude Crossing Maintain Rate (Maintain Climb Rate)	Corrective[8]	Maintain Vertical Speed, Crossing Maintain
RA Reversal (Climb to Descend)	Corrective	Descend, Descend NOW -- Descend, Descend NOW
Weakening of Positive RAs (After Down Sense RA)	Corrective	Adjust Vertical Speed, Adjust
Clear of conflict		Clear of conflict

List of TCAS RAs issued during the incident, as defined in DO-185A

1.6.2 Presentation of TCAS Equipment on Airbus

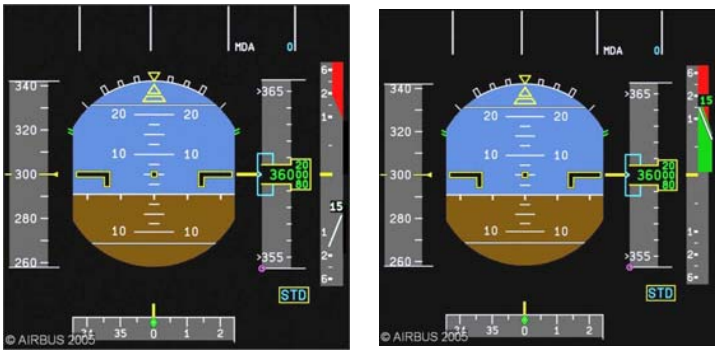
On Airbus aeroplanes, visual information about the TCAS is presented on the navigation displays (ND) and on the vertical speed indicators of the primary flight displays (PFD). The representation on the ND shows the horizontal position, status, relative altitude and vertical speed of an aircraft constituting a potential threat. In the case of an RA, the vertical speed indicator (VSI) indicates the range of vertical speed to avoid (an advisory of the preventive or corrective type) and the required manoeuvre (corrective advisories only).

[6] The traffic advisory is expected to trigger 35-48 seconds before the calculated minimum closing time while the RA is scheduled to trigger 15-35 seconds before it.

[7] Since the CVR data of DS1058 were not safeguarded, it is not possible to confirm the activation of the voice announcements for all these advisories, some of which seem to be transient on reading the parameters.

[8] Theoretically, the advisories «maintain vertical speed» should be considered as preventive advisories. Indeed they were regarded as such in previous versions of TCAS specifications. The change to advisories of the corrective type was made when version 7.0 was released to enable a visual representation (green area) of the manoeuvre required by these advisories.

TCAS information on the ND



TCAS information on the VSI
(preventive advisory on the left, corrective advisory on the right)

1.7 Meteorological Information

The weather forecasts were made on the morning of the incident by the regional Météo France centre in Strasbourg. They indicated *"a mass of unstable air due to diurnal changes associated with the passage of a small trough of low pressure. The low flow aloft and the presence of hot air in the lower layers are conducive to the development of isolated, slow-moving storm cells, locally fairly strong, affecting the terrain and its surroundings in the afternoon"*.

The satellite images at the time of the incident showed *"significant convective developments in the Hautes-Vosges with the probable presence of cumulonimbus clouds. Non-convective clouds are also present in the Basel Mulhouse region (altocumulus and cirrus)."*

At 17 h 00, cumulonimbus clouds were observed at 5,600 ft (2/8), altocumulus clouds at 9,900 ft (3/8) and cirrus clouds at 19,800 ft (7/8).

At 18 h 00, cumulonimbus clouds were observed at 5,600 ft (2/8), altocumulus clouds at 13,100 ft (3/8) and cirrus clouds at 18,100 ft (7/8).

At 17 h 30, the METAR for the Basel Mulhouse aerodrome was as follows:

METAR LFSB 291730Z 29006KT 9999 FEW056CB SCT100 BKN180 26/16 Q1018 NOSIG

1.8 Aids to Navigation

The air traffic radar display used for the approach to Basel Mulhouse is the IRMA 2000.

On 22 May 2010, malfunctions occurred on the IRMA 2000, with display delays and indiscriminate restarts on the TMA, Control Tower cab and LOC position screens due to an excessive number of tracks to be processed. On 3 June, a temporary solution was installed which consisted in withdrawing the single-radar sources of La Dôle and Nevers. They were reinstated on 22 June after the installation of a software update.

The same type of anomaly reappeared on 26 June 2010 on the INFO SIV, ORG BM, and RAD-INI control positions. The IRMA 2000 system was declared inoperative and Basel Mulhouse switched to conventional procedural control. A NOTAM was issued stating *"radar service not ensured in the Basel Mulhouse CTR, TMA and FIS."* On 30 June, the sources of the Dole and Nevers were withdrawn once again so that the system could be returned to service.

The local and national safety committees of the DSNA discussed the advantages and disadvantages involved in the use of unreliable displays in procedural control situations (unreliable conflict alerts, map displays, aeroplane position displays/ images, *"pseudo"* procedural control, unsafe STCAs). No method was defined or prioritised.

These two malfunctions are considered as *"serious"* by the DSNA. They occurred during spring weekends in which a large amount of traffic using VFR was observed. When extending the Basel FIS as part of the recovery of the lower airspaces from the CRNA-E, the IRMA central processing units (CPUs) were changed in anticipation of the increase in the number of radar sources to be integrated. On the date of the incident, however, the DTI had not determined valid saturation thresholds under operational conditions for the equipment dedicated to the IRMA 2000 system. Excessive load values had been measured in the plant but were not considered to be representative of operational conditions.

Date	IRMA 2000 sources at Basel Mulhouse				
	DACOTA	STR	Single-radar sources (secondary)	Single-radar sources (primary)	Total
22/05/2010	500	270	1500	80	2350
26/06/2010	360	258	1514	79	2211

Summary provided by the DTI of the number[9] of tracks processed when the two malfunctions occurred

[9]The figures shown above correspond to the peak values of the sources inputting the IRMA workstations at the time of the malfunctions. At the time close to the malfunction on 26 June (± 30 min), the number of tracks in use ranged between 1970 and 2211.

1.9 Telecommunications

Between 16 h 36 and 17 h 36, the crews of 10 incoming aeroplanes and 4 outgoing aeroplanes were in contact with the Basel-Mulhouse approach controller.

The trainee controller issued his first message on the approach frequency at 16 h 44; 3 aeroplanes were approaching at that time.

A maximum of 4 aeroplanes on the frequency simultaneously was reached at 17 h 03 and then at 17 h 33.

At 17 h 27 min 43, when the trainee controller cleared the crew of AF7343 to climb to FL110, three aeroplanes were on the approach frequency.

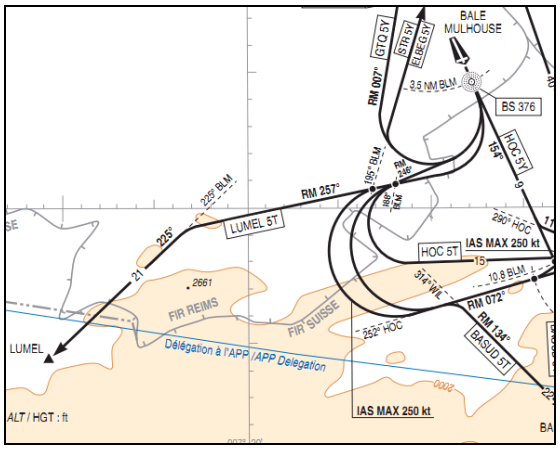
1.10 Aerodrome Information

Basel Mulhouse is a controlled civil aerodrome open to public air traffic.

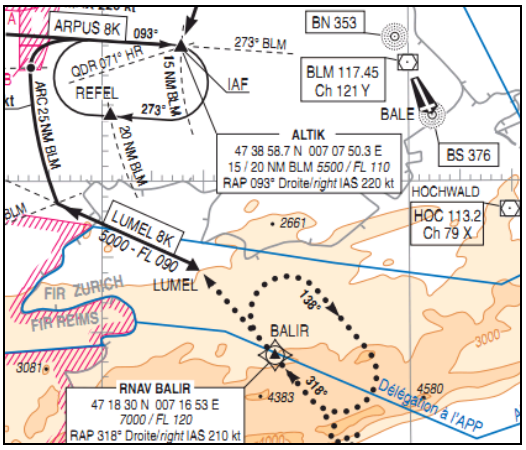
It has two runways:

- 08/26, which is 1,820 meters long and 60 meters wide. It has no instrument approach system;
- 15/33, which is 3,900 meters long and 60 meters wide. The 2 QFUs for this runway have an ILS.

The associated airspaces include a class D control zone (CTR) and a terminal control area (TMA), which consists of several parts, class D or E.



Standard departure route runway 15



Standard arrival route

1.11 Flight Recorders

1.11.1 DS1058 Flight Recorders

The aeroplane was equipped with a flight data recorder (FDR) and a cockpit voice recorder (CVR) in accordance with the currently applicable regulations.

The FDR, a Honeywell Model 4700, was a Solid-State Flight Data Recorder (SSFDR) with a recording capacity of at least 25 hours. The recorder was read out by EasyJet Switzerland and the resulting file was forwarded to the BEA. This file contained a little more than 53 hours of data, including those for the event. The decoding document used to transform the raw data into engineering data has some 500 parameters.

The CVR information about the event was not preserved because the recorder was used after the incident for a period longer than its recording capacity.

1.11.2 AF7343 Flight Recorders

The aeroplane was equipped with an FDR and a CVR in accordance with the currently applicable regulations.

The FDR was not removed by the company after the incident. However, the aeroplane was also equipped with a Direct Access Recorder (DAR), the contents of which were read out by Air France. The flight data for the event were then sent to the BEA. The decoding document used to transform the raw data into engineering data has some 370 parameters.

The CVR, of TEAM make, p/n AP71232101, is a Solid-State Flight Cockpit Voice Recorder (SSCVR) with a recording capacity of 2 hours. After being saved by the crew, the recorder was received at BEA on 2 July 2010 to be read out. It was not possible, however, to recover all the data in its memory using the official data readout bank provided by the manufacturer. It was therefore decided to visit the TEAM premises on 9 July 2010 to read the CVR with their own data read bank. All the data, including those for the event, were recovered after the second readout, which also helped to highlight an internal malfunction of the data readout bank provided for the BEA by the manufacturer TEAM. The latter has set up a corrective action plan to address the problem thus identified. The action plan was being implemented at the time of writing this report.

1.12 Wreckage and Impact Information

Not applicable.

1.13 Medical and Pathological Information

Not applicable.

1.14 Fire

Not applicable.

1.15 Survival Aspects

Not applicable.

1.16 Tests and Research

1.16.1 Opposite inputs to the TCAS RA

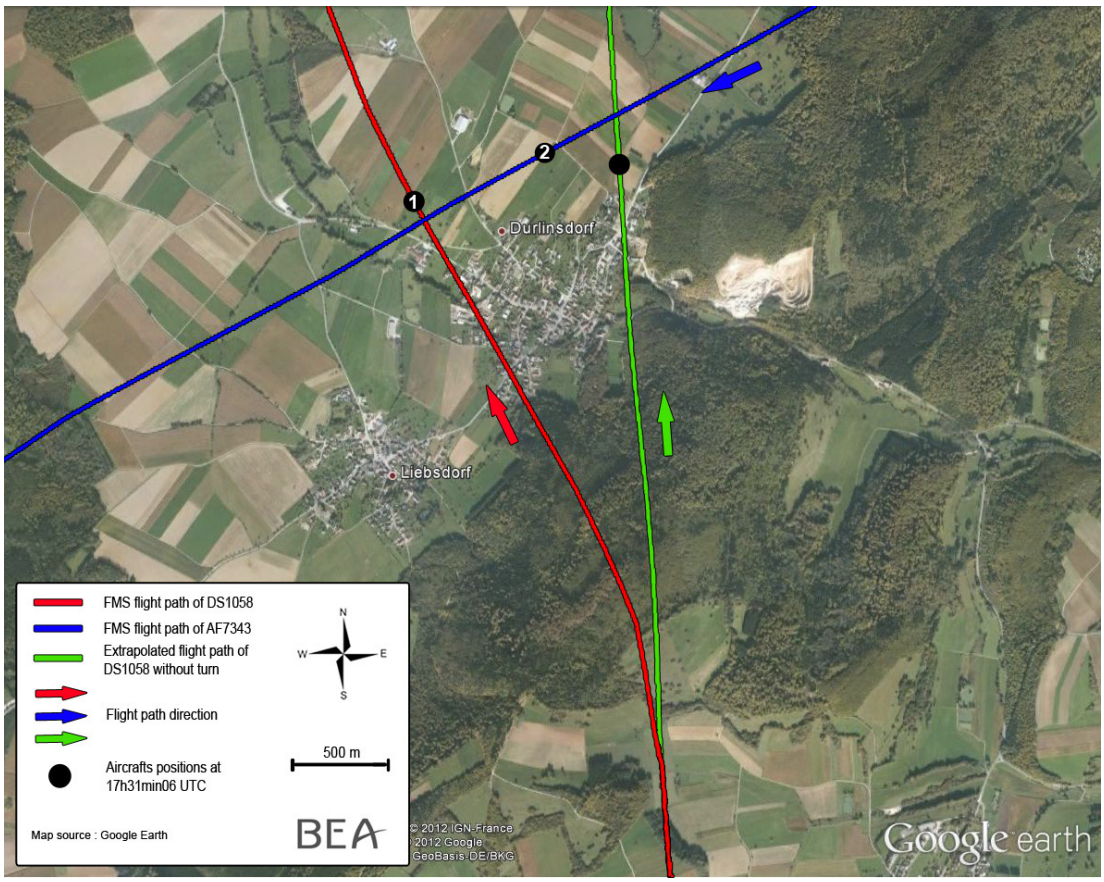
In 2003, an investigation by the BEA into a serious incident[10] found that the pilot had an opposite reaction in response to the RA *"adjust vertical speed"*. The error was due to the difficulty encountered the crew in interpreting the alert, leading in particular to an instinctive reaction by the pilot flying. The ergonomics of TCAS alarms, combined with the stress on the crew, was considered a contributing factor. Since then, many changes have been made to ACAS standards and the system installed on Airbus aeroplanes. In addition, certain operators have paid particular attention to contradictory corrections.

The BEA has sought to identify the different types of RA leading to erroneous crew inputs, in particular *"monitor vertical speed"*. The operators EasyJet Switzerland and Air France were requested to authorise use of the results of their systematic analysis of flight data. In both cases, the algorithms used did not enable the detection of contradictory corrections for this RA in particular.

[10] 23 March 2003: airprox between two Airbus aeroplanes registered F-GPMF and F-GHQA.

1.16.2 Turn following RA

Analysis of the flight paths showed that the turn by the pilot of DS1058 made his aeroplane pass in front of AF7343 and not behind it, as it would have done if it had kept a straight path.



The positions of the aeroplanes shown on this diagram do not correspond to the point in time at which the minimum angular separation occurred. At that time (i.e. two seconds later), the distance between points 1 and 2 was smaller. In turning left, therefore, DS1058 did not increase the separation with AF7343.

1.17 Information on Organisations and Management

1.17.1 TCAS Procedures

The Airbus TCAS procedure for aeroplanes of the A320 and A330/A340 families does not provide for specific inputs at the onset of the TA except for visual acquisition of traffic concerned. The disengagement of the AP and FDs[11] occurs when the RA is triggered. EasyJet Switzerland has incorporated the Airbus TCAS procedure verbatim into its documentation.

TCAS WARNINGS

■ **Traffic advisory : "TRAFFIC" messages**

Do not maneuver based on a TA alone.
Attempt to see the reported traffic.

■ **Resolution advisory : All "CLIMB" and "DESCEND" or "MAINTAIN VERTICAL SPEED MAINTAIN" or "ADJUST VERTICAL SPEED ADJUST" or "MONITOR VERTICAL SPEED" type messages**

– AP (if engaged) ..... OFF
– BOTH FDs ..... OFF
– Respond promptly and smoothly to an RA by adjusting or maintaining the vertical speed, as required, to reach the green area and/or avoid the red area of the vertical speed scale.

Excerpt from the Airbus TCAS procedure (FCOM A319)

In 2003 and 2004, Air France modified the TCAS procedure for its Airbus A320 and A330/A340 aeroplanes. The new procedure provides for the disengagement of the FD as soon as a TA occurs. No formal internal company document has been provided to the BEA explaining the reasons for the change or indicating whether a preliminary study had been carried out. In 2010, the department in charge of flight safety carried out an analysis of the Air France procedure taking operational experience into account. The analysis concluded the divergence ought to be reconsidered.

[11] The disengagement of the FDs after the AP allowed the ATHR to be maintained in SPEED mode.

Several arguments have been put forward for this, including the following:

- the modified procedure provides no decisive advantage;
- the RAs may not be preceded by TAs. In this case the procedure may cause the crew to forget to disengage the FD;
- the early disengagement of the FD without engaging the AP is identified by the airline as a contributing factor to deviations from the flight path. They often favour the triggering of RAs of the *"adjust vertical speed"* or *"monitor vertical speed"* type, in which the reaction of the crew is considered less reliable.

Furthermore, this procedure goes against the operating principle of the new system developed by Airbus, the AP/FD TCAS mode, already installed on the A380.

Finally, to prevent the issuing of unnecessary RAs in the presence of potentially conflicting traffic:

- Airbus recommends limiting the vertical speed of the aeroplane to 1,500 ft/min when it is less than 2,000 ft from the target altitude;
- Air France specifies in its operations manual that the rate of climb or descent must be limited to 1,000 ft/min when approaching the authorized flight level.

1.17.2 TCAS Training and Exercises at EasyJet Switzerland

During initial instruction, the TCAS is discussed theoretically in the ground and computer-aided training courses. In practical terms, three exercises are carried out on a flight simulator.

As part of recurrent training and proficiency testing, TCAS exercises were scheduled two out of three years (2007, 2008 and 2010). The pass criteria were for *"technical"* skills (SOP monitoring, phraseology, accuracy and smoothness of manoeuvres, proper use of automation) and *"non-technical"* skills (prior awareness of conflicting traffic, relevance of immediate inputs, monitoring of inputs by the PNF, awareness of the relative position of other aircraft during the manoeuvre).

Between 2007 and 2011, EasyJet Switzerland identified 21 cases of repetition of the TCAS exercise on a flight simulator, which represents less than 2.2% of all the TCAS exercises carried out. Nine of them were not detailed by the instructor/examiner in their report, while nine others were attributed to non-compliance with the procedure. The latter included non-disengagement of the AP and FDs and inadequate monitoring of PF inputs by the PNF. Finally, three cases involved flight path handling, including an incursion into the area to be avoided and excessive longitudinal input.

EasyJet Switzerland indicated to the BEA that the simulator enables training in TCAS procedures:

- only in an IFR environment;
- according to extremely conventional scenarios that crews can easily anticipate;
- in an environment that is very different from the mixed conditions encountered in real cases, with unexpectedly close series of TAs and RAs, and above all visual meteorological conditions (VMC) that change the perception of the TCAS environment.

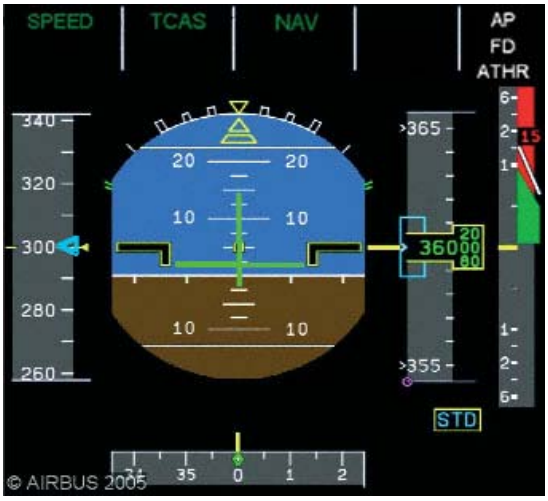
Furthermore, EasyJet Switzerland also indicated to the BEA that they established the following SMS processes:

- statistical monitoring of TCAS data;
- individual monitoring of pilot performance;
- integration of this information in the airline's Safety Management System;
- use of a Safety Index as a basis for decisions on preventive actions.

1.17.3 AP/FD TCAS Mode

Airbus has developed a new system called *"AP/FD TCAS mode"*. In addition to the voice announcement and the required manoeuvre, which continues to be shown on the VSI, this AP guidance mode can be used:

- by the AP, if it is engaged when the RA occurs, to guide the aeroplane in the required manoeuvre;
- by the FD to indicate[12] to the pilot the attitude required to fly or pursue the requisite manoeuvre.



Example of the display of a TCAS RA
"Adjust vertical speed" on an aeroplane equipped with the AP/FD TCAS mode

In the case of a preventive RA, the TCAS mode is triggered to draw the attention of the crew. The current longitudinal modes of the AP and the FD are maintained if they ensure the vertical speed is maintained. Otherwise, the modes switch to V/S with the current vertical speed as the target.

The AP/FD TCAS mode is standard equipment on the Airbus A380 and has been proposed as a retrofit on the Airbus A320 and A330/340 families since 2011.

1.17.4 Conventional Procedural Control and Associated Training

In a conventional procedural control situation, two aircraft cross paths by maintaining the regulatory vertical separation[13] as long as they do not consider themselves to be moving away from landmarks downstream of the crossing point.

[12] If the FDs are disabled, they will be automatically re-enabled when the resolution advisory is triggered.

[13] In the Basel TMA, the standard vertical separation is 1,000ft.

This type of control is on the initial training schedule given during the first module at ENAC. In air traffic control organisations such as Basel Mulhouse, it is covered by an exercise forming part of *"training for unusual situations."* Simulation scenarios are provided for this purpose. Controllers can ask to attend as many simulation sessions as they wish. On the date of the incident, the trainee controller and his instructor had performed simulations of radar failure. Neither of them had actually controlled using conventional procedures before the start of their cycle of shifts during which the incident occurred.

The particulars of procedural control at Basel Mulhouse are included in an operational instruction of 2006 and were partly included in the operational instruction given to the controllers on the day of the incident. In the second instruction it is recalled that standard LUMEL departures are not separate from the BALIR holding area. The traffic capacities and rates in these cases are also mentioned. Specific weather conditions that may cause a deviation from conventional flight paths are not taken into account.

Nothing restricts instruction being undertaken in a procedural control situation.

1.17.5 Airspace Transfer and Associated Safety Studies

In 2004, the Operations Division of the DSNA initiated a project to transfer parts of the lower airspace from the East Area Control Centre to the Northeast Air Navigation Services of Basel Mulhouse, Strasbourg and Metz Nancy Lorraine. The purpose on the one hand was to increase the capacity of the East Area Control Centre in upper airspace, and on the other to expand and join the flight information services (FIS) to improve VFR/IFR compatibility.

The transfer of this airspace to Basel Mulhouse was scheduled for 22 October 2009. Given the lead-time for publication, the deadline for acceptance of the change by the DSAC was 24 September 2009.

In view of this change, in accordance with European Regulation No 2096/2005 and DSNA internal procedures, the Northeast ANS carried out a safety study from April 2008 onwards. It was the subject of 34 referenced meetings and conference calls between April 2008 and August 2009. In addition, the safety report refers to 18 other safety studies on amendments related to the change in airspace, conducted by different entities of the DSNA, to complement the safety report.

The process began by defining the scope of the study, which was voluntarily restricted *"to innovations caused by the specific nature of the work of en route controllers"*. It was followed in October 2008 by determining the WCS (worst-case scenarios) on the basis of an analysis involving personnel from the Safety, Quality and Security Mission (MSQS) of the DSNA, Northeast ANS and East ACC. The 4 WCS identified were adverse operational conditions associated with the loss of separation and oncoming terrain.

The Basel Mulhouse air traffic control organisation and ACC-East continued with the development of causal trees. The identified causes were divided into four categories: technical, human, procedures, pilot. Twelve technical causes were associated with the radar; none of them concerned the load capacity of the display equipment at Basel Mulhouse in the future configuration integrating the new airspace. Based on the identified causes, *"means of reducing the risk of prevention and protection"* were determined in order to reduce the probability of occurrence and the potential severity

of the WCS. These means were used to establish safety requirements, various entities then being requested to provide proof that the requirements were met. The Technology and Innovation Directorate (DTI) was mandated to provide 8 substantiating documents covering 6 safety requirements. The substantiating documents were included in the technical section of the safety report drafted by the DTI.

In July 2009, the DTI found it necessary to replace the CPUs at the Basel Mulhouse IRMA2K after performance issues occurred. This issue was considered to be *"unrelated to the safety report"*. They were scheduled to be replaced as quickly as possible so that the controllers could familiarize themselves with the new system before the airspace transfer. The installation took place on 4 August 2009. The replacement of the equipment was the subject of an EPISTIL[14], the first version of which was completed after 15 September 2009. The EPISTIL was referenced in the technical section but was not included in the list of substantiating documents to be provided for the safety report. The version of 12 October 2009 was given to the BEA. It does not take into account the change in airspace concurrent with the change in equipment. Two WCS were determined. Only one possible cause was identified and associated with one of them. It concerned the failure of the IRMA 2K CPU. On this basis, the risk assessment associated with the two WCS by the DSNA did not require the drafting of a safety report for the change of hardware.

[14]Preliminary Assessment of Impact on Technical Computing and Software Safety.

Theoretically, the EPISTIL relating to the change of the IRMA CPUs should have been produced before commissioning the CPUs. However, another EPISTIL on the change of the tile module of the radar processing system (STR) for the airspace transfer to Basel drafted previously on 29 May 2009 identified the increase in the radar data stream as a cause of a WCS, leading to a backlog of information. The DTI considered that measurements of the RENAR and IRMA2000 loads were required in response to the WCS. These measurements were made and found to be satisfactory.

The excessive load threshold was assessed at the factory and mentioned in the technical section of the safety report on the airspace transfer. Although not considered to be particularly representative of reality, it was felt to be acceptable in relation the number of tracks usually out coming from DACOTA and STR sources. These were considered at the time to be predominant in terms of load capacity.

The CASD issued a positive opinion on 17 September 2009 on the *"transfer of the ACC-E sector to Basel Mulhouse"*. Due to the dissociation by the DSNA of the problem concerning the change of the CPUs, this change was not mentioned in the analysis or in the approval of the CASD.

1.18 Additional Information

1.18.1 Interview with the Instructor Controller

The instructor controller explained that the incident occurred at the end of his second shift in a cycle of 3 working days after 3 days of rest. He joined the trainee controller who was already at the approach position. He plugged his headphone into the adjacent control panel in order not to interfere with the trainee controller and to have better communication with the coordinator controller. The context was marked, on the one hand by the unavailability of the radar display for several days, and on the other by the stormy weather conditions. The workload at the start of the session was heavy because of traffic and the associated coordination operations. He decided first

of all to turn off the screen to prevent the trainee controller from being tempted to look at him to provide flight path instructions. Shortly before the takeoff of AF7343 and the arrival of DS1058, he decided to turn it back on to have a short debriefing with the trainee.

He remembered hearing the initial clearance to FL110 transmitted by the trainee to AF7343, a level consistent with the presence of DS1058 stable on FL120. According to him, the trainee controller took into account the strip of a second incoming aeroplane, then at FL120, and requested the crew of DS1058 to descend from FL120 to FL110. He was then in the process of managing the change in the flight path of DS1058 with the coordinator controller and did not notice that clearance right away. When he realized it, he noted that it was consistent with the FL100 circled on the strip of AF7343. Shortly after, a discussion took place between him and the trainee controller on horizontal separation methods. On the screen, he then saw AF7343 cross FL100 and detected the conflict with DS1058. He alerted the trainee controller who requested AF7343 to maintain FL100. The STCA visual alert occurred at approximately the same time.

1.18.2 Interview with the Trainee Controller

The trainee controller explained he had worked on the two days prior to the day of the incident, at which time the radar display was already unavailable. On the day of the incident, he spent one hour at a position for which he was already qualified. He then went to the approach position for the rest of his shift. He took a break for about 15 minutes about one hour before the incident occurred. At the time of the incident, the radar screen was on.

He cleared the crew of AF7343 to climb to FL110 thinking he had said FL100. He did not pay attention to the crew readback as he was thinking about the strategy to adopt for a second incoming aeroplane that was descending to FL120, which he had just seen on the radar screen. Finally, to integrate this new aeroplane, he decided to request the crew of DS1058 to descend to FL110.

During the conflict, he did not communicate any traffic information since he could not provide relative altitudes because of the absence of any radar display. In addition, he stated that the STCA visual alert was triggered but that this was standard in the case of stabilization with a scheduled separation of 1000 ft.

Although the day was not particularly busy in terms of traffic, the lack of radar meant more resources were mobilised. He had already had the opportunity to control without radar on the simulator, and to control during stormy weather conditions. On the other hand, he had never faced a situation involving both conditions. He explained the simulation scenarios dedicated to breakdowns of radar displays never included deviations from conventional flight paths. He indicated that the vertical separation occurred at 1,000 ft but that there were no procedures at Basel Mulhouse on horizontal separation in a procedural control situation. As far as he was concerned, the method to be used was not very clear.

1.18.3 Interview with the Instructor, Right Seat PF during Flight DS1058

The instructor of flight DS1058 was the right seat PF during the incident flight, as part of Line-Oriented Flight Training (LOFT) of the trainee captain. He explained that during the arrival at Basel Mulhouse, they requested an avoidance heading to the right to avoid a thunderstorm cell. Shortly after, he heard the crew of AF7343 make an avoidance request to the left. He also heard the controller's instruction about that aeroplane's climb but he did not remember the flight level.

This configuration (incoming aeroplanes from the south and outgoing aeroplanes from QFU 15) is common at Basel Mulhouse and identified as conducive to losses of separation. For this reason, he was not surprised by the occurrence of the TA. He observed AF7343 on the TCAS first of all. In particular because he was aware that the ATC services had no radar, he considered this situation to be exceptionally worrying in terms of the TCAS events he had experienced beforehand. He was surprised by the rapid triggering of RA after the TA and the nature of the first RA. According to him, the sequence comprising the TA and the succession of various RAs took place quickly.

Given the supposed flight path of AF7343 and the information available on the TCAS about its relative position, he expected an RA inviting it to climb or not to descend. Despite this, he explained he did not intentionally make a nose-up input when the first RA occurred: *"monitor vertical speed"* (don't climb). Thereafter, during the sequence of RAs, he basically followed the TCAS indications on the VSI. Concerning the callouts, he did not clearly remember that of *"increase climb."* The inversion of the TCAS mode and then the increase in vertical speed required on the VSI confirmed his belief that the situation was critical.

The TCAS procedure observed by his airline is that of the manufacturer. When a RA occurs it provides for the disengagement of the AP by the PF and of the FDs by the PNF on request from the PF. Due to the speed of the sequence and his state of stress, he disabled the AP but did not disable the FDs or ask the PNF to disable them. For this reason, being aware that the FDs were still engaged and the possible consequence on the management of thrust on the ATHR, he decided to revert to *"manual flight"*: he disabled the ATHR and then moved the thrust levers during the various resolution manoeuvres. During A320 type rating by the manufacturer, some of the airline crews developed a practice different from the procedure of the manufacturer and the airline, which consists in disengaging the FDs as soon as the TA occurs, in order not to overload the crew when the RA occurs. According to him, the instructors at that time did not object to that practice.

Being aware of the position of the conflict on his right, he voluntarily made a left turn in order to increase the separation. He saw AF7343 during the turn.

He feared a collision during the incident. After landing, he requested the crew be relieved in coordination with a pilot from the airline who was serving as the duty officer at Basel Mulhouse. The instructor said he did not think about safeguarding the CVR and that it was not suggested by the duty officer.

Without being able to precisely measure their influence, he believed that several factors may have affected his management of the flight path:

- the occurrence of the callout *"monitor vertical speed"* associated with a red zone on the VSI when in fact that RA required no manoeuvre;

- the difficulty in assessing the magnitude of the manoeuvres to be performed on the VSI, given the logarithmic scale;
- his positioning in the right seat when recent TCAS exercises were carried out in the left seat.

1.18.4 Interview with the Trainee Captain, Left Seat PNF during Flight DS1058

The trainee captain indicated that when the TA was triggered, he called out to the PF: *"You have control"*. Among the callouts by the TCAS, he remembers hearing the TA then an advisory *"descend"*, followed by an advisory *"climb."* He did not remember whether the PF requested he disconnect the FDs. He thought that when the first RA occurred (i.e. *"monitor vertical speed"*), the PF made a nose-up input.

He said the sequence of RAs came very quickly. The series of powerful vertical accelerations, including the negative acceleration, made him lose sight of the instruments. He considered he was influenced by the situation and was surprised by various factors such as the reversal of the RA or the left turn made by the PF. In retrospect, he wondered whether he ought to have intervened, in particular to moderate the extent of the manoeuvres.

1.18.5 Interview with the Crew of Flight AF7343

The crew of flight AF7343 considered that the sequence of RAs and TA was extremely dense and fast. The RAs were basically followed by the PF on the basis of the visual indications from the VSI.

2 - ANALYSIS

2.1 Management of the Sequence by the Controllers

The trainee controller and the instructor controller had never controlled using conventional procedures at Basel Mulhouse before the cycle of shifts. After the incident, the trainee controller expressed his uncertainty about how to operate under these conditions. The unusual context and the presence of storm cells made great demands on the resources of these officers during the training session.

The trainee took into account a new incoming aeroplane based on the radar display which had been switched back on by the instructor. With this in mind, he considered requesting DS1058 descend to FL110. Although he had not yet given this instruction, he made an error in speech in clearing the crew of AF7343 to climb to this level thinking he had indicated FL100. He did not take the readback into account. Finally, nearly one minute later, he requested DS1058 descend to FL110.

In these unusual conditions, the instructor controller positioned himself between the trainee controller and the coordinator controller in order to facilitate exchanges between the two positions. In making that move, he no longer fully supervised the trainee controller. He did not hear the descent clearance to FL110 given by the trainee to DS1058. He could not check the consistency of his actions in a continuous manner.

Although they were in a procedural control situation and during a training session, the controllers relied on the unreliable radar display that they had switched on. It should be noted that the controllers could not be certain that the radar image on display was reliable. The local and national safety committees of the DSNA discussed, without coming to any conclusion, the advantages (conflict alerts, map displays, aeroplane position displays), and disadvantages (*"pseudo"* procedural control, unsafe STCAs) involved in this practice. In general, after this incident, the DSNA considered it was necessary to undertake an analysis at the national level on training in procedural control and the related instructions.

The simultaneous use of procedural control and an uncertain radar image increased the workload of the controllers and may have helped create confusion about the positions of the aircraft.

2.2 Safety Study Prior to a Change

The malfunctions of the Basel Mulhouse radar display system which occurred on May 22 and June 26, 2010 were serious: specifically, the slowdown in the radar image on several positions may not have been detected by the controllers. During the incident, the unavailability of the radar display may have contributed to the imprecise management of the sequence at the air traffic control level. The fact that the crew of flight DS1058 was aware of this unavailability may have played a stressful role when the RA was triggered.

These dysfunctions were due to the mismatch of the radar display system with the characteristics of the traffic involved. The latter had increased after the transfer of part of the airspace from the ACC-East to the Basel Mulhouse air traffic control organisation a few months beforehand.

In view of the change, a large-scale safety study was carried out by the DSNA. It started several months before the date set for the transfer and the substantiating documents required for the study provided input for decision-making whether to continue the project. However, from the outset, the scope of the study and the worst-case scenarios were maintained at the operational level by essentially operational entities of ACC-East and the Basel Mulhouse air traffic control organisation. The DTI was included in the study in order to confirm its control of the *"means of reducing the risks"* determined by the operational entities in question and associated with the *"technical causes"* also deduced by these entities. At this stage, no initiative was undertaken as part of the safety study encouraging the DTI to identify other technical causes that might lead to new operational consequences.

Quite apart from the safety study, the DTI was late in identifying the need to replace the CPUs of the radar display system. The replacement therefore had to be quickly organized in order to meet the schedule for the airspace transfer. The associated safety study was therefore carried out in parallel to the actual installation and was not integrated into the overall safety study. The urgency of the situation resulted in a failure to take into account the limitations in terms of representativeness assigned to the tests on the equipment carried out at the factory, and in a lack of coordination with the line agencies to determine the actual procedures for implementing the equipment. In fact, the identification of worst-case scenarios was incomplete, in particular those potentially related to the slowdown of the radar images on several workstations.

Furthermore, time pressure also led to deviations with regulatory requirements, in particular in carrying out the safety study after the installation of new equipment.

The regulatory authority did not mention the changes of CPUs in its analysis. It was not possible to determine whether the DSNA informed CASD about this change before it was effective. The fact that the case was handled at a central level by the CASD may have complicated the settlement of an essentially local problem.

2.3 Vertical Speed on Approaching the Stabilisation Level

The crew of flight AF7343 was cleared to climb to level 110. On passing the 100 level, its vertical speed was greater than 3000 ft/min although DS1058 represented potentially conflicting traffic. Although no TA or RA had yet been triggered, this vertical speed was excessive in relation to Air France procedures and Airbus recommendations which require, in the case of potentially conflicting traffic, to limit vertical speed on approaching the authorised flight level. It may therefore have had an influence on the occurrence of the TA on the one hand, and on the interval between the TA and RA on the other. However, it was not the cause of the reversal of the RA.

Airbus is considering a new altitude capture law in case of conflicting traffic (occurrence of a TA), which could smooth the flight path on approaching the assigned level, thus reducing the vertical speed and reducing the risk of the occurrence of indiscriminate RAs. This automatic limitation is an improvement in safety, the principle of which could be studied by the certification authorities in order to extend it to all the aircraft used in modern public transport.

2.4 Management of the Sequence by the Crew of Flight DS1058

The crew of flight DS1058 was based in Basel Mulhouse. The instructor PF knew the configuration for simultaneous LUMEL departures and BALIR ALTIK arrivals and considered it to be conducive to loss of separation. On the day of the incident, the unavailability of the radar image for controllers as well as the presence of storm cells and the probable need to deviate from conventional flight paths, were known to the PF. In this context, the flight path of AF7343 alerted him. The particular attention he therefore paid to this potential conflict was justified by the occurrence of the TA. Several factors may have increased his stress level:

- the short interval between the TA and the first RA;
- the occurrence of the initial RA, which did not correspond to the resolution of the conflict he had anticipated;
- the inversion of TCAS modes followed by the RA "increase climb" confirming the worsening situation over time.

Note: when the TAs occurred, AF7343 was making an avoidance turn away from a storm cell. The change in the situation subsequent to the turn and the rate of climb greater than 3000 ft/min may have accelerated the occurrence of the first RAs. Furthermore, the interpretation by the PF of DS1058 of the crossing in the vertical plane did not take into account all the characteristics in three dimensions, because it was based on the two-dimensional display of the two aircraft on the ND. He did not have the information about the vertical crossing that the crew of AF7343 had via the RA "maintain vertical speed, crossing maintain". Finally, the reversal of the TCAS advisories can occur as a result of inputs considered to be minimal. When the first RAs occurred, the vertical speed of AF7343 was decreased in accordance with the instruction from the controller (maintain FL100), while on DS1058, it was increased by the nose-up input of the PF. These two tendencies were contrary to the initial resolution logic of the TCAS. Although they were short, they may have played a part in reaching the thresholds at which a reversal became necessary.

Several inputs by the PF suggest a deterioration in his level of performance due to increasing stress and to the pressure associated with the immediate actions he had to perform:

- non-application of the TCAS procedure;
- positioning the sidestick to nose-up for two seconds when disengaging the AP;
- the return to *"manual control"* of the thrust may testify to his acute need to control the situation as much as to his concerns about the FD;
- sharp nose-down and then nose-up inputs and then the left turn away from the position of the conflicting traffic.

Concerning the left turn during the resolution manoeuvre, the PF explained that his intention was to increase the separation margins. He did not realise that making a turn in the same direction would not help to resolve the conflict and, had it been less pronounced, might even have worsened the situation. This manoeuvre by the PF was based on fragmentary signals on the basis of which he constructed a representation of the situation. Moreover, the relative position of the conflicting traffic as presented by the TCAS can not in itself constitute sufficient information to manoeuvre in the

horizontal plane; TCAS is not designed for this purpose. In general the pilot must continue the scheduled flight path in the horizontal plane when the RA occurs. The investigation[15] into the incident on 1 August 2011 to the aeroplanes registered F-GPYO and LX-FUN describes a sequence in which the turn made on the basis of TCAS information decreased the horizontal separation.

[15]http://www.bea.aero/docspa/2011/f-yo110801/pdf/f-yo110801.pdf

The PNF was not included in the manoeuvre due to the immediate cessation of teamwork. The speed and intensity of the inputs did not allow him to reintegrate the process, in particular to monitor the PF inputs.

The PF of flight DS1058 had received the training required to carry out his duties as captain and instructor. He was experienced and competent in terms of the checks he had performed. The incident shows that these criteria do not guarantee a consistently high level of performance, especially when the pilot is subject to stress. In this case, the investigation did not identify all the underlying and detailed causes for the stress he was under. Furthermore, it is likely that simulator-based TCAS training does not reflect realistic operational situations such as those encountered during this event.

The analysis of flight data is based on the use of queries that are not conducive to the detection or in-depth analysis of new risk factors. The analysis of this information remains a challenge for the continuous improvement of systems as well as the operational and organisational procedures. The detection and analysis of various sources of information in which the signals can sometimes be low-level is therefore a possible area of improvement in the overall operation of the SMS.

2.5 TCAS Equipment and Procedures

Given the risk of a mid-air collision, the context in which a TCAS RA occurs is liable to stress crews. The TCAS procedures, for both preventive and corrective RAs, provide for the disengagement of the AP in order to monitor the flight path or manoeuvre in the vertical plane. The sudden change from automatic to manual flight created stress that caused the over-control.

Automating the TCAS resolution, when the AP is engaged, could mitigate exposure to the risk of an inappropriate response (direction and strength in particular). This type of system is offered by one manufacturer, installed as standard on one type of aeroplane and proposed as a retrofit on other types. The situations in which the safety improvement might be maximised, i.e. when both of the conflicting aeroplanes are equipped with the system, are therefore rare.

In addition, the RA *"monitor vertical speed"* of the preventive type, does not require any longitudinal input nor is any target manoeuvre displayed to this effect. Its occurrence in the cockpit of flight DS1058 nevertheless triggered two opposing inputs by the PF. The first, immediate, short and concomitant with the disengagement of the AP, was a nose-up input. It brought the vertical speed into the exclusion zone. Although it is not possible to accurately determine whether the anomaly was detected by the PF, the second input was sharply nose-down. The initiation of the two inputs mentioned in the incident does not appear to result from any interpretation and therefore from any confusion specific to the mode of representing the information in the RA *"monitor vertical speed"*. In his interview, the PF also confirmed that the occurrence of an RA of whatever type may provoke in him a need for a reaction due to the implicit risk of collision and anxiety generated by the aural and visual alarms.

3 - CONCLUSION

The loss of separation that characterized this serious incident was due to an error in speech by the trainee controller, who cleared AF7343 to climb to FL110, a flight level to which he planned to clear the crew of DS1058 to descend and to which he actually cleared them shortly thereafter, and the non-detection of that error by the instructor controller.

The following may have contributed to the error in speech and to the fact it was not detected:

- the safety study and rapid implementation of CPUs that were unserviceable at the time of the serious incident;
- the unusual situation for each of the two controllers, combining conventional control procedures, the use of a radar declared inoperative and weather avoidance requests;
- the contact role undertaken by the instructor controller between the trainee controller and the coordinator controller was not conducive to the supervision of the trainee controller.

It is possible that the vertical speed of AF7343 played a role in the sequence in which the TA and then the RA occurred.

The worsening of the loss of separation, evidenced by the reversal of the TCAS RAs, was due to the conjunction of:

- the tendency to decrease the rate of climb of AF7343 further to an instruction from the trainee controller asking the crew to maintain FL100, given prior to the triggering of the TCAS RA «maintain vertical speed, crossing maintain», inviting the crew on the contrary to maintain a constant rate of climb;
- a brief nose-up input by the PF of flight DS1058 when the AP was disengaged after the TCAS RA «monitor vertical speed» inviting the crew not to climb was issued.

The minor injury to a cabin crew member of flight DS1058 was due to the abrupt manoeuvres by the PF, at the time subject to increasing levels of stress in response to the successive TCAS RAs.

The malfunctions of the radar display system were due to the mismatch between the equipment as it was configured and the traffic liable to be taken into account. Inadequate coordination between the services and the time constraints did not facilitate the detection of this anomaly during the safety studies carried out for changes made prior in the incident.

4 - SAFETY RECOMMENDATIONS

Note: in accordance with the provisions of Article 17.3 of Regulation No. 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation in no case creates a presumption of fault or liability in an accident, serious incident or incident. The recipients of safety recommendations report to the authority in charge of safety investigations that have issued them, on the measures taken or being studied for their implementation, as provided for in Article 18 of the aforementioned regulation.

4.1 Automation of ACAS Resolutions

The investigation showed that despite the updates to ACAS standards, specifications and TCAS systems on the basis of operating experience, some manoeuvres associated with the occurrence of a resolution advisory remain hazardous. These manoeuvres can lead to injuries to occupants when they are sudden, and in some cases even threaten the reliability of this ultimate protection against the risk of mid-air collision.

Consequently, the BEA recommends:

- **that ICAO study the inclusion of resolution automation when autopilot is engaged as an ACAS standard. Such a study should specifically consider the direct and indirect effects of automation on the ability of crew members to remain aware of the situation and fly manually when necessary. [Recommendation FRAN-2013-058]**

4.2 Preventive Resolution Advisories

The triggering of a preventive resolution advisory, although it requires no immediate manoeuvre, leads a pilot to react in an instinctive manner.

Consequently, the BEA recommends:

- **that ICAO study the impact on safety of classifying all resolution advisories (RA) of the preventive type as traffic advisories (TA) only. [Recommendation FRAN-2013-059]**

4.3 Use of Radar Images during Procedural Control

The radar image of the Basel-Mulhouse air navigation service was declared to be unserviceable but it displayed information that was used by the instructor controller to check the actions of the trainee controller. Although procedural control was in effect, the controllers relied on information declared to be unreliable but consistent with the current traffic. There are no instructions from the DSNA on the use of a radar image declared to be unserviceable.

Consequently, the BEA recommends:

- **that the DSNA define a clear instruction on the use of radar imagery when it is uncertain and when procedural control is in use. [Recommendation FRAN-2013-060]**

4.4 Smooth Vertical Flight Path when Approaching a Flight Level

AF7343 was climbing at a rate of more than 3,000 ft/min when it was within 1,000 ft of the authorised flight level, in the presence of converging and conflicting traffic. This high rate may have further shortened the lead-time between triggering the TA and the RA. Airbus is studying the implementation of an automatic system to gradually decrease the vertical speed of an aeroplane as it approaches the altitude or flight level selected by the crew.

Consequently, the BEA recommends:

- **that EASA study setting a standard for aeroplanes' smooth vertical flight paths when approaching a level selected by the crew. [Recommendation FRAN-2013-061]**

APPENDIX

The BEA has taken into account the comments of its Swiss counterpart, the Swiss Accident Investigation Board (SAIB).

Only the following paragraph was not included in full. That is why it is appended to this report.

"In this context, without wishing to go into details that would go beyond the scope of this consultation, we should like to make the following general remarks.

The weight given to issues related to the radar display and inappropriate reactions to TCAS alarms seems high compared with that given to the problem of the failure of the safety system of air traffic control. First, the problem with the radar was already known and had been declared a few days previously; it conditioned the working methods to be applied, namely those of procedural control. Secondly, the overreactions to the TCAS alarms were not the cause but the consequence of what is described in the draft report as an "error in speech" of the trainee controller.

In the specific control configuration at time of the incident, safety was guaranteed first of all by the systematic separation rules of procedural control. Little information is provided in the draft report on this issue, and the use of an unreliable radar display could therefore be interpreted as an integral part of this type of control; it should be recalled that the unreliable radar display actually caused the "error in speech" of the trainee controller. Furthermore, the instructor controller has a safety function in the pair that he forms with the trainee. Information on rules and practices involved in this responsibility and the analysis of their application could better highlight the complexity and requirements of this function and explain the safety error that occurred.

In conclusion, procedural control rules that were apparently poorly defined or improperly followed, the use of the radar display in this context of conventional control and a lack of rigour in the supervision of a trainee controller were in our opinion the primary causes of the incident. Under these conditions, the "error in speech" committed by the trainee controller could not be detected. The technical problem of the radar and inappropriate reactions to the TCAS alarms, both of which are discussed in detail in the draft report, in our opinion mask the main cause of the incident.

Therefore, we do not consider the safety recommendations proposed to be justified within the meaning of their definition in Annex 13 to the Convention on International Civil Aviation (Aircraft Accident and Incident Investigation): first, automating the resolution would certainly prevent hazardous avoidance manoeuvres but would have had no effect on the primary cause of the incident. Secondly, maintaining traffic advisories and preventive resolution advisories as they stand would only shift the problem of inappropriate reactions to RAs, not solve it. Finally, in technical terms, a resolution advisory, even preventive, is different from a traffic advisory because it falls within a smaller range of Traffic Advisory Units (TAU) and indicates a range of vertical speeds to be avoided."

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