Release August 2015
Report revised on 21. August 2015

Report

Accident on **29 March 2013**
at Lyon Saint-Exupéry Airport (France)
to the Airbus A321
registered **SX-BHS**
operated by **Hermes Airlines**
chartered by **Air Méditerranée**

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

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.

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.

This report was revised on 21. August 2015 :

- correction of an error in the note[(2)] on page 10

- Updating and formatting of appendix 9

Table of Contents

Glossary

AAL	Above Aerodrome Level
A/THR	Autothrottle
AFM	Aircraft Flight Manual
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AMC	Acceptable Means of Compliance
AOC	Air Operator's Certificate
AP	Autopilot
APU	Auxiliary Power Unit
ASR	Air Safety Report
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATO	Approved Training Organization
ATPL	Air Transport Pilot's Licence
B/RNAV	Basic area Navigation
BKN	Broken
BSCU	Braking System Control Unit
CAS	Calibrated Air Speed
CPL	Commercial Pilot's Licence
CRM	Cockpit Resource Management
CVR	Cockpit Voice Recorder
D-ATIS	Digital - ATIS
DGAC	Direction Générale de l'Aviation Civile - *French Civil Aviation Authority*
DP	Dew Point
EASA	European Aviation Safety Agency
ETD	Estimated Time of Departure
FAP	Final Approach Point
FCOM	Flight Crew Operating Manual

FCTM	Flight Crew Training Manual
FCU	Flight Control Unit
FD	Flight Director
FDR	Flight Data Recorder
FL	Flight level
FMGS	Flight Management and Guidance System
FMS	Flight Management System
FSO	Flight Safety Officer
ft	Feet
G/S	Glide Slope
GPWS	Ground Proximity Warning System
HCAA	Hellenic Civil Aviation Authority
IAC	Instrument Approach Chart
IAF	Initial Approach Fix
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IR/ME	Instrument Rating/Multi-Engine
JAA	Joint Aviation Authorities
Kg	Kilogram
Kt	Knots
LDA	Landing Distance Available
LOC	Localizer
LVP	Low Visibility Procedure
MGC	Flight Management and Guidance Computer
MMEL	Master Minimum Equipment List
ND	Navigation Display
NM	Nautical Mile
OSD	Operational Suitability Data
PAPI	Precision Approach Path Indicator

PF	Pilot Flying
PFD	Primary Flight Display
PIREP	Pilot Report
PM	Pilot Monitoring
QAR	Quick Access Recorder
QNH	Elevation when on the ground
RFFS	Rescue and Fire-Fighting Service
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minima
SCT	Scattered
SMS	Safety Management System
SOP	Standard Operating Procedure
STAR	Standard Terminal Arrival Route
TCAS	Traffic Collision Avoidance System
TEM	Threat and Error Management
TRE	Type Rating Examiner
TRI	Type Rating Instructor
TRTO	Type Rating Training Organisation
V/S	Vertical Speed
VAPP	Approach Speed
VMC	Visual Meteorological Conditions
VRB	Variable
VREF	Reference Landing Speed

Synopsis

Unstabilised approach, longitudinal runway excursion

Aircraft	Airbus A321 registered SX-BHS
Date and time	29 March 2013 at 19 h 45[1]
Opertor	Hermes Airlines
Place	Lyon Saint-Exupéry Airport (69)
Type of flight	Public transport, International non-scheduled public transport of passengers
Persons on board	Captain (PM); copilot (PF); 5 cabin crew members; 174 passengers
Consequences and damage	Engines damaged

[1]Unless otherwise specified, the times in this report are expressed in Universal Time Coordinated (UTC). One hour should be added to obtain the legal time applicable in Metropolitan France on the day of the event.

Summary

The crew made a Category 1 (CAT I) ILS approach to runway 36R at Lyon Saint-Exupéry Airport. The meteorological conditions were such that low visibility procedures (LVP) were in place.

On passing the stabilisation height at 1,000 ft, the speed of the aeroplane was 57 kt above the approach speed. At 140 ft, an inappropriate increase in thrust by the autothrust maintained the aeroplane at high speed.

The flare was long and the aeroplane touched the runway at 1,600 metres past the 36R threshold. The aeroplane overran the runway and came to rest approximately 300 metres after the opposite threshold.

1 - FACTUAL INFORMATION

1.1 History of the Flight

Note: The history of the flight is based on the data from the flight recorders (FDR and CVR), recordings provided by air traffic services, statements by the flight crew and observations made at the accident site.

On the day of the accident, the crew of the Airbus A321 registered SX-BHS and operated by Hermes Airlines, made a return flight between the airports of Lyon Saint-Exupéry (France) and Dakar (Senegal) as part of a non-scheduled public transport passenger flight chartered by Air Méditerranée.

The crew took off from Lyon at 06 h 44 and landed in Dakar at 12 h 03. The Captain was pilot flying (PF) for this leg. In Dakar, problems with the catering delayed the flight by approximately 30 minutes. The final weight, which was higher than that planned for the flight back to Lyon, forced the crew to make a technical stop in Agadir (Morocco).

The crew took off from Dakar airport at 13 h 44 and landed in Agadir at 16 h 13. The copilot was the PF for this leg. In Agadir, an additional 8.6 tonnes of fuel were loaded.

The crew took off from Agadir at 17 h 02 bound for Lyon with call sign BIE 7817. The copilot was PF. The flight started normally.

At approximately 19 h 19, the aeroplane was descending towards FL280. Autopilot 2 (AP2), the flight directors (FD) and the autothrust (A/THR) were engaged. The crew prepared an arrival for runway 36R at Lyon Saint-Exupéry.

The PF listened to the ATIS Alpha broadcast information (recorded at 19 h 12), which provided the following specific information:

"Approach ILS 36R
Runway in use landing 36R
Runway is wet
Caution wind at 1500 feet reported 180° 15 Kts
Wind 140° 3 Kts
Visibility 400 meters
RVR's are above 2 000 meters
Slight rain and Fog
SCT 2000 correction 200 feet, BKN1800', BKN 6600'
T° + 8°
DP + 8°
QNH1004"

Between 19 h 20 min and 19 h 28 min, the crew conducted the approach briefing. The PF mentioned 400 metres visibility, two kilometres visibility on the runway extended centre line (RVR), as well as the presence of fog and a broken ceiling at 1,800 ft. The PF called out the wind at FL180 from 150° for 18 kts: *"flight level one eight zero, (it's gonna) be windy so one... one five zero eighteen knots"*.

He expressed doubt on the possibility of making a Category 1 (CAT I) approach, considering the low visibility. The PM replied that only the RVR had to be taken into consideration.

The crew conducted the briefing for the CAT I ILS approach to runway 36R after arriving via standard arrival MEZIN 1 D. The PF did not indicate whether he was going to make an ILS approach to runway 36R using procedure Y or Z, but mentioned an altitude of 4,000 ft[2]. The crew indicated that they were setting the decision altitude to 1,021 ft QNH (200 ft AGL) in the navigation system (FMS). Landing configuration *"CONF FULL"* was selected. The autobrake system was armed in LOW mode. The approach speed (Vapp) was 141 kt for a landing weight of 72 tonnes.

[2]The Final Approach Point (FAP) of the ILS 36R Y approach procedure is 10 NM from the threshold of runway 36R, and at 4,000 ft QNH
The FAP of the ILS 36R Z approach procedure is 6.9 NM from the threshold of runway 36R, and at 3,000 ft QNH

At 19 h 29 min, after clearance from the controllers of Marseille en-route control centre, the crew started descending towards FL140.

The vertical *"OPEN DES"* mode was engaged on the autopilot. The aeroplane was flying at a selected speed of 280 kt. A few minutes later, the PF selected a calibrated airspeed (CAS) of 250 kt.

At 19 h 35 min, on the Lyon approach frequency, the crew announced that it was descending towards FL140 using the ATIS Alpha broadcast information. The controller gave them clearance to descend to FL100, informing them that they were going to be radar-vectored towards the final ILS approach to 36R. He also informed them that ATIS Bravo was available. He added that the Low Visibility Procedure (LVP) was in force due to the presence of clouds.

At 19 h 36 min, the crew listened to ATIS broadcast information. This ATIS was ATIS Charlie, recorded at 19 h 35, which provided the following specific information:

- *"Approach ILS 36R*
  Runway in use landing 36R
  Runway is wet
  Caution wind at 1500 feet is reported southerly 15 Kts
  Low visibility procedures in force
  Wind 140° 4 Kts
  Visibility 1 100 meters
  Slight rain and mist
  BKN100', BKN 6600'
  T° + 8°
  DP + 8°
  QNH1004"

The PM wondered whether the LVP procedure should be in force despite visibility being 1,100 m: *"Why we have low visibility in force? With one thousand one hundred meters. So… we cannot go there"*.

At 19 h 37 min 48, the PM said *"We will down on the way to the ILS so descend as fast as possible"*. The PF replied that this is what he was doing.

At 19 h 38 min 02, the crew contacted the Lyon radar controller, who gave them a heading to intercept the localizer of runway 36R. The PM said *"intercept the localizer, four thousand checked, we have to be prepared"*.

At 19 h 38 min 44, the PM requested clearance to deviate 10° to the left to avoid a cloud. The controller gave clearance to deviate, and to descend to 5,000 ft QNH 1004. The PM correctly read back the QNH value.

At 19 h 39 min 12, the Lyon radar controller informed the crew of the application of the LVP procedure, and of the presence of broken clouds at 100 ft with a RVR greater than 2,000 metres.

At 19 h 39 min 29, the PM called out to the PF a QNH value of 1014. The crew selected this altimeter setting and the approach checklist was completed.

Note: Due to the erroneous altimeter setting (QNH 1014 instead of QNH 1004), the altitudes indicated are 300 ft above the QNH altitude on that day. In the following paragraphs, the altitudes indicated are QNH 1004 altitudes.

At 19 h 40 min 09, the aeroplane was flying at 230 kt (CAS) at an altitude of 8,500 ft QNH. The PM asked the Lyon radar controller whether they were allowed to intercept the localizer with the heading they were following. The controller replied *"That's approved, reduce speed 220 kt"*, and added *"descend 4,000 ft and you are cleared ILS 36R, leave 4,000 ft on the glide"*. The PM replied *"Ok, 4,000 ft, clear for the ILS and (leave them) on the glide"*.

At 19 h 40 min 35, AP1 was engaged.

At 19 h 40 min 59, the PF activated the approach phase. The PM drew his attention to the fact that he could use the flaps.

At 19 h 41 min 08, the PM selected configuration 1. The aeroplane descended through 7,570 ft QNH at a speed of 220 kt. The PM pointed out to the PF that this increased the rate of descent.

At 19 h 41 min 18, the PF suggested reducing the speed. The PM answered in the negative, saying that they needed a high rate of descent. He added: *"And now you can use speed brakes because now the ILS go lower because you have flaps"*.

At 19 h 42 min 27, 12.5 NM from the runway threshold, the aeroplane intercepted the localizer beam at 5,500 ft QNH at a speed of 217 kt. The Lyon radar controller cleared the crew to continue the descent towards 3,000 ft QNH and asked them to call back when they intercepted the *"glide"*. The PF selected an altitude of 3,000 ft QNH. 10 NM from the threshold of 36R, the aeroplane[3] was at 222 kt, and its ground speed was 251 kt.

At 19 h 42 min 43, the PM told the PF that the descent rate was good and that once established on the *"glide"* he would have to reduce the speed. The descent rate was about 2,000 ft/min and the speed was 218 kt.

At 19 h 43 min 02, the PM asked the PF to keep the airbrakes and to try to reduce the speed. The PF selected a speed of 207 kt then 205 kt a few seconds later. He told the PM that he was selecting 205 kt.

At 19 h 43 min 16, at about 9 NM from the runway threshold, the aeroplane intercepted the glide beam at 3,820 ft QNH with a speed of 217 kt and a descent rate of about 1 500 ft/min.

At 19 h 43 min 37, the PM told the Lyon radar controller that they were established on the glide. The controller asked them to contact the Lyon tower controller.

At 19 h 43 min 47, the aeroplane was 7 Nm from the runway. It was approximately at this distance that the crew indicated that they had the installations in sight.

[3]The aeroplane preceding SX-BHS was an A319 (Air France flight AF-DD). At 19 h 39 min, it was 10 NM from the threshold of 36R, lined up on the localizer at 4,100 ft with a ground speed of 250 kt. At that moment the QAR recording indicates a speed of 220 kt. At 19 h 39 min 36, the controller informed the Air France crew in French that he saw them as being a bit fast on his radar and asked them if they wanted to perform a missed approach. The crew of AF-DD told him they were going to extend the landing gear and that they planned to land. Further details are available in the Air traffic services document chapter 1.16.1.

At 19 h 43 min 53, the aeroplane was at 2,000 ft AAL and reached the selected target speed (205 kt). The PF requested the PM to select *"CONF 2"* as soon as possible. The PM, who was in contact with the Lyon tower controller, retracted the airbrakes, and selected *"CONF 2"* as the aeroplane passed 1,550 ft AAL at 203 kt.

At 19 h 44 min 15, the Lyon tower controller cleared the crew to land on runway 36R, and gave them the wind information (130° at 6 kt).

At 19 h 44 min 20, the PF selected a speed of 180 kt. The speed of the aeroplane was 204 kt.

At 19 h 44 min 28, the PF asked for the extension of the landing gear in order to reduce the speed.

At 19 h 44 min 50, the PM called out: *"You cannot reduce the speed, look"*. The speed was 199 kt.

On passing through 1,000 ft AAL, the speed was 57 kt above the Vapp (198 kt / 141 kt), and the selected speed was 180 kt. The aeroplane was established on the glide path, in *"CONF 2"*, with the landing gear extended and locked. The pitch attitude was -1°; the rate of descent was about -1,100 ft/min.

At the PM's request, the PF engaged managed speed mode at a radio altitude of 950 ft. The target speed automatically went to 153 kt (speed F on the speed tape on the PFD).

At a radio altitude of 850 ft and 193 kt, the crew selected configuration 3 and, a few seconds later, FULL configuration at 184 kt and a radio altitude of 625 ft. The target speed automatically changed to the Vapp (141 kt).

On passing through 500 ft AAL, the speed decreased to 179 kt (Vapp + 38 kt), and the pitch attitude was -4°.The vertical speed was greater than -1,100 ft/min.

The PF disengaged the autopilot at a radio altitude of 200 ft.

The aeroplane passed through radio altitude 140 ft with a pitch attitude close to 0°. The A/THR was still engaged and the N1 rotation speed of the engines, which were at idle (30%), started to increase.

On passing through radio altitude 80 ft, the N1 was 54%. The speed was 158 kt and started to increase.

On passing through radio altitude 60 ft, the aeroplane flew over the runway threshold with a tailwind component of 7 kt. The speed (CAS) was 160 kt.

The crew indicated that, on crossing the threshold, they noticed a localised fog patch on the opposite threshold.

About three seconds after passing through radio altitude 30 ft, the PF started to move the thrust levers towards the IDLE detent.

The PF maintained a low amplitude nose-up input (approximately ¼ pitch up) until the aeroplane reached a radio altitude of 23 ft. The pitch attitude increased from -1.4° to +1.7°. The rate of descent was approximately -600 ft/min. Then, the PF alternated nose-up and nose-down inputs, and the pitch attitude stabilised at approximately 0°.

At 500 metres beyond the threshold, the aeroplane was at altitude height of 21 ft above the runway. The PM called out that they were too high. N1 reached 69%.

The aeroplane descended below 20 ft and the synthetic voice called out *"RETARD"*[(4)].

One second later, the crew placed the thrust levers in the IDLE position and the A/THR disengaged. The speed was 163 kt and started to decrease. The PM started to apply nose-down inputs whereas the PF applied nose-up inputs.

The PM called out *"Leave it"* several times and applied a succession of harder nose-down inputs (1/2 pitch down) until touchdown. Meanwhile, the PF maintained a hard nose-up input (1/2 pitch up on average). The resulting input was nose up. During this phase, the synthetic voice called out *"DUAL INPUT"*.

At 19 h 46 min 03, the main landing gear touched the runway approximately 1,600 metres from the runway threshold. The ground speed of the aeroplane was 154 kt.

One second later, the spoilers were automatically deployed and the crew commanded maximum reverse thrust.

The crew applied energetic and asymmetric braking. The autobrake disengaged. Three seconds later, the deceleration of the aeroplane reached 0.4 g[(5)].

The aeroplane overran the runway at a ground speed of approximately 75 kt and came to rest approximately 300 metres from the threshold close to the ILS antennae area.

The crew informed the controller that the aeroplane was off the runway and that nobody was injured.

At 19 h 48 min 14, about two minutes after the aeroplane came to a standstill, the controller asked the crew whether they had shut down the engines.

At 19 h 48 min 30 the crew started the APU and then shut down the engines.

From 19 h 51 onwards, the Captain discussed the passenger evacuation the controller, and said : *"We can stay on board, we can... can wait because actually without... we don't have any problems with fire or something like that"*.

At 19 h 52 min 28, the Captain called the controller to ask him: *"Could you check the fire service any...any fire or something like that, because we can't see anything, to confirm"*.

At 19 h 52 min 47, the controller informed the crew that the fire service had not detected any problems visually.

(4)Voice message reminding the pilot that he must return the thrust levers into the "*IDLE*" position.

(5)In comparison, the deceleration target of the AUTOBRAKE in LOW mode is 0.17 g.

1.2 Injuries to Persons

	Injuries		
	Fatal	**Serious**	**Light/None**
Crew	-	-	7
Passengers	-	-	174
Other persons	-	-	-

1.3 Damage to the Aircraft

Both engines on the aeroplane were damaged. The landing gears were slightly damaged.

1.4 Other Damage

Protection barriers set up along the taxiways were damaged when the aeroplane overran the runway.

1.5 Personnel Information

1.5.1 Flight Crew

1.5.1.1 Captain

Male, 44 years old, of Greek nationality.

- Airline Transport Pilot License ATPL(A) issued by Greece on 17 July 2007;
- Captain since 25 July 2012;
- B737 100-200 type rating issued in 1996;
- B737 300-400 type rating issued on 11 October 2000;
- A320 type rating issued on 5 January 2010, extended every year;
- Rating for Cat I precision approaches issued on 25 January 2008;
- Crew Resource Management (CRM) instructor/examiner since 3 November 2008;
- Ground training instructor since 2005;
- Class 1 medical certificate valid until 29 August 2013;
- He had obtained an "ICAO level 5" grade in the English language.

Note: Hermes Airlines crews do not have permission to make Cat II/III precision approaches.

Experience:

- Total: 7,096 flying hours including 425 as Captain;
- On type: 1,346 flying hours including 425 as Captain;
- In the previous three months: 139 flying hours;
- In the previous month: 68 flying hours;
- In the previous 24 hours: 7 hours 50 minutes.

Professional Experience:

- He was a cadet in the Hellenic Air Force Academy in Greece from 1986 to 1989;
- He obtained his Commercial Pilot's Licence in 1990 from the Pegasus Flight School of Aeronautics in the United States;
- He worked as copilot (First Officer or copilot) for Olympic Airlines from 1996 to 2009.He had a total of 5,150 flying hours on Boeing 737 2/3/400;
- He worked as copilot for Olympic Air from 2009 to 2010. He had a total of 520 flying hours on Airbus A320;
- He was hired by Hermes Airlines on 24 October 2011 as a CRM instructor, then as First Officer.

Qualifications, recurrent training and checks as Captain:

He undertook the operator's conversion course as copilot from 27 October 2011 to 31 January 2012 (flight check). During the training and subsequent assessments, the Captain's professional level was qualified as *"good"*.

Selection, followed by specific training in the responsibilities of a Captain, was carried out from February to July 2012. During the training and subsequent assessments, the Captain's professional level was qualified as above standard *"very good"*, in particular during his 10-leg line flying under supervision that took place between 19 July 2012 and 24 July 2012. The Captain passed his line check on 24 July 2012 and was appointed Captain.

The last Operator Proficiency Check (OPC) performed on 16 January 2013 was found to be satisfactory.

The Captain was declared *"fit for duty"* during all of his recurrent training courses and checks.

Activities during the preceding days :

Between Friday, 22 March 2013 and Wednesday, 27 March 2013, the Captain was off duty at his home in Athens (Greece). He explained that he did not perform any special activities and that he felt rested and in good shape.

On Thursday, 28 March 2013, on the day before the accident, the Captain left Athens for Lyon via Paris Charles De Gaulle as part of two positioning flights. He left Athens at 7 h 00 and landed in Lyon at 13 h 30. He explained that he arrived at his hotel at around 14 h. He added that he went to bed at around 21 h 00. On 29 March, the day of the accident, he got up at around 4 h 00 and reported to the airport at around 5 h 00.

1.5.1.2 Co-pilot

Male, 26 years old, of Spanish nationality, resident in Spain.

- ATPL theory in 2009;
- Commercial Pilot's License CPL (A) issued by Spain on 8 October 2009, valid until 8 October 2014;
- A320 type rating issued on 31 May 2011, extended every year;
- Appointed copilot in September 2012;
- Class 1 medical certificate valid until 13 July 2013.

Experience:

- Total: 600 flying hours, of which 314 hours on type;
- In the previous three months: 55 flying hours, all on type;
- In the previous month: 45 flying hours, all on type;
- In the previous 24 hours: 7 hours 50 minutes.

Professional Experience:

- From 2005 to 2009, he attended a commercial pilot training course at the European University College of Aviation in Reus (Spain);
- He obtained his A320 type rating in 2011 at the Flight Crew Training Academy in Madrid (Spain);
- He had obtained an *"ICAO level 4"* grade in the English language with the organisation called *"Air-English*[6]*"* in 2011;
- He was hired by Hermes Airlines on 27 October 2011 as a copilot.

Recruitment, qualifications, recurrent training and inspections:

Recruitment:

When he was hired by Hermes Airlines, the copilot had a total of 202 flying hours on Piper Pa 28 and Diamond 40/42 (single-engine and twin-engine piston aircraft).

He attended an interview with the Director of Flight Operations (DFO) and the Head of Training at Hermes Airlines, followed by medical tests and a two-hour flight simulator assessment in Istanbul (Turkey) with a Type Rating Examiner (TRE).

Training at Hermes Airlines:

He carried out the operator's conversion course from 27 October 2011 to 2 September 2012.

From 27 October 2011 to 21 November 2011, he followed ground training courses[7].

On 7 and 8 November 2011, he completed two four-hour flight simulator training and control sessions in Istanbul with a Type Rating Instructor (TRI). The instructor found his level as a copilot to be in accordance with the operator's standards, with the exception of technical knowledge, knowledge of standard operating procedures (SOP), and airmanship skills, qualified as marginal.

He began his line flying under supervision on 25 February 2012, completing three legs. On 26 February he completed three legs as an observer, since the TRI considered that he had difficulties in understanding radio-telecommunications in English. The TRI advised him to continue his line flying under supervision with a *"safety pilot"*[8]until he could understand better. His line flying under supervision was suspended from 26 February to 30 July 2012.

The copilot indicated that he did not follow any training courses or exercises during this time period, with the exception of one flight simulator session in order to extend his A320 type rating in May 2012 in London (TRTO). The DFO and Head of Training explained that the copilot's line flying under supervision was suspended due to an insufficient number of flights that the operator had to make between February and July 2012.

On 30 July 2012, the copilot resumed his line flying under supervision with a *"safety pilot"* for the first three legs. He flew with three different TRI and completed 34 additional legs until 1 September 2012.

The copilot's line flying under supervision assessment file describes normal progress. However, one of the TRI with whom the copilot completed 7 legs in the middle of his training (14 to 19 August 2012) considered that his knowledge of aircraft systems and procedures was poor.

[6]Air-English is a Language Proficiency Organisation (LPO) approved by the Belgian Civil Aviation Authority (BCAA). The language proficiency test (FCL.055) included a comprehension questionnaire and an oral interview with an examiner.

[7]The ground training schedule is detailed in section 1.17.1.3 – Recruitment, qualifications, recurrent training and inspections.

[8]The operations manual of Hermes Airlines defines a *"safety pilot"* as an additional pilot (with more than 100 flying hours on type) required to fly with the trainee in line flying under supervision.

After 30 July 2012, he performed 37 legs and approximately 111 flying hours on Airbus, copilot passed his line check on 1 September 2012 and was appointed copilot. He began line flights as copilot on 2 September 2012.

Activities during the preceding days:

The copilot made a flight from Paris Charles de Gaulle (France) to Ovda (Israel) on 24 March 2013. The flight was carried out with an augmented flight crew.

The copilot explained that he left Valencia (Spain) on 28 March 2013 at 06 h 05 for Paris Charles de Gaulle, from where he flew to Lyon. He arrived at his hotel in Lyon at around 14 h. He added that he went to bed at around 21 h 00. On 29 March, the day of the accident, he got up at around 4 h 00 and reported to the airport at around 5 h 00.

1.5.2 Air Traffic Control Services Personnel Information

Manning in the IFR room and the control tower cab on 29 March 2013 at the time of first contact with BIE7817 was:

In the IFR room:

- INI and DEP sectors were grouped together with: a First Controller, one student and a First Assistant Controller;
- ITM sector (intermediate) open with a First Controller.

In the control tower:

A Tower Chief assisted by:

- A First approach Controller;
- A First Controller coordinator (approach and local);
- A First local Controller (Tower);
- A First ground Controller.

Manning in the IFR room and the control tower was in accordance with the Lyon ANS operations manual.

The controller of the INI sector had transferred SX-BHS to the ITM controller for the intermediate approach, who in turn transferred SX-BHS to the local controller during final and landing.

1.6 Aircraft Information

SX-BHS was manufactured in 1997. Its maximum take-off weight is 85,000 kg, and its maximum landing weight is 74,500 kg. It has a payload capacity of 220 passengers. It has two SNECMA CFM56-5B engines.

1.6.1 Airframe

Manufacturer	Airbus
Type	A321-111
Serial number	642
Registration	SX-BHS
Entry into service	17/01/1997
Certificate of airworthiness	No. 1514 dated 31/01/2012 issued by HCAA
Airworthiness examination certificate	028/012 valid until 05/10/2013
Use as of 29/03/2013	37,757 flying hours and 22,420 cycles

1.6.2 Engines

Manufacturer: SNECMA
Type: CFM56-5B 1/3

	Engine No. 1	Engine No. 2
Serial number	779226	779317
Total running time	37,199 hours and 20,803 cycles	34,139 hours and 20,587 cycles
Run time since overhaul	9,981 hours and 3,127 cycles	9,430 hours and 5,117 cycles

1.6.3 Weight and balance

When the event occurred, the weight and balance were within the limits set by the manufacturer. The weight recorded by the flight recorder (FDR) on landing was slightly less than 72,000 kg.

1.6.4 Maintenance

The maintenance manual, approved by the Greek Civil Aviation Authority (HCAA), details the maintenance programme. It complies with the manufacturer manuals.

The documentation indicates that the inspections recommended by the manufacturer and those required by airworthiness directives had been performed.

1.6.5 Airbus A321 systems and procedures

The systems and procedures below are extracted from the manufacturer's documentation (AFM, FCOM, FCTM) and from that of the operator. Details are included in ***appendix I***.

1.6.5.1 Normal procedures during an ILS precision approach

During an ILS precision approach, the objective is to stabilise the aircraft on the final glide path at the approach speed (Vapp), in the landing configuration and at 1,000 ft AGL (in IMC conditions). All the conditions below must be met before or at the stabilisation altitude:

❒ the aeroplane is on the nominal descending flight path (Glide Slope and Localizer);
❒ the aeroplane is in landing configuration;
❒ the thrust is stabilised and maintains the approach speed.

There is no excessive deviation from the following flight parameters:

❒ speed between Vapp -5 kt and Vapp +10 kt;
❒ pitch attitude between -2.5° and +7.5°;
❒ roll angle lower than 7°;
❒ vertical speed lower than 1,000 ft/min;
❒ LOC deviation lower than ¼ point;
❒ GS deviation lower than 1 point.

If the aeroplane is no longer under these conditions, the crew must initiate a missed approach, unless they consider that the deviations are negligible and can be corrected by applying minor inputs.

1.6.5.2 Managing speed in selected mode or managed mode during an approach

In Approach mode with the A/THR engaged, speed is managed by selecting a target speed that will be maintained by automatic adjustments of the engine thrust. The target speed can be:

❒ "managed" when the target is calculated by an on-board system (FMGS);
❒ "selected" when the target is manually selected by the crew on the Flight Control Unit (FCU).

For a landing that the crew plan to be in *"conf FULL"*, with a *"selected"* target speed, the manufacturer recommends manually displaying the S speed in approach configuration 1 (*"conf 1"*), then the F speed in *"conf 2"* and *"conf 3"* and, finally, the Vapp in landing configuration (or *"FULL conf"*).

In some circumstances (strong tailwind or significant weight), the deceleration rate may be insufficient. In this case, the manufacturer recommends extending the landing gear at less than 220 kt, and before selecting *"CONF 2 "*.

During a precision approach, the manufacturer recommends using the managed mode for speed management. The speed will then be managed by the ATH/R once the Approach mode is engaged.

1.6.5.3 Flare

The manufacturer indicates that in stabilised approach conditions, at an altitude of approximately 30 ft, the pilot must begin the flare and place the thrust levers in the *"IDLE"* position. The pilot must not let the aeroplane float, nor attempt to extend the flare by increasing the pitch attitude to make a soft landing.

The manufacturer recommends beginning the flare with a nose-up input on the sidestick, and maintaining it for as long as necessary. The manufacturer advises against nose-down inputs once the flare has begun. If a normal touchdown point cannot be reached, or if the aeroplane becomes unstable before the flare has begun, the crew must reject the landing.

The *"RETARD"* callout triggers at a radio altitude of 20 ft. It must be considered as a reminder rather than a trigger.

1.6.5.4 Rejecting the approach below the minima - Rejecting the landing

On the date of the accident, there was no *"Rejected Landing"* procedure in the operational procedures manual published by the manufacturer (FCOM). A *"Rejected Landing"* section was included in the training document (FCTM), stating that the crew could reject the landing at any time, provided the thrust reversers were not deployed.

Hermes Airlines had included in its Line Proficiency Check (LPC) a scenario with a go-around at 50 ft.

SECTION 4 4 Missed Approach Procedures	OTD	FTD	FS	A/C	Instructor's initials when training completed (Initial Type Rating only)	Checked in FS A/C	Passed	Failed
4.1 Go-around with all engines operating* after an ILS approach on reaching decision height			P*⇒	⇒			☑	☐
4.2 Other missed approach procedures			P*⇒	⇒			☑	☐
4.3* Manually go-around with the critical engine simulated inoperative after an instrument approach on reaching DH, MDH or MAPt			P*⇒	⇒		M	☑	☐
4.4 Rejected landing at 15m (50 ft) above runway threshold and go-around			P⇒	⇒			☑	☐

Extract from the Hermes Airlines LPC form

The Captain had performed this exercise once during his line checks in 2011 as a co-pilot. He did not perform it during his LPC during his training as a Captain. The co-pilot had performed it once in 2011.

1.6.5.5 Description of the operation of sidesticks, associated procedure and training

The two sidesticks are used for manual control of the aircraft in pitch and roll. Each sidestick has, among other things, a push button used to disconnect the autopilot and/or take precedence over the other sidestick.

When a pilot makes an input on the sidestick, her/his inputs are sent to the flight control computers. When both pilots make inputs on their sidestick, whether in the same or in opposite directions, the inputs are algebraically added and sent to the computers[9].

[9]The sum is limited to the equivalent of a full nose-up input applied on the sidestick of a single pilot.

Dual input is detected when deflections of more than 2° are applied on each of the two sidesticks for a time period called the confirmation time. The two lights *"SIDE STICK PRIORITY"* light up green and the voice message *"DUAL INPUT"* is called out. There may be a two-second period between the detection of the simultaneous deflections of more than 2° and the *"DUAL INPUT"* callout. This is due to the confirmation time, to the calculation cycles in the computer processors and the transmission between computers.

1.6.5.6 Automatic altitude callout

Depending on the configuration of the aeroplane systems, an automatic callout system may include altitude/minimum callouts to assist the crew. The synthetic voice may call out at 1,000/500 ft, as well as *"MINIMUM"*.

On SX-BHS, this option was available but disabled.

1.6.5.7 Emergency evacuation procedure

The *"EMERGENCY EVACUATION"* procedure is an emergency procedure described in the manufacturer's and operator's FCOM, FCTM and QRH.

This procedure is performed in two stages. The first phase does not formally instruct the crew to evacuate the aeroplane. It describes the first measures required to secure the aircraft (in particular shutting down the engines and the APU), as well as the information to provide to cabin crew and controllers. The second phase describes the procedure to follow once the crew has decided to evacuate, or not, the aeroplane.

1.7 Meteorological Information

1.7.1 Overall situation

The fairly rapid westerly flow produced rain and low clouds over the Lyon region. On the ground, winds were light and variable in direction.

1.7.2 Conditions observed at the site at the time of the event

- 1st layer: Partially cloudy with stratus cloud, with its base approximately 50 m/ ground;
- 2nd layer: Very cloudy with stratocumulus cloud at approximately 2,000 m;
- visibility on runway 36R: RVR 2,550 m; RVR 18: 1,590 m; RVR in middle of runway: 1,480 m;
- temperature: 8°C, Humidity: 99%, Wind: 130° / 06 kt, spot wind of up to 12 kt.

1.7.3 METARs and ATIS

LFLL 291930Z VRB03KT 1100 R36L/1700D R18R/2000N R36R/1800D R18L/P2000 - RA BR BKN001BKN066 08/08 Q1004 NOSIG=

LFLL 292000Z 13006KT 090V180 2000 BR FEW002 SCT009 BKN066 08/08 Q1004 NOSIG=

OBSMET 29/03/2013 19:40
LL V1200M 1000M S FBL RA VCFG H1BKN 100FT H2BKN 6600FT

19 h12 UTC - ATIS A	19 h 29 UTC - ATIS B	19 h 35 UTC - ATIS C
ILS approach to runway 36R Runway in use landing 36R Runway in use take off 36L Standard departure 4N, E, R Runway is wet NT60 **Caution wind at 1500 feet reported 180° 15 Kt** **Wind 140° 3 Kt** **Visibility 400 meters** **RVR's are above 2000 meters** Slight rain and Fog SCT 2000 correction 200 feet, **BKN 1800', BKN 6600'** T° + 8° DP + 8° QNH1004 QFE are available on ground frequency	ILS approach to runway 36R Runway in use landing 36R Runway in use take off 36L Standard departure 4N, E, R Runway is wet NT60 **Wind at 1500 feet is south 15 Kt** **Low visibility in force** **Wind 140° 3 Kt** **Visibility 1100 meters** **RVR's are above 2000 meters** Slight rain and mist **BKN 100', BKN 6600'** T° + 8° DP + 8° QNH1004	ILS approach to runway 36R Runway in use landing 36R Runway in use take off 36L Standard departure 4N, E, R Runway is wet NT60 **Wind at 1500 feet reported southerly 15 Kt** **Low visibility procedures in force** **Wind 140° 4 Kt** **Visibility 1100 meters** **RVR's are above 2000 meters** Slight rain and mist **BKN 100', BKN 6600'** T° + 8° DP + 8° QNH1004 QFE are available on ground frequency

Note: The meteorological conditions in IFR flight are defined by the meteorological conditions, expressed in relation to visibility and distance to clouds and ceiling being below the minimums specified for VFR flight. In VMC, visibility in flight below 10,000 ft AMSL must be higher than or equal to 5 km. On the day of the event, the ATIS messages stated that the visibility had changed from 400 m at 1,100 ft in the 20 minutes before the accident. IMC conditions were in place.

D-ATIS

Some airports broadcast ATIS via datalink (D-ATIS or Digital-ATIS). A D-ATIS message repeats voice-transmitted information in English only. A D-ATIS message is transmitted according to the air/ground communications protocol ACARS (Aircraft Communication Addressing and Reporting System).

1.7.4 Winds during approach

The ATIS mentioned a reported southerly wind of 15 kt at 1,500 ft. The wind during the approach was calculated based on the FDR data:

QNH altitude (ft)	Winds (kt)	Direction (°)
4 000	22	200
3 000	24	200
2200	32	200
1400	24	200
1200	18	200
200	12	150

1.8 Aids to Navigation

Lyon Saint-Exupéry Airport has radio navigation facilities. They were operational on the day of the event. Runways 36R and 36L are the only ones equipped for Cat III precision approaches. The crew was following standard arrival route (STAR) MEZIN 1D (IAF ARBON).

1.9 Telecommunications

The transcript of radio communications between the Lyon Saint-Exupéry controller and the crew of SX-BHS is in ***appendix 2***.

1.10 Airport Information

Lyon Saint-Exupéry airport is located in the Rhone valley at an altitude of 821 ft. It is open to public air traffic and has two parallel runways 18L/ 36R and 18R/36L.

In normal conditions of use, runway 18L/36R, which is 2,670 metres long (2,670 metres of LDA), is used for landings. Runway 18R/36L, which is 4,000 metres long, is used for take-offs.

Only the QFU 36R is cleared for LVP on landing.

Runway 18L/36R is equipped with an ILS on 36R. It has runway centre line lights with beaconing lights. The lights were operative at the time of the accident and in high-intensity mode.

The threshold and identification markings of runway 36R meet the regulatory requirements of the modified *"CHEA"* decree of 28 August 2003 relating to conditions for approval and to airport operation procedures.

The purpose of measuring the friction of a runway is to determine its intrinsic characteristics and to compare them with the regulatory standards. Airport operators are required to make these measurements every 2 years. The measurements were made in December 2012. The results met the standards required.

Lyon Saint-Exupéry Airport does not have the D-ATIS system.

1.11 Flight Recorders

1.11.1 General

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

Flight Data Recorder (FDR):

- manufacturer: Honeywell;
- model: 4700;
- type number: 980-4700-042;
- serial number: S/N: 09779.

It was a static recorder (SSFDR) with a recording capacity of at least 25 hours.

Cockpit Voice Recorder (CVR):

- manufacturer: L3-COM;
- model: A200S;
- type number: S200-0012-00;
- serial number: 01655.

This recorder has a recording capacity of at least 2 hours in standard quality and 30 minutes in high quality.

The aeroplane also had a non-regulatory flight data recorder called a Data Access Recorder (DAR). The flight data of the event could not be recovered by unloading the DAR memories. The origin of the problem could not be determined.

1.11.2 Readout of Data from Flight Recorders

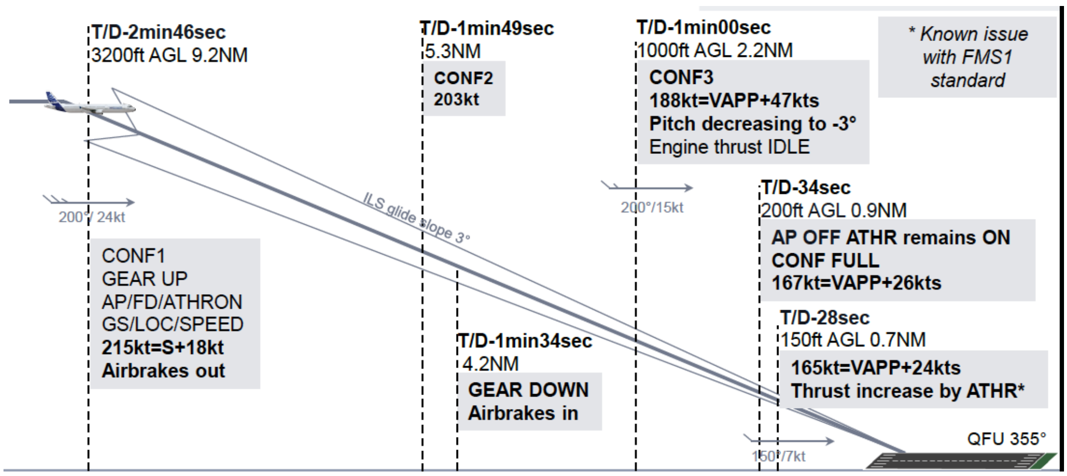
The CVR and FDR were synchronised using the autopilot disengagement warning.

1.11.2.1 Flight history and FDR graphs

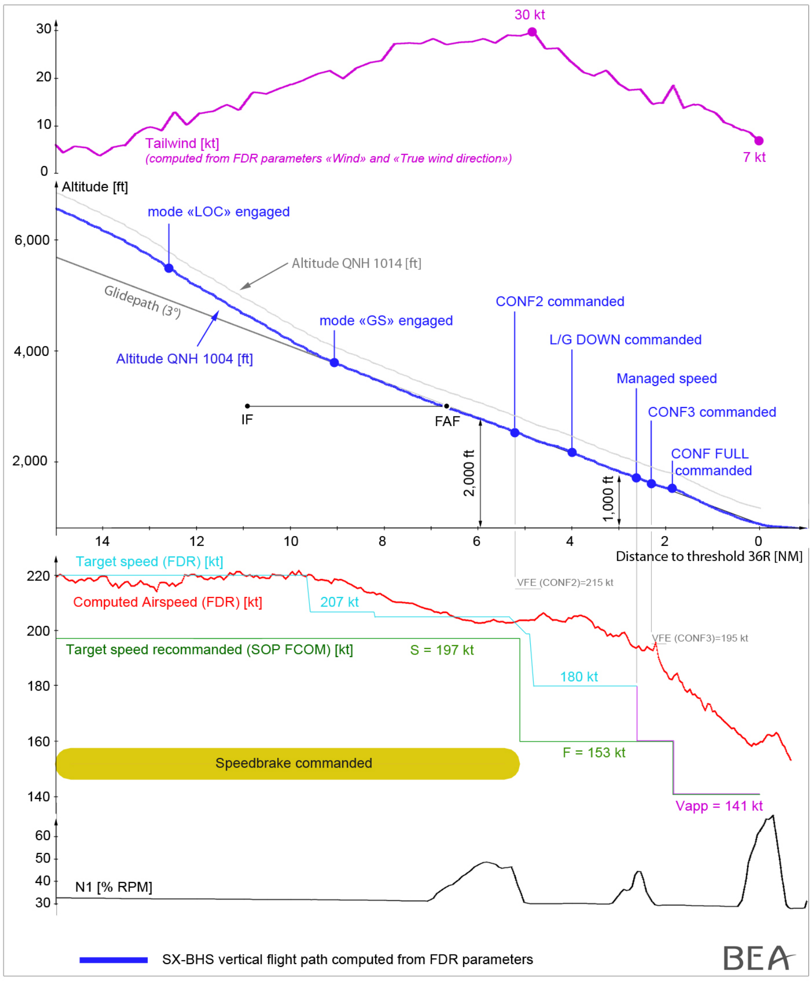
The history of the flight based on the parameters recorded on the FDR is in section *1.1 - History of the Flight*. The graphs for the event are provided in **appendix 3**.

1.11.2.2 Intermediate and final approach

The descent profile of the aeroplane and the changes in speed and aircraft configuration are shown in the following illustrations:



Source: Airbus



Aeroplane descent profile based on FDR data

The altitude recorded by the FDR is the pressure altitude in a standard atmosphere (QNH 1013).It was corrected to take into account the applicable barometric setting at the time of the approach (QNH 1004). The altitude with the wrong QNH (1014) was also plotted in order to show the altitude indicated to the crew.

In the conditions on the day of the event (weight of 72 tonnes), and with a plan to land in *"conf FULL"*, the characteristic speed targets were as follows:

- Green Dot for *"conf 0"* = 218 kt (target speed in clean configuration);
- S for *"conf 1"* = 197 kt (target speed with leading edge slats and flaps extended to 18° /10°);
- F for *"conf 2"* = 153 kt (target speed with leading edge slats and flaps extended to 22° /15°);
- F for *"conf 3"* = XXX kt (target speed with leading edge slats and flaps extended to 22° /20°);
- Vapp for *"FULL conf"* = 141 kt (target approach speed in FULL configuration with slats and flaps extended to 27°/35°);
- VFE *"conf 1"* = 230 kt;
- VFE *"conf 2"* = 215 kt;
- VFE *"conf 3"* = 195 kt;
- VFE *"FULL conf"* = 190 kt;
- maximum landing gear extension speed: 250 kt.

Comparison of the Airbus procedures with the crew actions recorded in the CVR and FDR

	FCOM	CVR AND FDR DATA
Before the final approach point (FAP) (3,000 ft/ 6.9 NM):	❒ select *"CONF 1"* at more than 3 NM before the FAF; ❒ check the aeroplane's deceleration towards *"S"*; ❒ the aeroplane must capture or be established on the *"glide"* in *"conf 1"* at speed *"S"* at the latest at 2,000 ft; ❒ if the speed of the aeroplane is significantly higher than S, after establishing *"glide"* or if the aeroplane does not decelerate, extend the landing gear. It is also possible to use the airbrakes. The crew must then be aware that use of the airbrakes leads to an increase in VLS; ❒ once the localizer is captured, if the aeroplane is below the glide, use the V/S mode.	❒ the aeroplane was in *"CONF 1"*; ❒ the aeroplane intercepted the glide at 3,820 ft QNH 1004 at 217 kt and a rate of descent of approximately - 1,500 ft/min; ❒ the PF selected a speed of 207 kt then 205 kt a few seconds later; ❒ shortly before the FAF, at approximately 7 NM and 3,000 ft, the speed of the aeroplane was stabilising towards the selected speed of 205 kt (S=197 kt);
At 2,000 ft (minimum):	❒ select *"CONF 2"*; ❒ the aeroplane must decelerate to the F speed.	❒ the tailwind component was increasing from 15 kt towards 30 kt; ❒ the PF requested to select *"CONF 2"* shortly before reaching 2,000 ft; ❒ the PM retracted the airbrakes and selected "CONF 2" at approximately 1,600 ft AGL
When *"CONF 2"* is selected:	❒ extend landing gear.	❒ the tailwind component reached 29 kt; ❒ the PF selected a speed of 180 kt.
When the landing gear is extended:	❒ select *"CONF 3"*; ❒ select *"CONF FULL"*; ❒ the aeroplane must decelerate to Vapp.	❒ the PM extended the landing gear and pointed out to the PF that the aeroplane was not slowing down; ❒ between 2,000 ft and 1,000 ft, the speed of the aeroplane oscillated between 193 to 210 kt[10]

[10]According to the manufacturer, the tailwind gradient can be the cause of the aeroplane's slow deceleration.

	FCOM	CVR AND FDR DATA
At the stabilisation altitude: 1,000 ft in IMC (conditions on the day of the accident)	❒ the aeroplane must be on the nominal glide path (Glide Slope and Localizer); ❒ the aeroplane is in landing configuration; ❒ the thrust is stabilised and maintains the approach speed; There is no excessive deviation from the following flight parameters: ❒ the speed is greater than Vapp- 5 kt or lower than Vapp +10 kt; ❒ the pitch attitude is greater than -2.5° or lower than +7.5°; ❒ the roll angle is not greater than 7°; ❒ the vertical speed is not greater than 1,000 ft/min; ❒ the LOC deviation is lower than ¼ point; ❒ the GS deviation is lower than 1 point.	❒ the aeroplane was on the nominal glide path (Glide Slope and Localizer); ❒ the aeroplane was not in landing configuration (CONF 2 and landing gear extended); ❒ the thrust was not stabilised ❒ the speed was 57 kt above Vapp (198 kt); ❒ the pitch attitude was -4°; ❒ the vertical speed was 1,100 ft/min.
Between 1,000 and 500 ft		❒ the PM asked the PF to engage the managed mode at 950 ft RA; ❒ the PM selected *"CONF 3"* at 195 kt at approximately 850 ft RA, followed by *"CONF FULL"* at 184 kt at 625 ft RA.

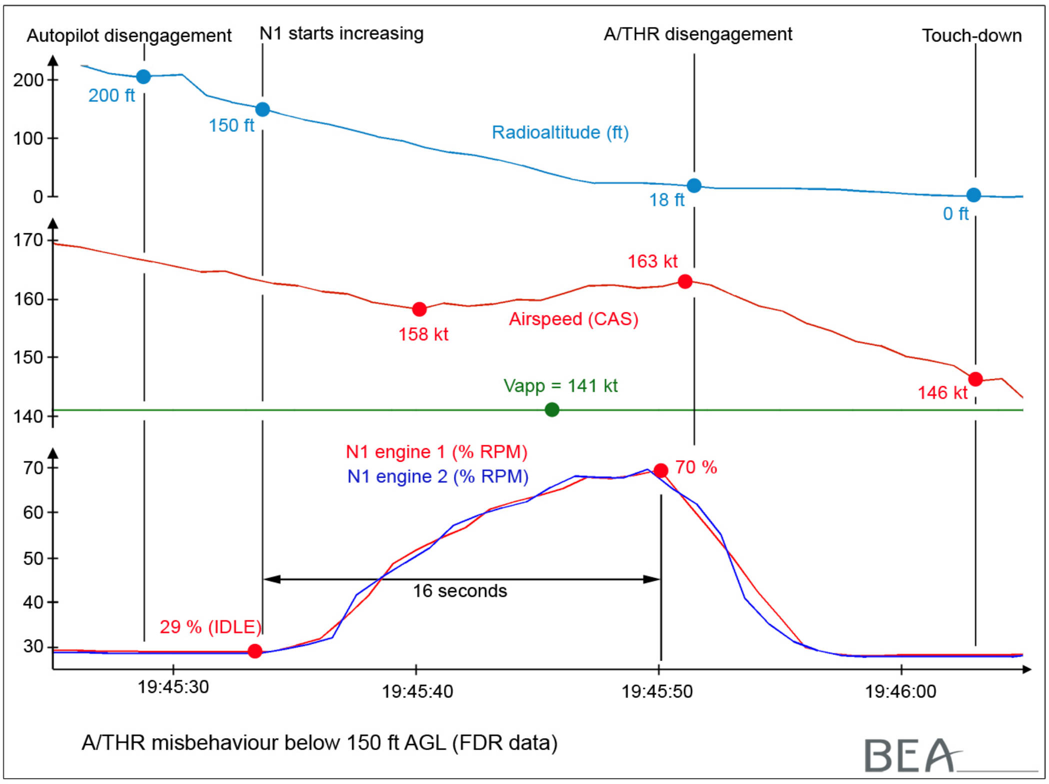
	FCOM	CVR AND FDR DATA
At the stabilisation altitude: 500 ft in VMC (conditions on the day of the accident)	❒ the aeroplane must be on the nominal glide path (Glide Slope and Localizer); ❒ the aeroplane is in landing configuration; ❒ the thrust is stabilised and maintains the approach speed; There is no excessive deviation from the following flight parameters: ❒ the speed is greater than Vapp- 5 kt or lower than +10 kt; ❒ the pitch attitude is greater Vapp than -2.5 lower ° or lower than +7.5°; ❒ the roll angle is not greater than 7°; ❒ the vertical speed is not greater than 1,000 ft/min; ❒ the LOC deviation is lower than ¼ point; ❒ the GS deviation is lower than 1 point.	❒ the aeroplane was on the nominal glide path (Glide Slope and Localizer); ❒ the aeroplane was in landing configuration (CONF FULL and landing gear extended); ❒ the thrust was not stabilised; ❒ the speed was 38 kt above Vapp (179 kt); ❒ the pitch attitude was -4°; ❒ the vertical speed was 1,100 ft/min.
At 140 ft		❒ the A/THR was still engaged and the N1 rotation speed of the engines, which were at idle (30%), started to increase.
At 60 ft		❒ the aeroplane flew over the runway threshold with a tailwind component of 7 kt; ❒ the speed was 160 kt.

1.11.2.3 A/THR behaviour

Note: The A/THR was engaged during the entire approach phase. The approach speed calculated by the FMGC was 141 kt. The autopilot was disengaged on passing a radio altitude of 200 ft.

On passing radio altitude 150 ft, N1 started to increase. The speed decreased to 158 kt then increased again. About 15 seconds after passing through 150 ft and crossing the runway threshold, N1 reached 70% and the speed was 163 kt.

On passing radio altitude 18 ft, the thrust levers were placed in the *"IDLE"* position and the A/THR disengaged. The N1 decreased to approximately 29% (IDLE). The speed of the aeroplane was 146 kt at touchdown of the main landing gear.



A/THR misbehaviour below 150 ft AGL (FDR data)

1.11.2.4 Flare

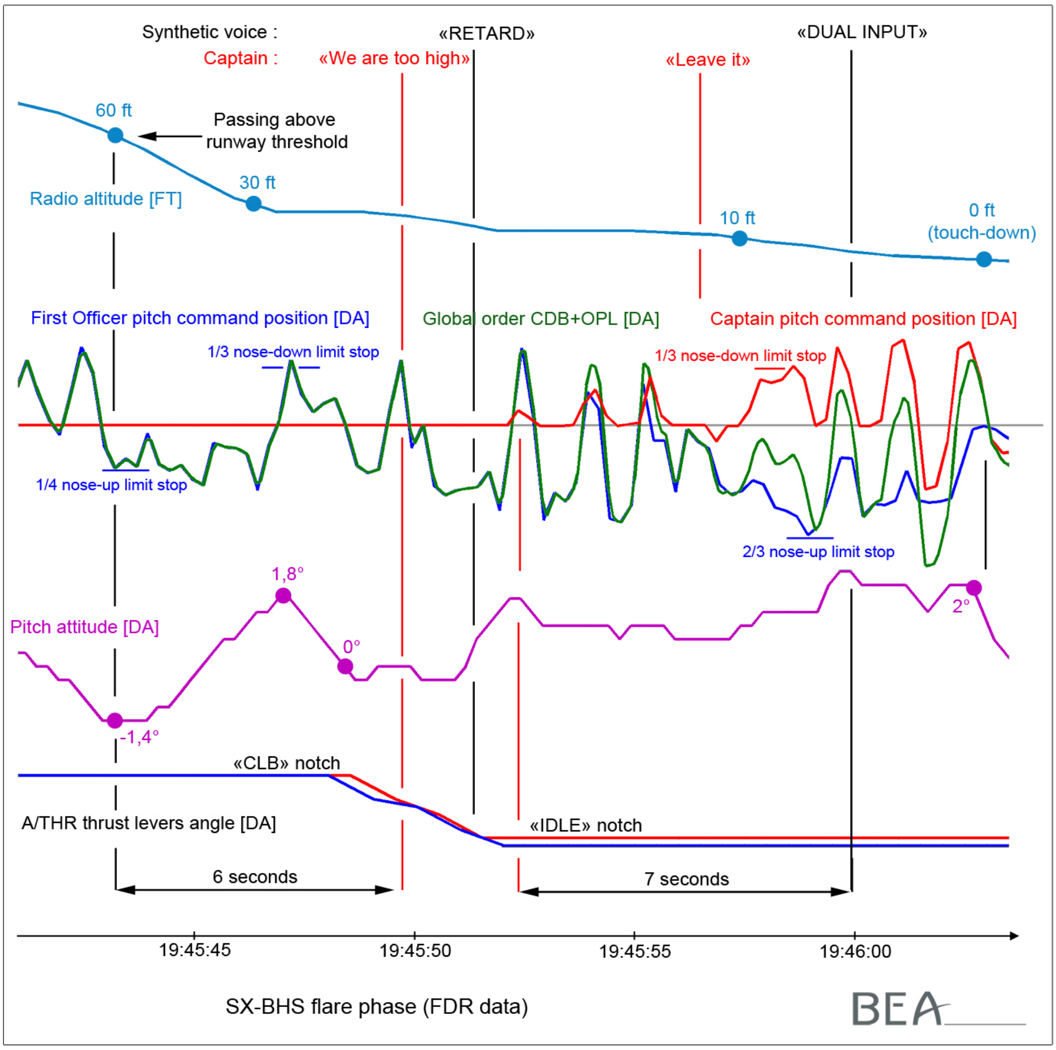
At a radio altitude of 60 ft, the aeroplane flew over the runway threshold. The PF made a nose-up input maintained on the sidestick (approximately 1/4 pitch up). The pitch attitude increased from -1.4° to 1.8°. During the following two seconds, the PF made a nose-down input (1/3 pitch down) and the aeroplane remained stable at radio altitude 23 ft. The pitch attitude was 0°.

About three seconds after passing radio altitude 30 ft, the aeroplane was at 18 ft and the PF started to move the thrust levers back to the IDLE position. The Captain called out *"We are too high"*, and the copilot replied *"Yes"*. The synthetic voice called out *"Twenty"*, followed by *"Retard"*. The PF placed the levers in the IDLE position and the A/THR disengaged.

The Captain made a succession of three nose-down inputs (deflections on the sidestick at 1.6°/1.9°/5.1°), while the copilot alternated nose-up and nose-down inputs (deflections between -10° and +8°). The Captain called out: *"Leave it"*. The *"DUAL INPUT"* callout was not generated during these simultaneous inputs, since the callout activation conditions were not met.

Approximately 13 seconds after crossing the runway threshold, the aeroplane was 10 ft above ground level. The Captain made another nose-down input, while the copilot maintained a nose-up input. A *"DUAL INPUT"* alarm was generated two seconds later, which is the expected time for it to trigger (confirmation time and calculation time).

The Captain repeated "Leave it". The pilots continued to make opposite inputs. The resulting prevailing input was nose-up until the wheels touched down approximately 18 seconds after crossing the threshold.



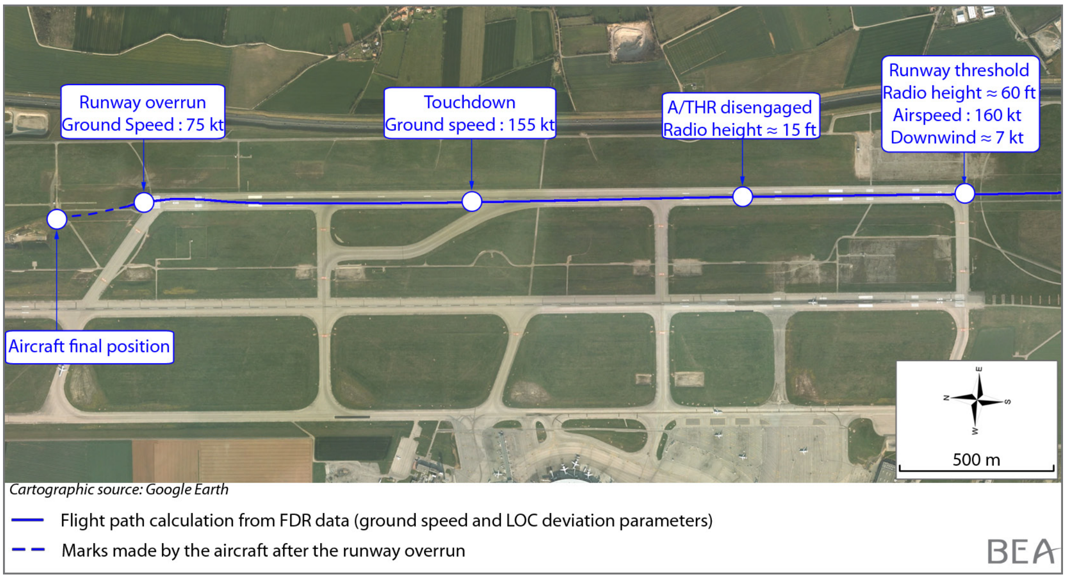
1.11.2.5 Flight path calculation after crossing the threshold

It is possible to calculate a more precise flight path than that obtained from the FMS positions recorded on the FDR.

The flight path was calculated based on other FDR data:

- the ground speed of the aeroplane;
- the *"Localizer"* guidance information.

The runway overrun (N 45°44'06.43'' E 5°05'30.70'') was used as the starting point for the iterative calculation used for calculating the previous positions of the aeroplane.



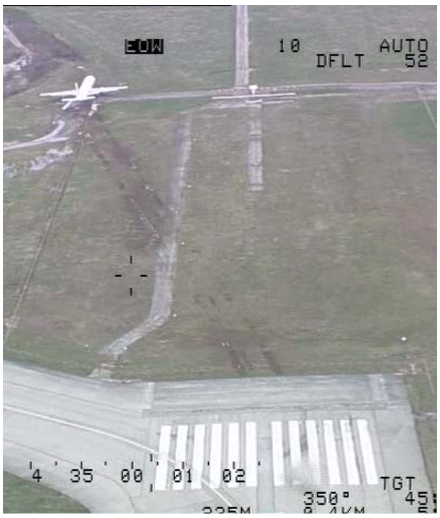
Flight path calculation starting from when the aircraft crossed the runway threshold

- ❒ **touchdown occurred approximately 1,600 metres from the runway threshold;**
- ❒ **the aeroplane overran the end of the runway at approximately 75 kt.**

1.12 Wreckage and Accident Aircraft Information

1.12.1 Examination of the site

After its runway overrun, the aeroplane continued to decelerate on a flat, grassy surface. The flight path curved to the left. The aeroplane came to a standstill after rolling off the runway for 308 metres outside the runway service areas, abeam the ILS antennas, and several dozen metres from a topographic depression located between the two runway centrelines. The depression was 225 metres long, 80 metres wide and approximately 15 metres deep. It was used as a firing range. It was filled in following the accident.



Source GTA

Source BEA

Photographs taken after the accident

1.12.2 Examination of the accident aircraft

The tyres showed no signs of damage, indicating that the wheels had locked up, which is typical of the effect of hydroplaning.

The main damage observed on the engines was located on the first low-pressure compressor stages, and was subsequent to the ingestion of debris and soil while rolling on the loose surface, and with the thrust reversers deployed.

1.13 Medical and Pathological Information

Blood tests were performed on the two flight crew members. No substance that may have altered their abilities was found.

1.14 Fire

Not applicable.

1.15 Survival Aspects

Not applicable.

1.16 Tests and Research

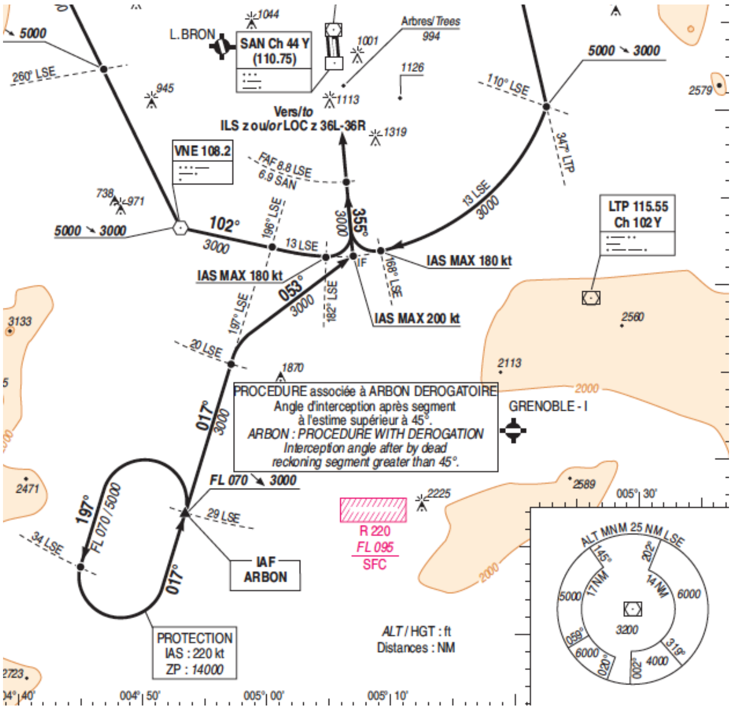
1.16.1 Air Traffic Services

The following information is based on the Lyon Saint Exupéry Tower/Approach Operations Manual and on the interview conducted with the Service Quality Manager of the airport's air traffic services.

ILS approach to runway 36R (IAF ARBON) after following STAR MEZIN 1D

AIP France file AD2 LFLL IAC 03 describes the flight paths required to align with the approach centreline from the initial approach fix ARBON after following STAR MEZIN 1D. The initial approach is followed by an intermediate and final approach using procedure ILS Z or LOC 36 R (***see appendix 4***).

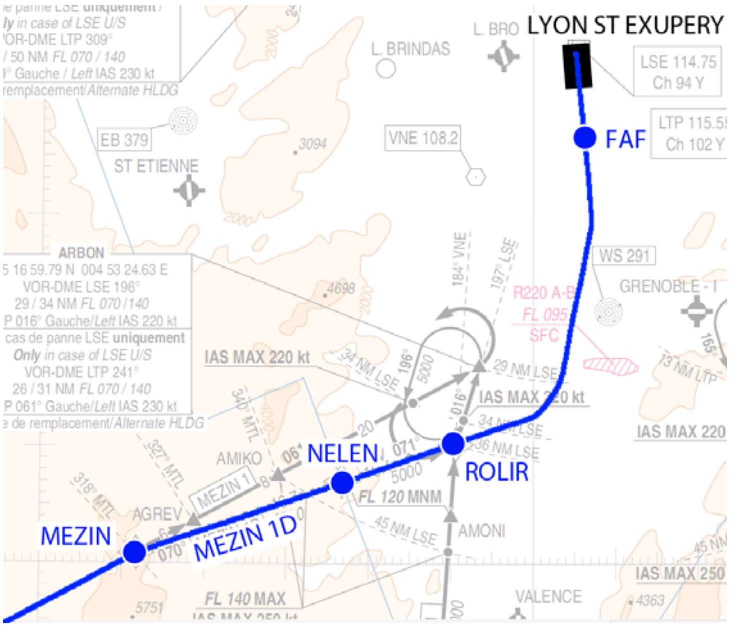
The FAP used during an approach via ARBON (by radar vectoring or normal procedure) is the FAP of the ILS approach to runway 36R using procedure Z, located at 6.9 NM/3,000ft.



Note: There is also an ILS 36R Y approach whose FAP is set at 4,000 ft and 10 NM from the threshold of runway 36R and whose IAF is GOMET south-east of the airport. The database recorded in the FMS on SX-BHS on the day of the accident only included the ILS 36R Z approach. In fact this generation of FMS does not allow for different ILS approaches to the same runway.

Radar vectoring

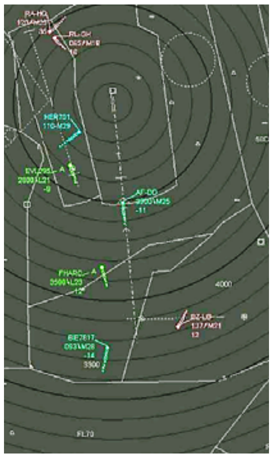
From the ROLIR waypoint onwards, the crew of SX-BHS was radar-vectored.



Approach via MEZIN 1D / Radar vectoring

During radar vectoring, the controller allows crews to descend while taking into account the thresholds of the various zones crossed (minimum radar safety altitude). The controller views the minimum radar safety altitude zones on his/her screen (IRMA MMI radar display).

Minimum radar safety altitude zones (AIP)



Display as seen by the controller

Until approximately 15 NM from the threshold of runway 36R, the minimum radar safety altitude of the zone was 3,300 ft. During the event, the controller gave clearance to descend to 4,000 ft in this zone. Air traffic services indicated that they could give clearance for 3,300 ft, but generally preferred to indicate 4,000 ft in order to avoid any confusion by the crews (to prevent a descent to 3,000 ft).

Interception of final approach path – Level flight IF-FAP

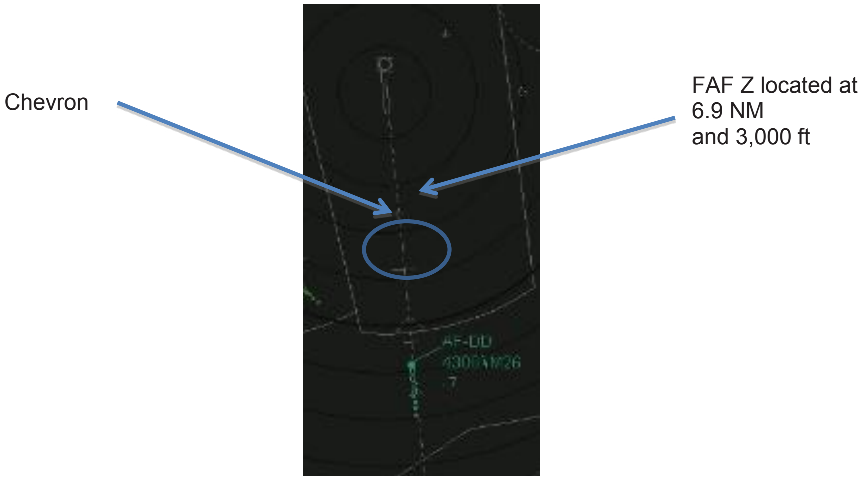
The French decree dated 6 July 1992 on procedures for organisations providing air traffic services to general air traffic aircraft (RCA / 3) states the following:

- *"10.7.3.1 The arrival, initial and intermediate approach phases of a radar-vectored approach start from the time radar vectoring is initiated for the purpose of positioning the aircraft for final approach, and end when the aircraft is:*
  - *a) ready to commence a surveillance radar approach; or*
  - *b) transferred to the precision radar approach controller; or*
  - *c) established on the final approach path of an aid other than the radar with which the pilot executes the final approach him/herself; or*
  - *d) given clearance to complete a visual approach".*

The operations manual of Lyon also mentions that:

- *"When the intermediate approach controller provides a pilot with the final radar heading to align with the final approach course, this should enable the aircraft to:*
  - *align with the final approach path at a maximum angle of 45 degrees;*
  - *level off for at least 30 seconds on the course before intercepting the nominal glide path.*

The controller can display the static chevron visualisation maps corresponding to the type of approach flown: intercepting before the chevron ensures the 30-second level flight period at 180 kt maximum".



IRMA MMI radar display with the chevron

The air traffic services indicate that, in practice, pilots attempt to make a continuous descent. As for controllers, they do not systematically attempt to radar vector the aeroplane to a level flight before the FAF (the preceding aeroplane, and that of the event did not level off). When the pilot reports that s/he is correctly established on the final approach path, this marks the end of radar vectoring.

Operations manual instructions when low visibility procedures (LVPs) are in force

Definition of LVPs

LVPs are the operating procedures implemented at an airport in order to enable:

- ❐ CAT II and CAT III precision approaches;
- ❐ low visibility take-offs (DFV/LVTO) when RVR < 400 m.

LVPs are enforced by the control tower chief when the RVR falls below 800 metres at the earliest, or when the ceiling falls below 300 ft, and at the latest when RVR = 550 m or ceiling = 200 ft. If there is no ceiling indication, the height of the cloud base (HBN) is used for triggering the LVPs.

Selecting runway mode of operation in LVP

Only QFU 36 is allowed in LVP at Lyon Saint-Exupéry. The runway mode of operation is selected by the control tower manager, in consultation with LOC control. The modes allowed in LVP are as follows:

- ❐ nominal parallel segregated runways: landings on runway 36R, take-offs on runway 36L;
- ❐ single, general purpose runway 36L: landings and take-offs on runway 36L;
- ❐ single, general purpose runway 36R, only if runway 36L cannot be used: landings and take-offs on runway 36R.

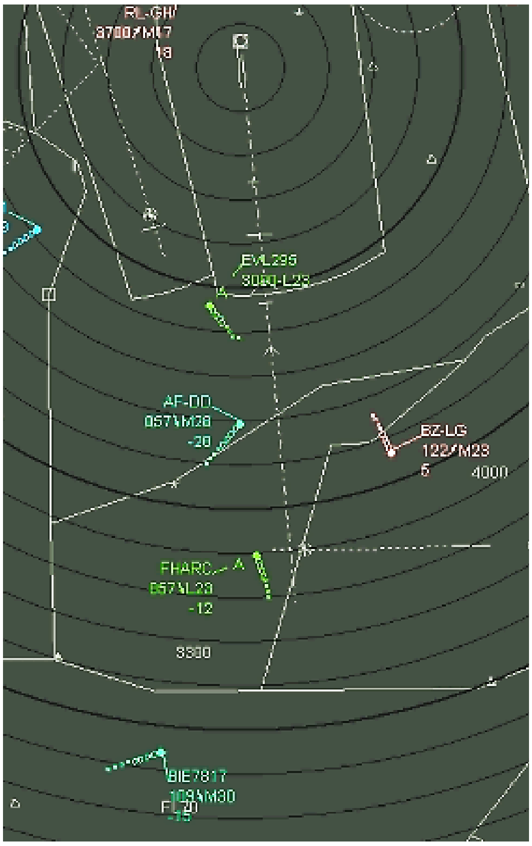
Whatever the circumstances, operating in reversed segregated mode (take-offs on runway 36R, landings on runway 36L) is strictly forbidden in LVP.

The operations manual also specifies the actions to be carried out by the intermediate approach controller when LVPs are in force:

- s/he displays the static map by list ILS LVP 36R or ILS LVP 36L;
- s/he ensures that aircraft bound for LFLL intercept the LOCALIZER at the latest 10 NM from the runway threshold (LVP chevron), with a maximum convergence of 30° and at a maximum speed of 160 kt.

The air traffic specify that regulating the speed of this procedure is not used for a ceiling LVP. This procedure is used when there is significant traffic.

Radar vectoring of SX-BHS and of preceding aeroplane (AF-DD)

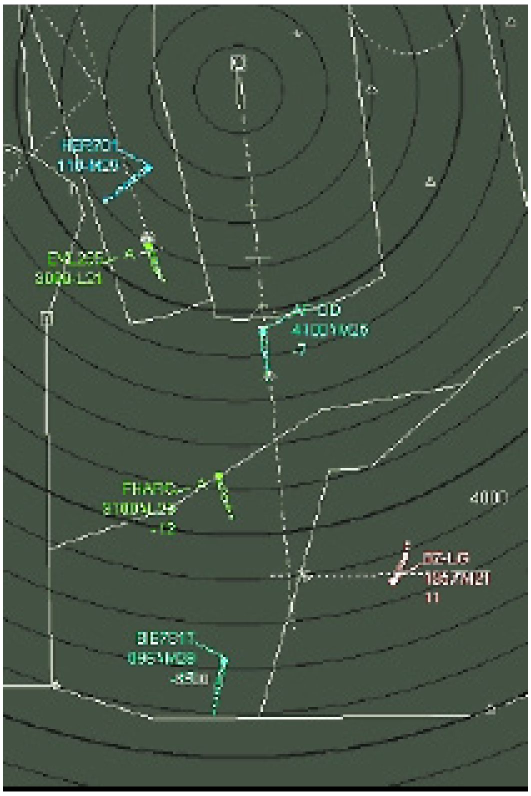


- **AF-DD at 5,700 ft at a ground speed of 280 kt**

  19:38:14 Lyon Radar to AF-DD: *"Air France Delta Delta, left turn to heading 020 to intercept, will that be OK for descent?"*
  19:38:19 AF-DD to Lyon Radar: *"Um, OK for Delta Delta. Can we continue to 3,000?"*
  19:38:24 Lyon Radar to AF-DD: *"Um, yes 3,000 if you want"*
  19:38:25 AF-DD to Lyon Radar: *"Yeah 3,000, it'll be easier that way, thanks"*.

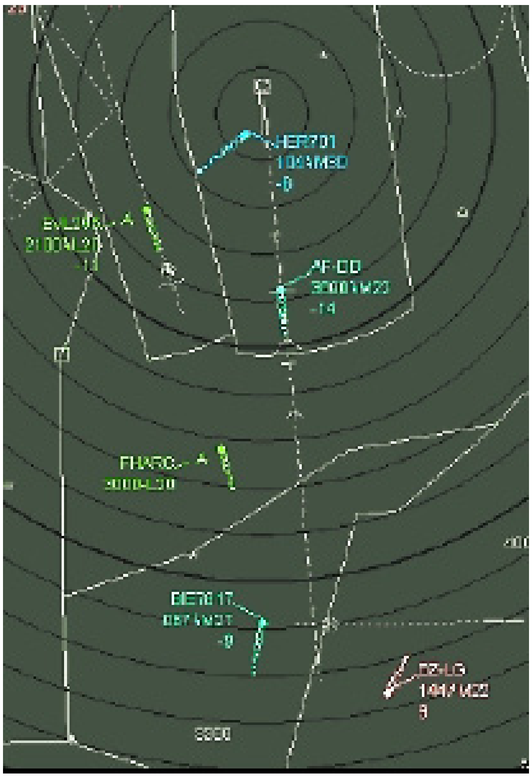
- **SX-BHS (call sign: BIE7817) at 10,300 ft at a ground speed of 290 kt**

  19:38:44 BIE7817 to Lyon Radar: : *"Lyon for Méditerranée seven eight one seven, requesting ten degrees to the left to avoid weather"*
  19:38:49 Lyon Radar to BIE7817: *"Méditerranée seven eight one seven, that's approved, descend five thousand feet"*.



- AF-DD is 10 NM from the threshold of 36R, aligned on the LOCALIZER at 4,100 ft with a ground speed of 250 kt (Radar). At that moment the QAR recording indicates a CAS of 220 kt.

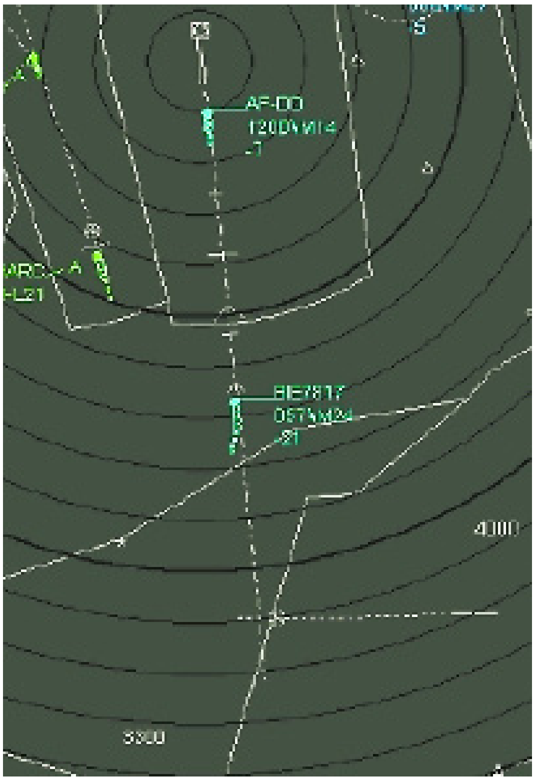
19:39:36 Lyon Radar to AF-DD: *"Air France Delta Delta, I can see you going a little fast, tell me if you want to perform the approach again, we could do it quickly"*
19:39:40 AF-DD to Lyon Radar: *"Air France Delta Delta, it's going to be OK we're extending the gear."*



- AF-DD crosses FAP (6.9 nm/ 3,000 ft) at 3,000 ft at a ground speed of 220 kt (radar) CAS = 182 kt (QAR)
- BIE7817 at 22 nm from threshold at 8,700 ft at a ground speed of 270 kt (radar) CAS = 227 kt (FDR)

19:40:09 BIE7817 to Lyon Radar: *"Lyon for Méditerranée seven eight one seven, can we intercept localizer with that heading?"*.
19:40:14 Lyon Radar to BIE7817: *"Seven eight one seven, that's approved, reduce speed two two zero knots"*.

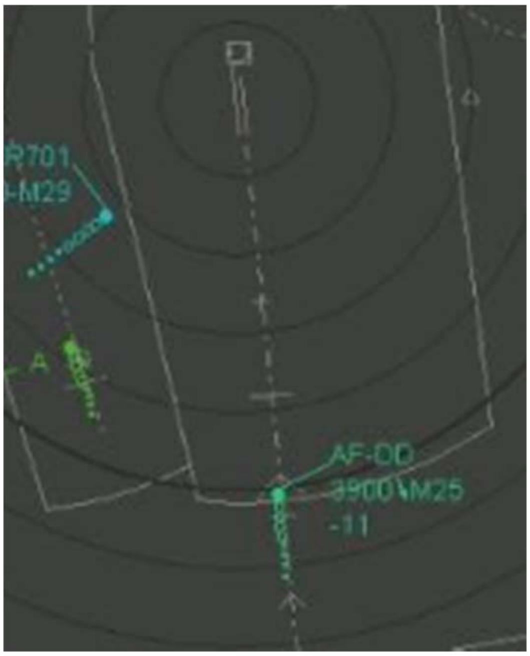
19:40:18 BIE7817 to Lyon Radar: *"Two two zero knots, we have already, Méditerranée seven eight one zero, clear for the approach runway three six right"*.
19:40:24 Lyon Radar to BIE7817: *"Seven eight one seven, descend four thousand feet and you're cleared ILS 36R right, leave four thousand feet on the glide"*.
19:40:30 BIE7817 to Lyon Radar : *"Ok, four thousand, clear for the ILS and (leave them on) the glide, Méditerranée seven eight one seven"*.



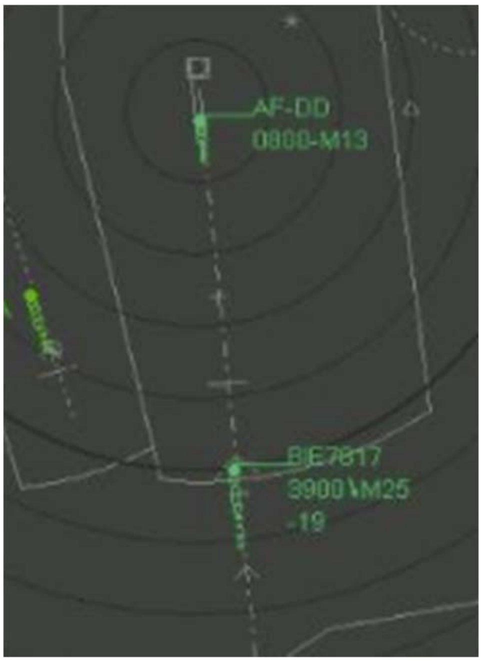
BIE7817 at 5,700 ft at a ground speed of 240 kt (radar). CAS = 217 kt (FDR)

19:42:27 Lyon Radar to BIE7817: *"Seven eight one seven, continue descent three thousand feet (*) call me back when you established"*.
19:42:32 BIE7817 to Lyon Radar: *"Three thousand feet (follow) the glide Méditerranée seven eight one seven"*.

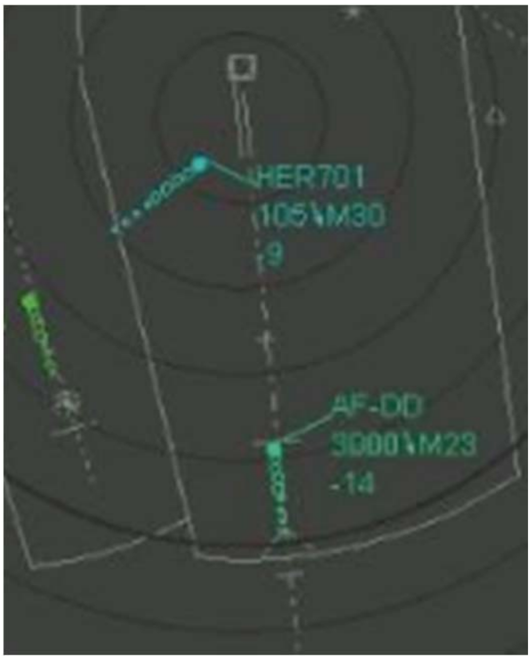
Flights AF-DD and BIE7817 (SX-BHS) arrived at the same speed on passing 10 NM (at the same altitude). AF-DD reduced its speed between 10 NM and the FAP at 6.9 NM with the extension of the landing gear, before selection of CONF 2, while flight BIE7817 kept roughly the same speed.



AF-DD - crossing 10 NM
Radar: ground speed of 250 kts
(CAS[FDR] = 220 kts, GS[FDR] = 249 kts)



BIE7817- crossing 10 NM
Radar: ground speed of 250 kts
(CAS[FDR] = 222 kts, GS[FDR] = 251 kts)



AF-DD - crossing FAF (6.9 NM) – Radar: ground speed of 220/230 kts (CAS[FDR] = 182 kt, GS[FDR] = 209 kt)

BIE7817 – crossing FAF (6.9 NM) – Radar: ground speed of 250 kts (CAS[FDR] = 206 kt, GS[FDR] = 241 kt)

Levelling off between the IF and the FAP, and managing speeds on approach

The controllers explained that pilots frequently request to follow the glide as early as possible. Although vectored in accordance with the rules, many of them position the aeroplane to intercept the glide upstream of the FAF and make a continuous descent. They added that air navigation services are subjected to this practice that is commonly imposed on them by flight crews.

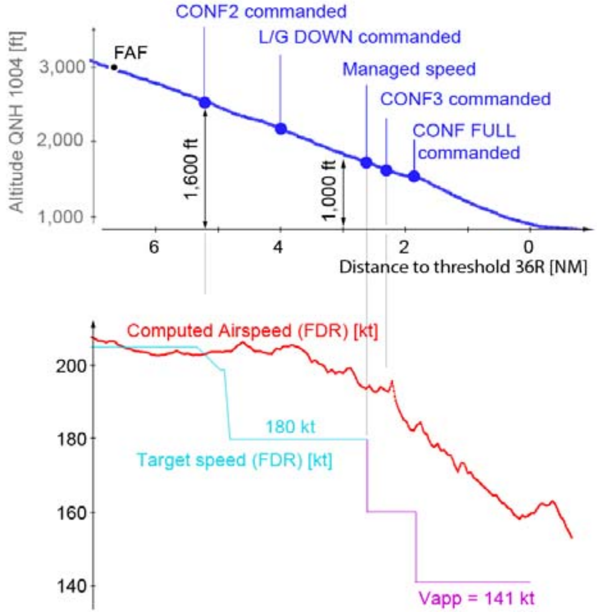
At Lyon, the *"Quality Service"* department explained that they regularly raised controllers' awareness on speed management. Furthermore, controllers had also been reminded of the thirty-second level flight period issue since the event.

1.16.2 Study of speed management on final approach

The manufacturer conducted a study on the deceleration of the aeroplane on final approach by making calculations based on the certified model of the aeroplane (aerodynamics, engines and autopilot flying laws).

Influence of the tailwind gradient on aeroplane deceleration

During the event, passing through about 2,400 ft QNH in descent (1,600 ft AAL), the crew selected the CONF2 configuration. They selected a target speed of 180 kt but the air speed (CAS) did not drop and remained stable at about 204 kt. The crew selected landing gear extension 15 seconds later, passing through 1,400 ft AAL. The CAS fell and reached 198 kt when passing through 1,000 ft AAL. During this sequence, the aeroplane was subjected to a significant drop in tailwind.



Based on the certified model of the aeroplane, the manufacturer estimated the change in the air speed (CAS) by using the hypothesis of an extension of the landing gear simultaneously with the switch to CONF2 configuration:

- ❐ for a constant tailwind of 25 kt ;
- ❐ for a dropping tailwind of 25 kt (2,400 ft QNH / 1,600 ft AAL) at 5 kt (on the ground), similar to the tailwind component encountered by the aeroplane during the event;
- ❐ CONF3 is selected when the aircraft reached VFE, which was 195 kt.

Altitude (QNH)	Altitude (AAL)	Calculation 1 Constant tailwind	Calculation 2 Tailwind dropping
2 400 ft	1 600 ft	CONF2 selected Landing gear extension selected CAS = 207 kt	
2 000 ft	1 200 ft	CONF3 selected	-
1 800 ft	1 000 ft	CAS = 187 kt (Vapp + 45 kt)	CAS = 196 kt (Vapp + 54 kt)
	900 ft	-	CONF3 selected
	800 ft	-	-
	500 ft	CAS = 161 kt	CAS = 174 kt

The results of the calculations show that, under the event conditions, the progressive drop in the tailwind penalises the reduction in aeroplane air speed (CAS) more than a constant strong tailwind. This result is mainly due to the fact that in constant wind conditions CONF 3 can be engaged earlier.

Application of SOPs and the landing gear extension procedure

During the event, the aeroplane intercepted the glide path at a speed of 218 kt (S+21 kt).

The SOPs (FCOM) state that where the speed is significantly higher than S when the aeroplane is established on the glide path, the landing gear must be extended.

The calculations in the study were made based on conditions similar to those of the event:

- intercepting the descent path in the « CONF1 » configuration with a CAS of 218 kt;
- a strong tailwind composite (25 kt) then a drop on passing through 2,400 ft QNH / 1600 ft AAL.

The SOPs used for the calculations were:

- managed speed;
- extension of the landing gear on intercepting the glide path (as the speed is significantly higher than S);
- selecting the successive configurations (*"CONF2"*, *"CONF3"*, then *"FULL"*) at speeds recommended in the FCTM.

The calculations show that under conditions similar to those of the event, application of the SOPs allows the aeroplane to pass through:

- **1000 ft AAL with a speed (CAS) of 151 kt (Vapp + 9 kt)**
- **500 ft AAL with a speed (CAS) of 142 kt (Vapp + 1 kt)**

1.16.3 Study of the behaviour of the A/THR

1.16.3.1 Description of the anomaly

The anomaly relates to the thrust calculation on aeroplanes equipped with the former FMGC B398 and B546 standards. The following models are involved:

- A320 CFM
- A321 CFM/IAE
- A319 CFM/IAE

(A320 IAE are not affected.)

For these aeroplanes, if the aeroplane speed is more than 10 kt above the target speed, the thrust value calculated by the FMGC is wrong between 150 ft and 50 ft radio altitude and is greater than the required thrust.

This malfunction causes an increase in thrust as the aeroplane approaches the ground, whereas a reduction is necessary because the speed is greater than 10 kt above the target speed.

1.16.3.2 Evaluation of the contribution of the behaviour of the A/THR

The study of the contribution of autothrust behaviour concentrated on the final part of the approach just before the increase in thrust from 150 ft radio altimeter height.

The guarantee of identical initial conditions for each scenario is ensured by a tailwind set at 7 kt (corresponding to the wind calculated during the event on entering the flare phase).

The former FMGC standard was simulated by programming the simulator with the increase in N1 of the event, when passing through a radio altimeter height of 150 ft.

Impact of the anomaly on the air phase

The air phase studied begins when the N1 parameters increase on passing 150 ft radio altitude. It ends at touchdown.

- **From 150 ft to 50 ft radio altitude:**

Calculations were performed by the manufacturer to try to reproduce the event by applying the same inputs on the sidesticks while simulating the thrust calculated by the new FMGC standard. These calculations were compared with the FDR data for the event.

The results show that the increase in N1 contributes to a 5 kt increase in calibrated airspeed on passing 50 ft radio altitude. An increase of the vertical speed of about 300 ft / min is also observed.

- **From 50 ft radio altitude to touchdown:**

The flare phase is a very dynamic phase during which the pilot constantly adjusts the attitude and the vertical speed of the aeroplane as a function of the aeroplane's response.

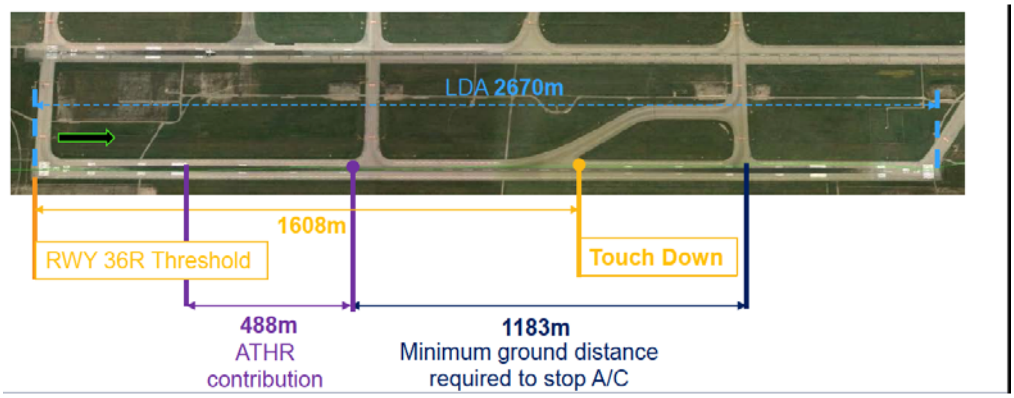
Simulator tests were performed at the manufacturer's facility with the Hermes Airlines Safety Officer, a BEA pilot and an Airbus test pilot.

The objective was to assess the contribution of the increase in N1 parameters during the flare phase for a standard flare technique. Several techniques for reducing the A/THR (placing the thrust levers in the IDLE position) were tested.

By applying a standard flare technique and an A/THR reduction at the latest at 20 ft with the old FMGC standard, one gets:

- **the distance between passing 50 ft and the touchdown point is increased by +130 to +500 metres;**
- **the calibrated airspeed (CAS) at touchdown is increased by +4 to +9 kt.**

An illustration below shows this:



Source: Airbus

Contribution of the A/THR anomaly to the extension of the air phase in the worst case scenario

Contribution of the anomaly to the roll distance

The manufacturer's simulations tried to assess the contribution of the increase in N1 parameters (old FMGC standard) on the speed and pitch attitude at touchdown in the framework of a standard flare technique.

The assumptions for the calculation are the following conditions:

- ❒ event weight and balance;
- ❒ WET runway;
- ❒ use of thrust reversers;
- ❒ braking: max braking.

	Air speed (touchdown)	**Ground speed** (touchdown)	**Pitch attitude** (touchdown)	Roll distance
Sim 1 (new FMGC standard)	150 kt	162 kt	4.4°	1,316 metres
Sim 3 (old FMGC standard)	159 kt	169 kt	-1°	1,401 mètres

In this example, the roll distance is increased by +85 metres in the case of the old FMGC standard with a standard flare technique.

1.16.4 Flare

The flare technique was compared with those of the two previous landings from the data recorded by the FDR. When landing in Agadir, the copilot carried out a touchdown at 900 metres without the A/THR having contributed to the long flare. During the previous two landings, the copilot and the Captain began to place the thrust levers in the *"IDLE"* position after the *"RETARD"* callout.

1.16.5 Assessment of runway condition

ATIS described the runway as being *"WET"*. The BEA has asked the manufacturer to make a more accurate estimate of the slipperiness based on the landing data recorded by the FDR.

The results showed that the rate of deceleration during the event (close to maximum braking) was between those calculated for DRY and WET runway conditions, assuming that maximum braking force was applied.

The runway condition on the day of the event is estimated to be WET.

1.16.6 Calculation of required landing distances (RLD and FOLD)

The recommended approach speed recommended in the procedures (SOP) is VREF +5 kt in FULL configuration for a landing with A/THR engaged.

The required landing distance RLD[11] is used for calculations made by the dispatcher for flight preparation. The FOLD[12] (Factored Operational Landing Distance) is the reference for the in-flight calculation.

The manufacturer calculated the RLD and the FOLD based specifically on the following hypotheses:

Runway condition (ATIS)	WET
Weight	71.8 T
Configuration	FULL
Speed	Vapp = VREF + 5 kt
Braking	Maximum manual
Thrust reversers	Max Rev applied at touchdown

At the time of the event, the tailwind was 7 kt passing a radio altimeter height of 50 ft. Two cases were thus decided on for the calculations:

Tailwind	RLD	FOLD
0 kt	1833 m	1734 m
10 kt	2127 m	2064 m

The results show that with the approach speed recommended in the SOPs, the calculated landing distance (FOLD from 1,704 to 2,064 m) is lower than the landing distance available (LDA) of 2,670 m for runway 36R.

(11) The RLD is based on the ALD (Actual Landing Distance) plus a margin. ALD is the distance between when the aeroplane passes 50 ft above ground level and when it comes to a standstill, and is partly based on the results of flight tests.

(12) The adjustments made for temperature and runway slope are taken into account in the calculation of the FOLD, as opposed to ALD or RLD.

1.16.7 Roll distance during landing

The manufacturer calculated the roll distance using the certified performance model of the aeroplane and the following assumptions:

- initial touchdown conditions of the event (speed, engines, speedbrake and reverser deployment sequence);
- maximum braking;
- runway condition between WET and DRY;
- max reverse up to 70 kt.

The roll distance calculated under the initial touchdown conditions in the event and with an optimal use of means to ground deceleration is 1,183 metres on a wet runway. The aeroplane would have overrun at 56 kt under these conditions.

This speed is lower than the overrun speed of the event (75 kt). This can be explained by the fact that the braking force applied by the crew was not the maximum (asymmetrical braking, transient brake release).

1.16.8 Examination of the braking system on SX-BHS

The examinations revealed no malfunction of the BSCU (Braking System Control Unit) or the brake units.

1.16.9 Description of the ROW/ROPS system

The ROPS (Runway Overrun Prevention System) is a system that assists the pilot during the approach and roll phases to avoid runway overrun. This system comprises:

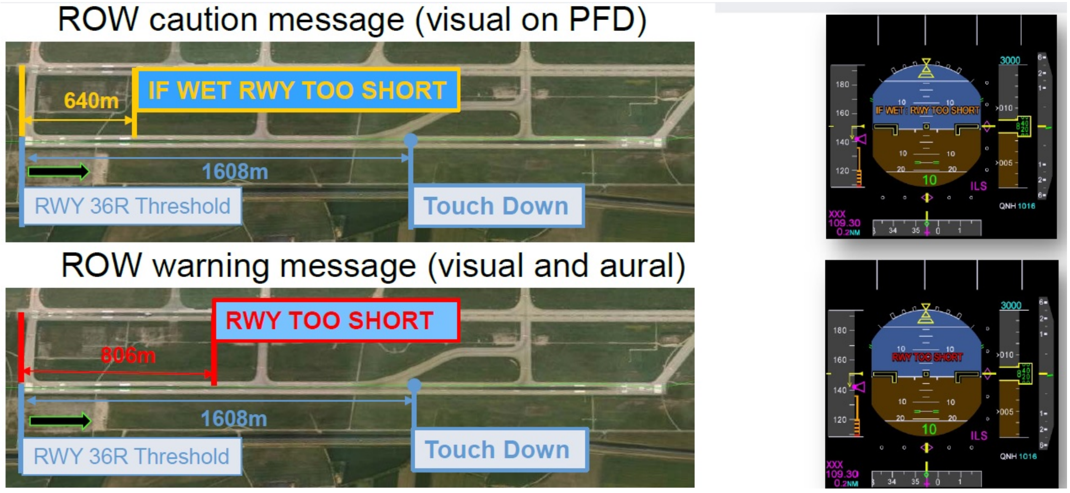
- the ROW (Runway Overrun Warning), which operates in flight and warns the pilot;
- the ROP (Runway End Overrun Protection), which operates during the landing roll, warns the pilot and provides braking assistance.

The ROW calculates in real time the landing distances for runway conditions DRY and WET, in relation to the position and the current energy of the aeroplane. It warns the crew when a runway excursion is predicted:

- if the calculation for WET runway condition is greater than the distance available, the system will display *"IF WET: RWY TOO SHORT"* on the PFD.

- if the calculation for the DRY runway condition is greater than the distance available, the system will display *"RWY TOO SHORT"* on the PFD. In addition, a voice callout *"RUNWAY TOO SHORT!"* is repeated in a loop below 200 ft.

The ROP calculates the remaining roll distance. If deceleration is not sufficient, the system displays *"MAX REVERSE"* on the PFD and automatically applies maximum braking if autobrake is engaged. In addition, a voice callout *"MAX REVERSE"* is repeated on loop if the thrust levers are not placed on REV MAX.



Source Airbus

SX-BHS was not equipped with this system. The old FMGC standard used on this aeroplane does not allow it to be installed.

Simulation of the ROW/ROPS system for the event

The objective of the simulations was to determine whether the ROW/ROPS system would have warned the crew in the case of the event.

Two tests were conducted. Each time, the pilot maintained a high pitch attitude during the flare to cover a distance similar to that of the event (1,600 metres).

			ROW		**ROP**
	Time (50 ft -> touchdown)	Distance (50 ft -> touchdown)	*"IF WET : RWY TOO SHORT"*	*"RUNWAY TOO SHORT"*	*"MAX REVERSE"*
Simu A	16.4 s	1,409 m	RA=15 ft	RA =10 ft	5 seconds after touchdown
Simu B	21.8 s	1,846 m	RA=20 ft	RA = 15 ft	1 second after touchdown

In both simulations, the system displayed *"IF WET: RWY TOO SHORT"* during the flare, then *"RUNWAY TOO SHORT"*. The aural warning called out *"RUNWAY TOO SHORT!"* .The ROP activated after touchdown.

The simulations indicate that during the event, the ROW would have warned the crew during the flare and the ROP would have triggered after touchdown.

1.16.10 Assessment of crew performance

1.16.10.1 Method used

Evidence-Based Training (EBT) Manual (*appendix 5*)

Since 2013, ICAO has provided assessment criteria for crew performance in Part II appendix 1 *"Core Competencies and Behavioural indicators"* of its Doc 9995 AN/497 *"Manual of Evidence-Based Training"*.

This documentation proposes definitions of each competence that makes up crew performance, and is based on a certain number of observable behavioural indicators.

The BEA used this methodology and identified these indicators based on the statements by the flight crew, listening to the CVR, the FDR data and all documentation provided by the airline and the manufacturer.

The investigation specifically covered the following technical criteria:

- the crew's ability to implement procedures (briefings, procedures and checklists, callouts);
- pilot's flying ability in manual and automatic mode;
- theoretical and procedural knowledge.

It also addressed the following CRM criteria:

- situational awareness;
- communication skills;
- leadership and teamwork;
- problem-solving ability and decision-making processes;
- workload management.

Note: the "knowledge" criterion does not formally belong to the criteria used by ICAO. Nevertheless, since this criterion is the subject of a specific evaluation by the manufacturer and major airlines, the BEA considered that it was appropriate to add it to the list of technical criteria evaluated.

1.16.10.2 Technical Criteria

Application of procedures (*source: EBT Manual Part II – App 1-1*)

Definition: *"The crew is expected to identify and apply the procedures in a manner consistent with the operator's procedures and the regulations in force, by demonstrating adequate skills at each phase of the flight"*.

Approach preparation

A crew is expected to conduct a briefing using a method addressing the key points of both the approach and the particulars of the day, including meteorology, infrastructure and possible state of fatigue. Concerning the flight path control, the procedures provide that one of the two pilots should read the FMGS insertions and the other check that they comply with the relevant documentation (chart used). The briefing should then allow the crew to determine the operational strategies to implement in order to safely and effectively address the particulars (threats) of the day.

Before beginning their approach, the crew was aware that they were not qualified for CAT III approaches. They reviewed the marginal visibility and ceiling conditions. They knew that the surface wind had a tailwind component and that the runway was wet.

The CVR recording indicates that, in his briefing, the PF described the flight paths as they appear on the Jeppesen chart and seemed to refer to the approach chart for ILS 36R Y. The crew, however, had no discussion about the selection of ILS 36R Y rather than ILS 36R Z. The files were read by the PF without the PM performing any cross-checks with the FMGS method while the latter only proposed the ILS 36R Z approach.

No specific comments were made about the known marginal weather conditions (ceiling/visibility). The crew did not mention the use of automated systems, the go-around technique, or the choice of the stabilisation height. After listening to the ATIS, the PF raised genuine doubts about the feasibility of a CAT I approach because of visibility. These doubts were not shared by the PM:

"**19 h 20 min 37,821 PF**: *That's foggy yeah, and we are in the limits, four hundred metres, the limits for the CAT two*
19 h 20 min 47,186 PM: *What is the visibility?*
19 h 20 min 48,789 PF: *Um... the visibility, four hundred metres*
19 h 20 min 52,216 PM: *We don't care about visibility, we care about the R V R*
19 h 20 min 54,242 PF: *RVR sorry, yes"*

The crew did not mention a possible diversion or waiting time. They did not mention the landing distances on wet runways taking into account the runway length, the weight of the aeroplane, which was close to the maximum landing weight (MLW), or the tailwind on the ground. No mention was made of possible fatigue after a duty period approaching 15 hours.

Precision approach procedures

The crew partially applied the procedures during descent and intermediate approach. The ATC Instructions for altitude and speed were complied with. The *"approach"* checklist was carried out normally. The crew activated engine de-icing and avoided the cloud masses. Heading adjustments were requested from the controller on the initiative of the PM, who indicated in his account having himself adjusted the heading selector, this task being normally carried out by the PF.

The crew knew that they were initially above the glide path of the ILS. When approaching the ground, the crew is expected to apply the *"intercept Glide slope from above"* procedure which provides for activating the G/S, levelling off, configuring the aeroplane in deceleration sequence and then selecting a vertical speed of about 2,000 ft/min to increase the slope.

They chose to keep a high speed in clean configuration, then in configuration 1, and to extend the airbrakes to increase the rate of descent.

The altimeter setting[13] was incorrect by about 300 ft; the setting error remained undetected until the landing.

During the final approach, in compliance with the procedures, the localizer centre line was intercepted in configuration 1 and the FMA standard safety callouts were carried out normally. However, the speed (S+20) was high and did not diminish until interception of the glide slope (G/S).

From 2,000 ft onwards, the crew questioned the high speed *"Look, we cannot reduce speed"*. However, these differences in speed did not trigger the expected callouts for deviations and did not lead to corrective actions.

On passing 1,000 ft, the aeroplane is expected to be established in final configuration at a speed close to Vapp. The procedure provides that the crew should call out the deviations and abort the approach if the corrective actions to come back to the target are too great.

At 1,000 ft, the aeroplane was still in configuration 2. The speed was Vapp+57 kt and the pitch attitude -4°. These deviations were not called out and did not lead to corrective action. The PM asked the PF to switch to managed mode.

The SOPs provide for a thrust reduction at around 30 ft. It was observed that the A/THR reduction was effective after reiteration of the *"RETARD"* callout at 20 ft. The flare phase was unusually long. The PM applied inputs on the controls and repeatedly called out *"leave it"*. The procedure for taking over control was not carried out.

"*Evacuation*" emergency procedure

After the runway overrun, as soon as the aeroplane comes to a standstill, the crew is expected to immediately apply the first measures of the emergency evacuation procedure in order to secure the aeroplane and enable access to rescue services.

The CVR recording indicates that the crew seemed shocked and did not apply the procedure. They initially engaged in non-operational discussions about the runway overrun. The Captain communicated with ATC and the cabin crew, the copilot seemed *"out of the loop"*. The engines continued to run for two minutes until the controller asked the crew whether they had shut them down.

Task-sharing

The two crew members are expected, particularly during the approach and landing phases, to maintain effective oversight so as to develop shared and adequate situational awareness. In particular:

- *the PF is responsible for applying and maintaining a flight path in line with the operational plan of action (briefing). S/he monitors the flight path;*
- *the PM acts on order from the PF, performs tasks as provided in the SOPs, including the monitoring of flight parameters, and communications with ATC.*

[13] The PF listened to and took note of the ATIS information - the QNH was 1004, the PM read back QNH 1004 to the ATC and called out to the copilot a QNH value of 1014. This erroneous value provided by the PM was not compared by the PF to the value he had noted when listening to the ATIS.

The CVR recording and the statements by the flight crew showed that task-sharing during the descent differed from the procedures. Following many doubts verbalised by the PF on how to conduct the approach, on several occasions the PM carried out tasks normally assigned to the PF:

- he decided and directly operated heading adjustments to avoid cloud masses;
- he told the PF to maintain a high speed and a high rate of descent to intercept the G/S;
- he asked for most of the changes in configuration (flaps and speedbrakes);
- he took the initiative for the checklists.

On the other hand, he partially completed the tasks assigned to the PM. The configuration and speed deviations were not called out.

Knowledge *(source: Airbus technical competencies)*

Definition: *"Crew members are expected to know and understand the relevant information, the operational procedures, the functioning of aircraft systems and the operational environment"*.

The interview with the PF showed that his knowledge of certain aeroplane systems and procedures was incomplete. He seemed not to know:

- the procedure to intercept the glide from above in V/S mode;
- the meaning of characteristic speeds (Green Dot, S and F);
- the value of the deviations to call out on final (speed, vertical speed, pitch attitude, etc.);
- the stabilisation criteria.

He was not able to explain the choice of the target speed values selected during the approach.

The interview with the PM showed that he had faulty knowledge of the criteria for speed stabilisation and missed approach, as well as of the emergency evacuation procedure.

Flight control *(source: EBT Manual Part II - appendix 1-2)*

Definition: *"The crew is expected to control the flight path with the level of automatic systems required by the phase of flight"*.

During the initial and intermediate approach, the energy and automatic systems management failed to stabilise the aeroplane at 1,000 ft.

The A/THR managed mode was used too late (900 ft RA) to provide for an effective speed reduction before passing 50 ft. In the absence of any particular speed constraints imposed on the ILS by the controller, the SOPs provide for the use of the managed mode.

On passing 150 ft RA, the crew did not establish any relationship between the increase in N1 parameters (30% to 70%) and the attitude, thrust and speed parameters.

During the flare phase, the FDR data showed significant inputs on the PF's sidestick. Eight seconds after passing 50 ft (time needed for a normal flare), the PM began to apply inputs on the controls. For ten seconds, dual inputs were recorded and the aeroplane was maintained flying due to an excessive pitch attitude. Despite the triggering of the *"DUAL INPUT"* alarm, the dual input condition continued until touchdown.

After touchdown, the crew made strong and appropriate inputs, applying maximum braking and extending the thrust reversers until immobilisation of the aeroplane.

1.16.10.3 Non-technical criteria (CRM)

Situational awareness (*source: EBT Manual Part II – appendix 1-4*)

Definition: *"The crew is expected to perceive and understand all the relevant information available and to anticipate factors that may affect the control of the flight".*

Before starting the approach, the crew was aware of weather conditions close to the minimums via the ATIS (visibility 400m, cloud at 100ft). They knew that the aeroplane was heavy, that the runway was 2,700 m long, that it was wet and that a tailwind trend was present on the ground. These items did not encourage the crew to define a suitable strategy, anticipate the aeroplane configuration, the need for a precise touchdown point and prepare for the missed approach. This could indicate that, at this stage of the flight, they lacked sufficient situational awareness.

Listening to the CVR conversations and analysis of the FDR data suggest a certain state of fatigue. Neither of the two pilots however explicitly mentioned it. Indeed, no particular strategy was in place to address it.

The crew did not realize that the presence of a tailwind component on the ground could be associated with a stronger wind component on final. Thus, they did not realize that the difficulty in reducing speed was related to a strong tailwind, nor did they try to confirm the value of the wind on the ND. Exchanges between the ATC and the Air France aeroplane that preceded it in the same conditions could have alerted them and changed their situational awareness, but the exchanges took place in French, a language that the crew did not understand.

The crew was not aware of the error in altimeter setting. They thought they were flying higher than the actual height of the aeroplane. Therefore, they probably did not perfectly understand the time remaining before landing.

The lack of automatic annunciations and callouts by the PM when crossing characteristic altitudes (1,000 ft and minimum) did not allow the crew to restore satisfactory situational awareness.

When passing 50 ft, the crew observed fog patches at the end of the runway. They did not perceive the presence of centreline lighting over the last 900 meters (alternating white and red lights). The callout of the PM *"We are too high"* and the input he applied on the control column eight seconds after beginning the flare suggest that at this moment he realized that this phase was unusually long[14]. The Captain's interview suggested that at that moment he had not yet realised that the remaining runway distance was short.

[14]Tests showed that the time observed between passing 50 ft and touchdown is about 7 to 8 seconds for a landing in the same conditions with a standard landing technique.

The PF explained that he heard the PM's message *"Leave it"* and the *"DUAL INPUT"* alarm and realized that the PM was applying inputs on the sidestick. However, he maintained his nose-up inputs until touchdown. This indicates that no crew member was aware of the consequences of dual input, including on the landing distance.

After the runway excursion, the aeroplane was in the fog and the ATC could not initially locate it. The CVR and FDR parameters indicate that the first items in the emergency evacuation procedure were not performed by the crew, still in shock from the accident. In particular, they did not think to shut down the engines and started the APU. The assessment of the risks to the aeroplane appears to have been incomplete and delayed the action of fire-fighters. During the interview, the Captain considered that there was no risk during and after the event in not performing the aeroplane evacuation procedure.

The actions or omissions of the crew during the different phases of the approach and the landing show that they were unable to construct an adequate mental picture of the situation encountered.

Communication skills (*source: EBT Manual Part II - appendix 1-1*)

Definition: *"The crew is expected to demonstrate efficient ability to communicate, whether in oral, non-verbal and written communication in both normal and abnormal situations. Listening to the CVR alone does not make it possible to analyse the non-verbal communications"*.

The two crew members did not have a common language and neither of them was of Anglo-Saxon origin. The Captain nevertheless had significant experience in the practice of aviation English. This was not the case for the copilot (PF) who had been line flying for only six months.

During the event, the copilot seemed to have some difficulty understanding the English language. Six months after finishing his line training, on the legs where he was PF, he continued to take ATIS messages for training. During the flight, however, he did not ask the PM to validate the information heard (by asking him, for instance, to pay attention to such information).

The PM stated that it took more effort than usual on his part to understand the PF's accent.

The PF struggled to express his doubts about the weather in a sufficiently precise and direct way to really alert the PM on the operational (rather than regulatory) feasibility of the approach. He did not reword his questions. In fact, his ability to share his ideas was ineffective.

For his part, the PM did not appear, at key moments, to demonstrate active listening, especially when he said: *"we don't care about the visibility, we care about the RVR"*, which closed the debate with no real possibility of reply from the PF.

Pilot-ATC communications

Despite their shared doubts about the reasons for the implementation of the LVP procedures, the crew did not ask the controllers for clarification.

The PM stated that he was confused by the fact the controllers were speaking French with the French-speaking pilots.

Thus, the limited communication skills of the crew seem to be an additional difficulty in this approach, which was prejudicial to the effective control of the flight.

Problem solving and decision making *(Source: EBT Manual Part II – appendix 1-3)*

Definition: *"The crew is expected to identify risks and solve problems, using a proper decision making process"*.

In view of the operational problems encountered, the crew were unable to collect the necessary information for an appropriate decision-making process.

Despite their doubts about the reason for the LVP conditions, the crew did not follow through with the search for additional weather information from ATC and did not develop an alternate strategy (including a missed approach and/or diversion). The crew also failed to understand the reasons for the lack of aeroplane deceleration.

Listening to the CVR indicated that the crew did not really consider any other options than landing.

Leadership and teamwork (*source: EBT Manual Part II – appendix 1-3*)

Definition: *"The crew is expected to show leadership and an ability to work as an efficient team"*.

The brevity of the briefing and the lack of real operational strategy prior to the approach did not allow the crew to identify potential difficulties specific to this approach to Lyon (TEM).

The quality of the teamwork was affected by the inadequate task-sharing described above. The PF was inexperienced and seemed uncomfortable with the actions to sequence and configure the aeroplane on approach. He almost always asked the PM about the actions, apologised and thanked him after almost every exchange. This may have led the PM to adopt a directive attitude, and led to a gradual deterioration in task-sharing as the workload increased. The PM then followed an *"flight instructor"* model without having been trained or having the experience to do so.

The cockpit showed the symptoms of unbalanced leadership, close to an *"autocratic"* situation, which could be explained among other things by the difference in experience between crew members.

Workload management (*source: EBT Manual Part II – appendix 1-4*)

Definition: *"The crew is expected to manage resources effectively, by prioritizing and performing tasks at the right time in all circumstances"*.

During the approach, the workload gradually increased. The changes in configuration had to be managed simultaneously with rapidly changing parameters. The presence of a strong tailwind caused closing on the runway faster than usual. The numerous contacts with the controllers often interrupted tasks. Finally, the frequent requests made by the PF to the PM significantly increased the latter's workload.

The PM seems to have reversed his priorities at 2,000 ft AGL. When the PF called for configuration 2, the PM gave priority to responding to an ATC request. This choice delayed the reduction in speed of the aeroplane at a key moment.

The PM also seemed to have partially taken over the PF function, and thus found himself in a work overload situation. To cope with it, he gradually relaxed the monitoring of the aeroplane parameters and was no longer able to fully play his role as PM.

1.16.11 Effect of fatigue on crew performance

The gap between the performance expected of the crew and the actions actually observed might be an indication of a state of fatigue, resulting in an alteration of response times, working memory, decision making and situational awareness.

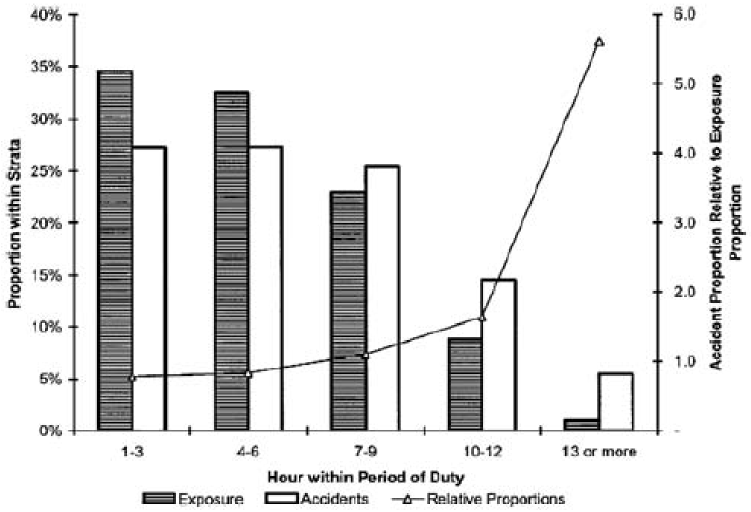
The BEA commissioned the IRBA (institute of biomedical research of the armed forces) to conduct a study on the impact of alterations in the sleep/wake cycle and aeronautical activities on the risk of fatigue in this situation (Study available in the appendices).

The study was based on the work schedules of the crew on the day of the accident and during the previous two months. The collected data were compared with those described in the scientific literature and with the values obtained using a bio-mathematical management model of the fatigue risk (SAFTE model) available to IRBA.

The results did not identify any alterations in the sleep/wake cycle likely to cause fatigue on the day of the accident or during the previous days. However the accident occurred at a time when the performance of the flight crew was likely to be the lowest.

This result is to be weighed against the fact that the modelling technique for fatigue does not take into account such factors as the number of legs flown, the actual workload or the flight duty period.

However, the flight duty period (14h50) is consistent with a significant increase in the risk of accidents and fatigue usually felt by crews. Several studies have demonstrated a relationship between the flight duty period and the drowsiness and fatigue felt (Bourgeois-Bougrine et al. 2003b, Powell et al. 2007, Powell et al. 2008), the frequency of air safety reports (ASR) in regional airlines (Cabon et al. 2012) and the frequency of accidents (Good 2003). A study conducted in the USA showed that 20% of accidents related to human factors occurred after ten hours of flight duty (Good 2003). Reduced to the relative amount of flying hours, this study reveals a slight increase in risk of accidents between ten and twelve hours of flight duty (relative risk, RR = 1.65) and a very significant increase beyond thirteen hours of activity (RR = 5.6). The relative risks are shown in the following graph in relation to the duty hours (RR in order on right).



Relative proportion of exposure to accidents as a function of the period of duty (Goode 2003)

The study showed that the crew's fatigue was not caused by an alteration in the wake/sleep cycle linked to the schedule or their activities the day before the accident.

The main fatigue factor identified for the day of the accident was a flight duty period of almost 15 hours.

1.17 Information on Organisations and Management

1.17.1 Hermes Airlines

1.17.1.1 General

Hermes Airlines was set up in 2011 by the CEO of Air Méditerranée. Air Méditerranée is the majority shareholder in Hermes Airlines. The latter is based in Greece and holds an Air Operator Certificate (AOC) issued by the Greek civil aviation authority (HCAA) on 8 August 2012 that is valid until 10 August 2015.

Hermes Airlines operates five aeroplanes, a Boeing 737, an Airbus A320 and three Airbus A321. These Airbus were previously operated by Air Méditerranée and were transferred to the Hermes Airlines AOC in the first half of 2012.

Hermes Airlines charters its aeroplanes to Air Méditerranée in the framework of an ACMI (Aircraft - Crew - Maintenance - Insurance) lease. Scheduling of Hermes Airlines flights and maintenance of the aeroplanes is ensured by Air Méditerranée.

Hermes Airlines operates flights from Greece, France, Sweden, Iraq and Djibouti as charter flights. Annual activity is primarily seasonal:

- *"low"* season between October and March (a monthly average of 250 flights);
- *"high"* season between April and September (monthly average of more than 600 flights).

This particular activity led the operator to hire seasonal pilots when the demand was high.

Hermes Airlines employs approximately 30 crews. Most of the Captains are Greek and are former pilots of Olympic Airways and Olympic Air. The copilots are mainly of Spanish, Italian and British nationality.

The information in the following paragraphs comes mainly from testimony provided by the operator's management team.

1.17.1.2 Operator's Operations Manual

The operations manual is one of the main means by which the operator ensures safe operation and compliance of its operations with regulatory requirements. The operations manual consists of four parts:

Part A - General / Basics

This section includes all the policies, instructions and operating procedures not related to a type of aeroplane.

Part B - Issues relating to the use of an aeroplane

This section includes all the instructions and procedures to ensure safe operation of an aeroplane type. It takes account of the differences between types, variants or individual aeroplanes used by the operator.

Part C - Information and instructions relating to routes and airports

This section includes all the instructions and information on routes and aerodromes.

Part D - Training

This part includes all the instructions relating to the staff training required to ensure safe operation.

The different parts in force on the date of the accident were written between February and October 2011. The manual was approved in its entirety by HCAA at the end of November 2011. The Director of Flight Operations (DFO) explained that this manual was a generic manual partly based on his experience with Alitalia.

This version of the operations manual (revision 0 and 1) contains:

- inconsistencies between different sections of Part A and Part D:
  - The prerequisites to fly as copilot or Captain differ from one chapter to another. In addition, it is stated in writing that these prerequisites may not be met depending on the needs of the operator.
- differences between Part B - Chapter 2 - *"A320 Normal Procedures"* and Chapter 13, *"Airline Policy"*:
  - Chapter 2 reproduces the procedures of the manufacturer's FCOM which recommends using the managed mode for precision approaches. Chapter 13 on the other hand recommends performing precision approaches using the selected mode at 160 kt up to 5 NM from the runway threshold and then to engage the managed mode.

The DFO explained that in accordance with the HCAA, a new operations manual correcting all the inconsistencies and differences was filed with the HCAA at the end of 2012 and approved by the HCAA after the accident. Details are included in appendix 7.

1.17.1.3 Recruitment, training, recurrent training and checks on flight crews

Hermes Airlines has defined for its flight crew training, practice and evaluation and/ or inspection programs whose contents, volumes and resources are described in the operations manual, Part D. This volume approved by the HCAA complies with EU-OPS regulations.

Within Hermes Airlines, the training is organised by the Director of Flight Operations (the only type rating examiner (TRE) of the operator) and the Designated Crew Training Manager (Type Rating Instructor (TRI). Several Captains are also Type Rating Instructors (TRI), Ground Training Instructors and three of them are CRM instructors. Hermes Airlines also uses contract TRE instructors employed by TRTOs based in Athens and in the United Kingdom. The operator does not have any flight simulator in Greece.

1.17.1.3.1 Recruitment of flight crew

According to the testimony of the DFO and the Head of Training, the recruitment conditions described below are those defined in the latest version of the operations manual. They point out that these conditions were those used before the accident, although they were not officially approved by the HCAA.

Recruitment process for copilots

The minimum requirements to hire a flight crew member are as follows:

- ❒ valid CPL license (including, among others, *"ICAO level 4"* in the English language and a valid Class 1 medical certificate);
- ❒ ATPL theory;
- ❒ IR/ME qualification;
- ❒ Multi Crew Course (MCC) training.

At the time of recruitment, the pilot candidate for a copilot position must to have a minimum of 200 flying hours, of which 30 on multi-engine aeroplanes;

The candidate is then subject to:

- ❒ an interview with the DFO and the Head of Training for behavioural assessment of the candidate;
- ❒ a medical test and a psychological test;
- ❒ an assessment test on a flight simulator (four-hour session with a TRE).

The DFO and the Head of Training said they encountered difficulties in recruitment and training at the time the airline was created.

In 2011, the operator had one Boeing 737 with crews specifically composed of former pilots from Olympic Airways experienced on Boeing.

From January to March 2012, Hermes Airlines took over operation of four Airbus. The operator then had to recruit and train in a very short time the crews required to operate these new aeroplanes. Having difficulties in recruiting copilots experienced on Airbus, it recruited pilots who had recently obtained their type rating on Airbus A320/A321 but with no prior experience of public transport of passengers. The operator stated that about half of the copilots recruited (9 out of 20) had a total of 200 flying hours, including 30 on twin-engine aircraft. It added that since the creation of Hermes Airlines, about 40 pilots had been recruited and 10 were rejected during training.

Hermes Airlines officials explained that because of the «low cost» profile of the operator, the recruitment of young inexperienced copilots was also economically more interesting than that of experienced copilots.

Process for recruitment of Captains

The minimum requirements to employ a flight crew member as a Captain are as follows:

- a valid ATPL;
- IR/ME rating;
- Multi Crew Course (MCC);
- *"ICAO level 4"* in the English language;
- A valid Class 1 medical certificate;
- minimum experience of a total of 5,000 flying hours in public transport or 3, 000 flying hours on type within Hermes Airlines.

The majority of active Captains at Hermes Airlines are flight crew that have gained wide experience on Boeing with Olympic Airways.

1.17.1.3.2 Flight crew training

Co-pilot training

During their copilot training, pilots with less than 500 flying hours on type follow the operator's conversion course, which consists of 5 phases:

- Ground courses and assessment (4 days of 8 hours);
  - Day 1 (8h): Introduction – Aircraft systems
  - Day 2 (8h): Aircraft systems
  - Day 3 (8h): B/P RNAV – RVSM- TCAS- GPWS – Aeroplane differences
  - Day 4 (8h): Performance – Weight and balance
- Ground courses and assessment on safety/rescue and security (2 days of 8 hours);
- Practice and assessment on flight simulator (a four-hour training session and a four-hour assessment session);
- Line flying under supervision and line check (a total of 100 flying hours or a minimum of 40 legs);
- CRM Training (1 day of 8 hours).

This training meets the requirements of OPS 1.945 (*see Section 1.17.3 Regulatory Aspects*) without any margins in relation to each of the quantitative criteria taken in isolation (minimum experience of 200 h to begin the SADE, number of simulator sessions, duration of line flying under supervision).

The DFO and the Head of Training explained that line flying under supervision is not always easy to carry out because the charter business of the operator does not always make it possible to program the number of flights required for the continued implementation of line flying under supervision. Thus the line flying under supervision of the copilot on duty in the accident flight began in February 2012 (low season) and was suspended between 26 February and 30 July 2012 (high season).

Captain training

The training course includes:

- ❒ specific training in the responsibilities of a Captain;
- ❒ training and proficiency check in a flight simulator;
- ❒ line flying under supervision (for flight crew with a type rating, the line-oriented flight training consists in flying at least 10 legs);
- ❒ a line check;
- ❒ CRM training.

1.17.1.3.3 Recurrent training and checks for flight crew

Recurrent training of flight crew

All flight crew members undergo recurrent training and checking specific to the aeroplane type or variant on which they fly. Recurrent training of flight crew members includes:

- ❒ ground and refresher courses including:
  - ■ training in crew resource management (CRM);
  - ■ training in safety/rescue and security.
- ❒ flight simulator training covering emergency and abnormal procedures.

Recurrent checking of flight crew

Annual recurrent checks of flight crew members include:

- ❒ two proficiency checks;
- ❒ one line check;
- ❒ one safety, rescue and security check.

1.17.1.4 CRM course

CRM training consists of a two-day joint training course for flight crew and cabin crew members, delivered in the English language.

During these courses, the following regulatory issues are addressed:

- ❒ CRM overview;
- ❒ Communication;
- ❒ Decision making process;
- ❒ Team concept;
- ❒ Stress;
- ❒ Situational awareness;
- ❒ Airline subjects (including sterile cockpit policy).

CRM training was based on that provided by Olympic Airways and adapted to Hermes Airlines. It did not contain TEM-related items, or items related to the specific risks of the airline such as an airline in the process of being established, multi-cultural crews and often inexperienced on Airbus or in their new role.

The operating risks identified by the flight analysis are not addressed during the training (overshoots, dual input phenomena).

1.17.1.5 Safety organization at the airline

The Flight Safety Officer (FSO) explained that at the time of the accident, Hermes Airlines had begun implementing its Safety Management System (SMS). He added that a safety organization already existed before the SMS. It included the FSO, working full-time, and two part-time pilots who operated from May 2012 to October 2013.

1.17.1.5.1 Feedback system

Three types of reports are available to crews in order for them to inform the FSO about incidents or unusual situations:

- **mandatory incident report**: in accordance with regulatory requirements, crews must report certain incidents encountered in flight. These reports are sent to the operator and to the HCAA;
- **voluntary report**: crews may also report events if they encounter unusual situations whether or not related to flight safety;
- **anonymous reports**: a letter box located in the premises of the operator in Athens allows staff to anonymously report an event.

In 2012, Hermes Airlines carried out 5,295 flights and the FSO handled thirteen mandatory incident reports, and three voluntary reports not related to safety. No anonymous reports were received.

In 2013, Hermes Airlines carried out 4,248 flights and the FSO handled seventeen mandatory incident reports, eight voluntary reports not related to safety and five anonymous reports.

The FSO explained that crews were sometimes reluctant to write reports for fear of being ill-considered. His main objective was therefore to build trust in order to create a culture of safety within the airline.

The FSO added that in the months before the accident, the newness of the operator and the specific nature of its seasonal activity had resulted in a small volume of flights. It was therefore difficult to identify safety issues representative of the operation. The FSO stated that at that time he mainly distributed generic safety documents (Flight Safety Foundation's publications, manufacturers' publications, etc.) to raise awareness among the crews.

1.17.1.5.2 Flight analysis

The FSO is responsible for flight analysis. The raw flight data (DAR) are sent to a company that returns the decoded flight data to the FSO. The FSO chose to monitor twenty categories of events, including:

- dual inputs;
- unstable approaches;
- late reduction of the A/THR during landing;
- long flares;
- overshoots.

The flight parameters to be analysed are defined by the company that decodes the QAR data. The FSO has a software program enabling him to identify the number of occurrences in each category of events. These were divided by the operator into three levels of severity according to the values of the selected threshold parameters (details are provided in ***appendix 8***).

The FSO drafts an annual report based on statistical analysis of these twenty categories of events. Only the events with the highest level of severity are taken into account in the annual report to estimate difficulties.

The FSO had concluded the 2012 annual report stating that unstable approaches and dual input events were the categories of events to be given priority. He added that the parameters chosen were not always representative of the actual situation and that an effort to coordinate with the company carrying out the flight analysis was necessary to improve the settings. The detection thresholds for dual input, overshoot and unstable approach were therefore modified in 2013.

In summary, the detailed analysis of flight parameters was not possible at the end of the first year of operation and the FSO had to base his action on trends.

1.17.1.5.3 Safety meetings

The FSO organizes safety meetings (Safety Security and Quality Board Meeting SS & QM) at least once a quarter, involving officials from various departments of the operator (Accountable Manager, Quality Manager, DFO, Head of Training, etc.). These meetings are based on reports from pilots and flight analysis. They aim at identifying measures to improve safety and correct detected deviations. They focus on the following points:

- crew reports;
- flight reports;
- safety organization.

At SS&QM meetings held in 2012 and in February 2013, the following points were addressed:

- a complete overhaul of the operations manual (SS&QM of June 2012);
- the flight analysis highlighted the following:
  - Overshoots
  - Late reduction of the A/THR during landings

On 6 March 2013, the Head of Training sent a letter to instructors asking them to focus training on the above-mentioned issues.

Alimos 06.03.2013
Ref.No: 01/2013

Root Cause Analysis

Following the SS&QB meeting 01/2013, that took place today in the Flight Safety Dpt. I would like to point out that during the first three months of 2012 five (5) aircraft were inducted into **"Hermes Airlines"** AOC. The expansion in equipment and manpower was very big with consequence to have a lot of training flights until the end of August 2012 when the crews were stabilized as far as training and numbers is concerned.
So the trends that were noticed, during that period, were due to high conversion/transition training volume.
Training Dpt. must issue a notice to all Instructors (LCC's, LTC's, TRI's, TRE's, SFI's & SFE's) as well as to all contacted training facilities, during flights and simulator sessions, focusing in paying special attention to the following trends which were noticed during FDM analysis.

- Normal rotation technique and avoidance of under rotation during take-off.
- To avoid long flare during landing and to aim for the 1000 ft. point.
- To avoid late reduction of power during landing.
- To use the correct deployment of reverse thrust, upon landing. (Within 2 secs from touch down)

Excerpt from the letter sent by the RDFE to the instructors

The FSO also explained that flight analysis allowed him to identify the recurring problem of dual input. According to him, the non-application of the control take-over procedure probably resulted from the long experience of the Captains on Boeing 737 where this procedure does not exist. Verbal information was given to crews during recurrent training. The FSO stated that the number of copilots in line flying under supervision increased the recurrence of the phenomenon.

In October 2012, Hermes Airlines in coordination with the HCAA, amended its operations manual Part B - Chapter 13, *"Airline policy"*. It is no longer recommended for crews to perform a precision approach using the selected mode at 160 kt to 5 NM from the runway threshold and then to switch to managed mode. The Airbus procedure, recommending the use of managed speed mode, replaces the previous procedure (successive selections of characteristic speeds based on the aeroplane configurations).

In addition, for the sake of simplification, the stabilization altitude is 1,000 ft regardless of the IMC or VMC conditions.

1.17.1.6 Flight planning and preparation

Scheduling for Hermes Airlines is undertaken by Air Méditerranée. Hermes Airlines nevertheless checks that the flight schedules provided by Air Méditerranée meets regulatory requirements on flight and duty time limitations for crews as well as the requirements relating to rest periods.

A charter flight request from a tour operator is usually issued one week before the flight and confirmed no later than two days before the flight date. The number of passengers is deliberately overestimated to ensure that the catering service will be sufficient.

On the day before a flight, Air Méditerranée staff publish a first set of operational flight plans. The scheduled payload is calculated on the basis of the estimated number of passengers and the standard mass values for passengers and luggage. For long flights approaching the fuel endurance limits of the aeroplane, alternate operational flight plans (with a technical stopover) may be prepared to address a real payload greater than expected.

Planning for flight of 29 March 2013 between Lyon and Dakar

28 March 2013, the day before the flight

Air Méditerranée operations handed over a flight dossier to the crew and Hermes Airlines with flight plans for a direct round trip Lyon-Dakar and Dakar-Lyon.

Alternate flight plans with a stopover in Agadir for the Lyon-Dakar and Dakar-Lyon flights were also included in the flight dossier:

- ❒ BIE 7816 flight from Lyon to Agadir - Estimated Time of Departure (ETD) 06h15 - estimated flight time 02h48 - estimated payload 13,460 kg;
- ❒ BIE 7816 flight from Agadir to Dakar - Estimated Time of Departure (ETD) 09h30 - estimated flight time 02h45 - estimated payload 13,460 kg;

- ❒ BIE 7816 flight from Dakar to Agadir- Estimated Time of Departure (ETD) 13h30 - estimated flight time 02h33 - estimated payload 13,630 kg;
- ❒ BIE 7816 flight from Agadir to Lyon - Estimated Time of Departure (ETD) 16h35 - estimated flight time 03h05 - estimated payload 16,630 kg.

The staff of Air Méditerranée operations sent an email to the flight planning staff of Hermes Airlines on 28 March 2013. It stated that the flight would probably include technical stopovers on the round trip and asked for an augmented crew.

The Lyon-Dakar flight was used to position another Hermes Airlines A320 crew that was to fly from Dakar on 30 March 2013. Hermes Airlines then suggested to the Captain to accept being replaced by this crew on this leg. Flying only the return leg, he would have then met the flight duty period in case of a stopover in Agadir. The Captain explained to investigators that he had rejected the proposal because the other (A320) crew had fewer cabin crew members than his (A321) crew.

29 March 2013, the day of the flight

When preparing the outbound flight to Lyon on 29 March 2013, the crew received a weight and balance sheet indicating an actual payload of 13,125 kg, and 142 passengers, including one baby, and their luggage. The actual payload was less than expected and thus allowed the crew to make a direct flight from Lyon to Dakar.

In Dakar, when preparing the return flight, the weight and balance sheet indicated a payload of 16,592 kg and 174 passengers (171 adults, 2 children and a baby) and their luggage. This payload was 2,782 kg above that provided by the Air Méditerranée operations (13,810 kg). It remained close to the payload specified in the alternate operational flight plans with a technical stop in Agadir (16,630 kg).

Duty time of the crew on 29 March 2013

In its Operations Manual, Chapter 7, Part A, Hermes Airlines defines the flight duty period as the period from one hour before the estimated off-blocks time (reporting time) and 15 minutes after on-blocks time.

	Direct flight Lyon-Dakar-Lyon Planning of 28 March 2013	Flight Lyon-Dakar-Agadir-Lyon Planning of 28 March 2013	Flight Lyon-Dakar-Agadir-Lyon Flight carried out on 29 March 2013
Lyon Reporting time	05h15	05h15	05h15
Dakar	Landing: 12h05 Take-off: 13h15	Landing: 12h05 Take-off: 13h20	Landing: 12h03 Take-off: 13h44
Agadir		Landing: 15h50 Take-off: 16h35	Landing: 16h13 Take-off: 17h02
Lyon	Landing: 18h50	Landing: 19h40	Landing: 19h46
Flight duty period of the crew	**13h50**	**14h50**	**14h55**

During the 2012-2013 winter season, the Lyon-Dakar-Lyon flight was carried out by Hermes Airlines seven times out of 19. Due to the low number of flights performed, the FSO explained that he was not able to gather information about any possible difficulties relating to these flights in relation to duty time being extended in case of a stopover. He added that, at the time of the accident, safety information was not shared with Air Méditerranée, which had performed the other twelve flights[15].

The FSO also explained that because of the economic pressure felt by the staff of the airline, it was considered more appropriate to extend the duty period to 15 hours as provided for by the regulation (*OPS 1.1120, see section 1.17.3.3*) rather than use an augmented flight crew.

1.17.2 Greek civil aviation authorities (HCAA)

Meetings were organized between HCAA and BEA to identify whether Hermes Airlines had encountered difficulties in complying with the regulatory requirements after the issuance of an Air Operator Certificate (AOC).

HCAA continuously monitors twenty operators holding a Greek AOC. Due to staff numbers, each inspector is responsible for overseeing three operators on average. The inspectors usually carry out monitoring actions (checks or inspections) every four or five months.

The Hermes Airlines operations manual was approved in its entirety by HCAA at the end of November 2011 despite inconsistencies in the requirements to fly as copilot or Captain and the note authorising the operator not to meet its criteria if need be. This last inconsistency had not been detected by the HCAA.

A new operations manual correcting all the inconsistencies and differences was filed with the HCAA at the end of 2012 and approved by the HCAA after the accident.

HCAA indicated that the team of inspectors was replaced at the end of 2012. BEA only had access to information relating to monitoring actions carried out by the new team.

[15] It should be noted that Air Méditerranée operates Airbus 321-200s (additional centre fuel tank) having a higher fuel endurance than the SX-BHS (an A321-100), thus reducing the likelihood of having to make a stop at Agadir and thus avoiding the additional service time generated by this technical stopover.

In its 2012 annual report, the management team of Hermes Airlines identified two priorities in terms of training and practice:

- ❒ prevention of unstable approaches;
- ❒ dual input phenomena.

During an audit conducted in April 2013, after the accident, the HCAA asked Hermes Airlines to expedite the implementation of corrective actions in response to the risks identified by the flight analysis. The HCAA described its expectations as follows:

- ❒ *"It is recommended that consideration should be given by management regarding corrective actions that deals with training info. To training organization / instructors (that derived from data that constitute an alert situation). A more detailed and immediate action should be given"*.

1.17.3 Regulatory Aspects

1.17.3.1 General

As of the date of the accident, the applicable regulation was defined by European Commission Regulation (EC) No. 859/2008 (also known as *"EU-OPS"*). The OPS Part 1 of this document prescribes requirements applicable to the operation of any civil aeroplane for the purpose of commercial air transportation by any operator whose principal place of business is in a Member State of the European Union.

On 25 October 2012, the European Commission published (EU) regulation N°965/2012 (AIR-OPS) which lays down technical requirements and administrative procedures related to air operations. The 1st package consisting of annexes I to V of this new regulation was applicable by all Member States of the European Union from 28 October 2014 at the latest.

This 1st package consists of:

- ❒ A Cover Regulation, comprising 10 articles that contain the following elements:
  - a description of the aims and objectives of the regulation;
  - definitions of the terms used in the cover regulation;
  - the applicability of these regulations;
  - the transition measures;
  - the effective date: 28 Oct. 2012;
  - the implementation date (opt-out).
- ❒ Five appendices (or Part) including:
  - Part ORO (Organisation Requirement for Air Operators);
  - Part ARO (Authority Requirement for Air Operations).

The Member States' regulatory authorities must apply common procedures in order to satisfy the need to ensure uniform application of the common requirements. The European Aviation Safety Agency (EASA) has drawn up Acceptable Means of Compliance (AMC), as well as guidance material (GM) to facilitate the required regulatory uniformity with regard to the application of the regulation.

The *“Acceptable Means of Compliance (AMC)“* are non-binding standards adopted by EASA which define the means that may be used to establish compliance with the regulation and how the regulation is implemented. If an operator wishes to use means of compliance other than those specified in an AMC then the operator must submit them to its regulatory authority for approval.

The guidance material (GM) designates the non-binding documents that serve to illustrate the meaning of a requirement or a specification and are used to support the interpretation of regulations and the acceptable means of compliance.

1.17.3.2 Regulation regarding flight crews

EU-OPS

The regulatory requirements regarding flight crews are described in OPS 1 subpart N: *“Flight Crew”*.

The section of Hermes Airlines’ operations manual which relates to the requirements for qualifications, training and inspections complies with the minimum requirements in the regulation.

Thus, a pilot who holds a CPL (minimum of 200 flying hours) and a type rating may fly as a copilot as long as s/he has attended and passed the operator’s conversion course which notably includes, as per the provisions in OPS 1.945:

- ❒ ground training;
- ❒ training and an evaluation on a simulator (two 4-hour sessions);
- ❒ 40 sectors or 100 flying hours on type (line-oriented flight training);
- ❒ a line check.

AIR-OPS

The regulatory requirements regarding flight crew will be described in part ORO subpart *“FC”* (Flight Crew) to replace OPS 1 subpart N: *“Flight Crew”*.

They do not differ from EU-OPS regulation Subpart N with respect to the regulatory requirements for flight crews in the following areas:

- ❒ minimum experience requirements to operate as copilot or Captain;
- ❒ crew composition.

In addition to the previous regulations, GM1 ORO.FC.220 (b) specifies that if an operator’s conversion course cannot be completed without a delay, then the operator should evaluate the flight crew member to determine how much of the course needs to be repeated before allowing the flight crew member to continue with the remainder of the operator’s conversion course.

1.17.3.3 Regulations regarding flight and duty time limitations and rest requirements

EU-OPS

The regulatory requirements regarding flight time limitations applicable to operators are described in OPS 1 subpart Q.

Flight duty period (FDP) is defined as being "…*any time during which a person operates in an aircraft as a member of its crew. The FDP starts when the crew member is required by an operator to report for a flight or a series of flights; it finishes at the end of the last flight on which he/she is an operating crew member*".

OPS 1.1105 stipulates that the maximum basic daily FDP is 13 hours (OPS 1.1105, point 1.3). This FDP must be reduced by 30 minutes for each sector from the third sector onwards with a maximum total reduction of two hours.

The maximum daily FDP can be extended by up to one hour. The maximum number of extensions is two in any seven consecutive days.

OPS 1.1120 on unforeseen circumstances in actual flight operations (commander's discretionary powers) defines a concession from OPS 1.1105.

Taking into account the need for careful control of the instances implied underneath, during the actual flight operation, which starts at the reporting time, the limits on flight duty, duty and rest periods prescribed in this Subpart may be modified in the event of unforeseen circumstances. Any such modifications must be acceptable to the Commander after consultation with all other crew members and must, in all circumstances, comply with the following:

- ❒ the maximum FDP referred to in OPS 1.1105 point 1.3 above may not be increased by more than two hours unless the flight crew has been augmented, in which case the maximum flight duty period may be increased by not more than 3 hours;
- ❒ if, on the final sector within a FDP, unforeseen circumstances occur after takeoff that will result in the permitted increase being exceeded, the flight may continue to the planned destination or to an alternate aerodrome;

The operator shall ensure that:

- ❒ the Commander submits a report to the operator whenever a FDP is increased at his/her discretion or when a rest period is reduced in actual operation;
- ❒ where the increase of a FDP or reduction of a rest period exceeds one hour, a copy of the report, to which the operator must add his/her comments, is sent to the Authority no later than 28 days after the event.

The maximum basic daily FDP of 13 hours may thus be increased to up to 15 hours.

No definition is provided in this regulation of an "*unforeseen circumstance*". The ICAO in its document FRMS – Fatigue Risk Management System (Doc 9966) provides the following definition:

"Unforeseen operational circumstance. An unplanned event, such as unforecast weather, equipment malfunction, or air traffic delay, that is beyond the control of the operator. In order to be considered unforeseen, the circumstances must occur or become known to the operator after the flight has begun (after the moment the aeroplane first moves for the purpose of taking off)".

There are no AMC or GM in the current regulations that relate to flight and duty time limitations and rest requirements.

AIR-OPS

The regulatory requirements (Regulation No 83/2014 of 29 January 2014) regarding flight and duty time limitations and rest requirements are described in part ORO subpart *"FTL"* (Flight Time Limitations). This regulation will apply as from 18 February 2016.

ORO.FTL.205 Flight Duty Period

Operators are especially requested to establish specific procedures for Captains to enable them to reduce the FDP or increase rest periods in special circumstances that might result in significant fatigue.

This regulation also amends the maximum daily FDP. It is still a maximum of 13 hours but decreases with the slot in which the FDP starts.

Maximum daily FDP — Acclimatised crew members

Start of FDP at reference time	1–2 Sectors	3 Sectors	4 Sectors	5 Sectors	6 Sectors	7 Sectors	8 Sectors	9 Sectors	10 Sectors
0600–1329	13:00	12:30	12:00	11:30	11:00	10:30	10:00	09:30	09:00
1330–1359	12:45	12:15	11:45	11:15	10:45	10:15	09:45	09:15	09:00
1400–1429	12:30	12:00	11:30	11:00	10:30	10:00	09:30	09:00	09:00
1430–1459	12:15	11:45	11:15	10:45	10:15	09:45	09:15	09:00	09:00
1500–1529	12:00	11:30	11:00	10:30	10:00	09:30	09:00	09:00	09:00
1530–1559	11:45	11:15	10:45	10:15	09:45	09:15	09:00	09:00	09:00
1600–1629	11:30	11:00	10:30	10:00	09:30	09:00	09:00	09:00	09:00
1630–1659	11:15	10:45	10:15	09:45	09:15	09:00	09:00	09:00	09:00
1700–0459	11:00	10:30	10:00	09:30	09:00	09:00	09:00	09:00	09:00
0500–0514	12:00	11:30	11:00	10:30	10:00	09:30	09:00	09:00	09:00
0515–0529	12:15	11:45	11:15	10:45	10:15	09:45	09:15	09:00	09:00
0530–0544	12:30	12:00	11:30	11:00	10:30	10:00	09:30	09:00	09:00
0545–0559	12:45	12:15	11:45	11:15	10:45	10:15	09:45	09:15	09:00

The regulation relating to FDP extensions in cases of unforeseen circumstances has not changed. Nevertheless, it is mentioned that in case of unforeseen circumstances liable to result in significant fatigue, the Captain should reduce the FDP or increase the rest period as provided in specific procedures developed by the operator.

AMCs and GMs (AMC1, GM1 ORO.FTL.205) are associated to part ORO.FTL. AMC1 ORO. FTL.205 specifies the following:

"UNFORESEEN CIRCUMSTANCES IN ACTUAL FLIGHT OPERATIONS — COMMANDER'S DISCRETION

(a) As general guidance when developing a commander's discretion policy, the operator should take into consideration the shared responsibility of management, flight and cabin crew in the case of unforeseen circumstances. The exercise of commander's discretion should be considered exceptional and should be avoided at home base and/or airline hubs where standby or reserve crew members should be available. Operators should assess on a regular basis the series of pairings where commander's discretion has been exercised in order to be aware of possible inconsistencies in their rostering.

(b) The operator's policy on commander's discretion should state the safety objectives, especially in the case of an extended FDP or reduced rest and should take due consideration of additional factors that might decrease a crew member's alertness levels, such as:

(1) WOCL[16] *encroachment;*

(2) weather conditions;

(3) complexity of the operation and/or airport environment;

(4) aeroplane malfunctions or specifications;

(5) flight with training or supervisory duties;

(6) increased number of sectors;

(7) circadian disruption; and

(8) individual conditions of affected crew members (time since awake, sleep related factor, workload, etc.)".

[16] **Window of Circadian Low** (WOCL) defines the low phase of the circadian rhythm. The part of the circadian biological clock cycle where subjective fatigue and sleepiness are most notable and the most disadvantageous for mental or physical work.

1.17.3.4 Regulation regarding flight data monitoring

EU-OPS

The regulatory requirements regarding flight data monitoring are described in OPS 1.037.

The operator is required to define a flight data monitoring programme to be integrated into its accident prevention and flight safety programme. This programme involves using digital flight data pro-actively to improve aviation safety.

EU-OPS does not provide any indication or method with regards to carrying out flight data monitoring.

AIR-OPS

The regulatory requirements regarding flight data monitoring are described in Part ORO.AOC.130 – Flight data monitoring, which replaces OPS 1.037.

The AMC and GM (AMC1, GM1 and GM2 ORO.AOC.130) are associated and are more precise than those associated with the EU-OPS regulation. They detail the organisation, methods and objectives of the flight data monitoring programme.

1.17.3.5 Regulation regarding the oversight of an operator by its regulatory authority

EU-OPS

The EU-OPS regulation, unlike the AIR-OPS, does not contain any specific requirements regarding the execution of operator oversight operations by the regulatory authorities.

The following documents were considered as references applicable to this subject:

- *ICAO document 8335 - Manual of procedures for operations inspection, certification and continuing oversight – Chapter 9;*
- *JAA Administrative and Guidance Material (JIP) - Part 2 OPS Procedures - Chapter 5 Procedures for assessing the continued competence of an AOC holder, including annex 5.*

The aim of the continuing oversight operations performed by the regulatory authority is to ensure that the requirements specified in the applicable regulation continue to be complied with subsequent to the granting of an Aircraft Operator Certificate. The aim of these oversight operations is not to systematically and exhaustively check all the regulatory requirements; they are instead based on oversight themes that cover all aspects of the operation. In particular, they are not a substitute for the checks carried out by the operator, since the latter holds primary responsibility for the regulatory conformity of the procedures implemented.

Continuing oversight is specifically structured around four types of oversight action, which are performed and followed-up by authorised inspectors:

- programmed oversight actions, on the ground or in flight, described in an annual programme;
- unannounced oversight checks, performed on the ground on the operator's premises;
- checks of the documents sent by the operator to the authority;
- unannounced checks carried out on the aircraft.

During oversight operations, the operator must be able to demonstrate to the regulatory authority that it is in compliance with the regulatory requirements.

AIR-OPS

To comply with Part-ORO.GEN.200 *"Management system"*, the operator must establish a management system which should include in particular:

- a clear definition of the line of responsibility throughout the operator's structure;
- a description of the operator's doctrine and general principles in relation to safety, which together constitute the safety policy;
- identification of the hazards for aeronautical safety resulting from the operator's activities, their assessment and the management of the associated risks, including the measures taken to mitigate the risk and to check their effectiveness.

The management system must be appropriate to the size of the operator and the nature and complexity of its activities, and take into consideration the hazards inherent to these activities and the associated risks.

To comply with Part-ARO GEN 305 "Oversight programme *"the competent authorities"* shall implement oversight based on an assessment of the risks. It states that the oversight programme must be developed to take into account the specific nature of the operator and the complexity of its activities.

The associated AMC and GM (AMC2 ARO.GEN.305(b) *"Oversight programme – Procedures for oversight of operations" and GM1 ARO.GEN.305(b) Oversight Programme – Financial Management"*) describe the elements to be considered during audits and inspections.

It states that in the first months of a new operation, the oversight inspectors should be particularly alert to the following points:

- application of irregular procedures;
- inadequate facilities or equipment;
- ineffective management control of the operations;
- indications of a significant degradation in the organisation's financial resources.

Operational Suitability Data (OSD)

In January 2014 the regulation introduced the notion of OSD. The principle of OSD requires that the aircraft manufacturer supply a certain quantity of data in order to ensure safe operation of aircraft.

These data are approved by EASA in the context of type certification. They are then used by operators and training organisations. These data include:

- the minimum equipment list MMEL;
- type-specific data for training pilots, cabin crew, and maintenance teams;
- data for simulator validation.

The OSD was introduced with the aim of better understanding the specific features of the aircraft as identified during type certification, during operational use.

1.17.3.6 Oversight of HCAA by EASA

In the framework of its responsibilities, EASA conducts inspections of national authorities (in order to ensure that the latter meet their mandatory obligations and oversee the correct application of the European Regulation by operators under their responsibility.

From 7 to 9 March 2012, EASA conducted an inspection of the HCAA. As part of this inspection, EASA also carried out an inspection of Hermes Airlines.

European Regulation EU 628-2013, on working methods of the European Aviation Safety Agency for conducting standardisation inspections and for monitoring the application of the rules of Regulation (EC) No 216/2008 of the European Parliament and of the Council, specifies in article 21 *"Access to information contained in inspection reports"*:

"3.Where information contained in an inspection report relates to ongoing safety investigations conducted in accordance with Regulation (EU) No 996/2010 of the European Parliament and of the Council, that information shall be made available without delay to the authority in charge of the safety investigation".

On 24 June 2013, in accordance with article 21 previously mentioned, the BEA asked EASA to supply it with the report on the last inspection that it had carried out.

On 23 July 2013, EASA supplied the BEA with the Hermes Airlines inspection report from March 2012. EASA also supplied BEA with a redacted version of the HCAA inspection report which did not include the deviations noted. The full report was only supplied to the BEA on 29 May 2015 during the draft consultation phase of this Final Report, which included a paragraph relating to EASA's position which did not appear to be in accordance with article 21 of EU 628-2013.

The report that was finally supplied by EASA includes some points on EASA's preoccupations with regarding HCAA's ability to effectively ensure its role as oversight authority of its operators due to a drop in staff numbers and an increase in workload.

It also specifically mentioned that:

- the number of Flight Operations Inspectors (FOI) had been reduced by three-quarters between 2010 and 2012;
- the HCAA was not able to undertake its oversight programme (75 % of inspections had been performed);
- the HCAA was not able to ensure that operations manuals from its operators remained up-to-date and effectively reflected any possible changes within one of its operators' operational activities.

1.18 Additional Information

1.18.1 Interviews

1.18.1.1 Captain

The Captain said he had planned to fly the round trip from Lyon to Dakar in only two legs. He was PF on the outbound flight during which he tried to save fuel using the pre-determined point (PDP) procedure. He added that the Lyon-Dakar flight required a lot of attention because he kept looking for the optimal level.

During the stopover in Dakar, he was preparing the return flight when he was informed that the Zero Fuel Weight had increased from 63 tonnes to 65.9 tonnes. The return flight could not be direct. He said he called Air Méditerranée operations in France and decided to make a technical stopover in Agadir. He said he had found that there would be some delay and decided to take more fuel to increase speed by 2 Mach points (0.80) to make up some time.

The copilot was PF for the Dakar-Agadir-Lyon flight. The stopover in Agadir lasted thirty minutes. When arriving in Lyon, they were radar vectored for a landing on runway 36R. The Captain stated that the RVR was then 2,000 meters and that 1,200 meters was called out later. The Captain added that he personally adjusted the heading to avoid cloud masses. These adjustments resulted in intercepting the localizer slightly too high for the glide slope intercept. He said he used the speedbrakes to increase the rate of descent and reduce speed. When capturing the glide slope, he tried to reduce the speed by extending the landing gear. He then completed the *"before landing"* checklist to stabilize at 500 ft. He said that he had the entire runway in sight from a distance he estimated at about 7 NM. He added that when approaching the minima, the beacon lights of the runway were blurred. The PF disconnected the autopilot.

The Captain explained that when they arrived over the runway they lost sight of the opposite end of runway 36R because of a fog patch. He stated that the PF began the flare at that moment and the aeroplane was very close to the ground. He explained that he felt that the aeroplane did not touch down but was floating above the runway. With the fog, everything seemed difficult and he was worried. He added that he did not envisage rejecting the approach or the landing. He saw a taxiway to his left and so thought it was the first one. He realized that the aeroplane would not touch the runway in the touchdown zone 300 meters from threshold 36R.

After touching down, he decided to apply manual braking and to fully deploy the thrust reversers instead of using the autobrake mode (LOW) which was initially engaged. He stated that during the landing roll, he did not feel any deceleration and tried to stop the aeroplane on the runway. He indicated that the aeroplane was too fast to clear the runway using the last taxiway and therefore decided to stay on the runway centre line.

He indicated that, on approaching the opposite threshold, he first steered to the right to avoid the touchdown zone of the opposite threshold and keep maximum braking efficiency as that zone was contaminated with tyre rubber. He then steered to the left during the runway excursion so as not to collide with the localizer antennae.

When the aeroplane came to a stop, he found that no fire warning lights were lit and that the brake temperature was low. He contacted the controller, who informed him that the rescue and fire-fighting services (RFFS) had been dispatched. He said that he had instructed the chief flight attendant to keep the passengers in their seats as there was no justification for an emergency evacuation. He added that he had started the APU and stopped the engines and asked for the after-landing checklist. He added that the passengers were calm and waited for the buses and boarding bridges to disembark.

The Captain said that he had had no rest period during the three legs of the flight. He added that he had already flown twice with this copilot and stated that the latter was inexperienced and required special attention throughout the flights. He added that he sometimes had difficulty in understanding him because of his accent. He stated that he was confused by the fact the controllers spoke French with the French-speaking pilots.

He had already flown an Agadir-Dakar flight as Captain with an augmented flight crew.

He explained that he had not noticed the tailwind during the descent and approach, and that he did not use the ND to obtain information about the wind. He stated that he did not check the QNH setting because they were flying high and too fast and were trying to reduce speed. He explained that he mostly focused his attention on the outside. During his interview, the Captain stated that, according to him, the maximum speed stabilization value was equal to the approach speed +20 kt.

He explained that he had never carried out a Cat III ILS approach because he was not yet qualified at Hermes Airlines to perform this type of approach. With his previous employer, he had only carried out Cat II ILS approaches, nor had he carried out missed approach at low altitude.

He added that he received Airbus training on taking over control during his type rating. The training consisted of a theoretical course on system operation and associated procedures.

1.18.1.2 Copilot

The copilot stated that he had left Valencia (Spain) on 28 March 2013 at 06 h 05 for Paris Charles de Gaulle, from where he flew to Lyon. He arrived at his hotel in Lyon at around 14 h 00.

On 29 March 2013, he presented himself at Lyon airport at around 04 h 00. He said he had had a good night's sleep and felt rested. During flight preparation, he expected there to be additional crew. The Captain called Operations and decided to undertake the flight with a two-man crew. They discussed the possibility of a stopover in Agadir.

During the Lyon-Dakar flight, the Captain was PF. They used the pre-determined point procedure (PDP). The copilot said he did not take a *"controlled rest"* during this leg. He added he did not like this kind of rest and he preferred to have a good night's sleep the night before. In Dakar, a delay in the supply of food and zero fuel weight increase of 2.9 tonnes prompted the Captain to make a stopover in Agadir. The copilot was the PF for the Dakar-Agadir-Lyon return flight.

On approach to Lyon, the copilot said that it was he who listened to the ATIS to train himself in this exercise. He noted the information he had understood on a sheet of the flight dossier. He remembered a visibility of 400 meters, an RVR of 2,000 feet and a broken ceiling at 100ft. He was not aware of the strong tailwind conditions announced in the ATIS, nor did he notice this trend on the ND.

He explained that he then provided the approach briefing for the Captain. He informed the Captain of his concerns about the meteorological conditions, telling him they were almost bound to make a Category II ILS approach. The Captain replied that the RVR allowed a Category I ILS approach. He did not refer to this point later.

During the approach, he explained that he chose to manage the speed in selected mode because other pilots had recommended that option. They felt that this method was more effective than the use of managed mode. He stated that he did not know how he chose the speed values he selected. The interview with the PF showed that his knowledge of certain aircraft systems and procedures was inadequate. He seemed not to know:

- ❒ the procedure to intercept the glide slope from above with V/S mode;
- ❒ the meaning of characteristic speeds (Green Dot, S and F);
- ❒ the stabilization criteria (speed, vertical speed, pitch attitude, etc.).

Once on the glide, the copilot found it difficult to reduce speed. He therefore used the speed brakes, flaps and landing gear in order to stabilize at 500 ft He saw the full length of the runway at a distance of 7 to 8 NM from threshold 36R. He stated that due to the high humidity, the beacon lights were blurred.

He estimated that the aircraft had stabilized as it passed 500 ft during descent. He disconnected the autopilot at 200 ft. He did not notice any increase in engine N1 after passing 150 ft.

At 50 ft, the appearance of a layer of fog above the opposite threshold made it impossible for him to clearly distinguish it. He did not consider aborting the approach. In his previous flights, he had never made a missed approach or a diversion.

At about 20 ft, he began the flare with the same technique as he normally used. He considered that the aeroplane was not descending. He made a long flare and disconnected the auto-thrust when he heard the synthetic voice call out *"RETARD"*. He did not notice that the Captain was using his sidestick until he heard the *"Dual Input"* warning.

After touchdown, the Captain took over the controls and energetically braked by keeping the thrust reversers deployed.

After stopping the aeroplane off the runway, the Captain coordinated with the tower controller and firefighting services. The Captain felt that there was no risk of fire or danger to the passengers and it was decided to wait for the gangways to disembark the passengers.

The copilot added that he had flown with the Captain and that the latter was his CRM instructor. He had never undertaken the Lyon-Dakar flight but had already flown long distances with an augmented flight crew.

He added that he had never carried out a Cat II or Cat III ILS approach, nor had he made a missed approach or an in-flight diversion.

1.18.2 Previous events

The following chapters deal with some events reported to the BEA. Details are included in ***appendix 9***.

1.18.2.1 A/THR anomaly

- Serious incident on 11 July 2011 in Bamako (Mali) involving the Airbus A320-214 registered 6V-AII operated by Air Senegal.

As of the date of publication of this report, the Safety Investigation report on this incident has not yet been published by the Malian authorities.

1.18.2.2 Unstable approach and runway excursion

- Accident on 16 October 2012 on the Lorient Lann Bihoué aerodrome (56) involving Bombardier CRJ-700 registered F-GRZE operated by Brit Air[17].

1.18.2.3 Dual input

- Serious incident on 28 May 2006 in Zaragoza (Spain), Airbus A320[18].
- Accident on 14 February 2012 in London Luton, Airbus A319[19].

1.18.2.4 Dual input phenomenon mentioned in the ASR database of the DGAC

The DGAC database indicates that 145 mandatory incident reports (ASR) by the crews of French operators involving the triggering of *"DUAL INPUT"* alarms have been recorded.

Cases of dual input mainly follow the scenarios listed below according to their frequency of occurrence:

- ❒ during the final approach phase or the flare when the copilot is PF. In many cases the copilot is on line flying under supervision;
- ❒ during a missed approach;
- ❒ during turbulence;
- ❒ due to involuntary input of one of the crew members on his sidestick.

1.18.2.5 Study on Aeroplane State Awareness during Go-Around

In 2013 the BEA published a study on loss of control on the approach during a go-around. One aspect mentioned in this study deals with the wind information provided to crews[20].

(17) http://www.bea.aero/docspa/2012/f-ze121016.en/pdf/f-ze121016.en.pdf

(18) http://www.fomento.gob.es/NR/rdonrdonlyres/21313F00.98A2_4F14_A582_4D0A8FA188/2006.029.IN.ENG.pdf

(19) https://www.gov.uk/aaib-reports/airbus-a319-111-g-ezfv-14-february-2012

(20) http://www.bea.aero/etudes/asaga/asaga.php

1.18.2.6 Serious incident on 11 April 2012, at Lyon St-Exupéry, Airbus A320 SX-BHV operated by Hermes Airlines

In November 2014, the BEA published a report on the serious incident on 11 April 2012 to the Airbus A320 registered SX-BHV on approach to runway 36L at Lyon Saint-Exupéry Airport (France)[21].

1.18.3 Actions to Improve Safety

1.18.3.1 European Action Plan for the prevention of runway excursions

A working group coordinated by Eurocontrol and consisting of operators, manufacturers and authorities defined a European Action Plan for the Prevention of Runway Excursions (EAPPRE)[22]. Published in January 2013, this plan contains recommendations and guidelines for the attention of airport operators, aircraft operators, air navigation service providers, aircraft manufacturers, civil aviation authorities and EASA. Some of these recommendations are relevant in the case of the runway excursion that occurred in Lyon.

Operational measures for the prevention of runway excursions

1. "The aircraft operator must publish company criteria for stabilized approaches in their Operation Manual. Flight crew should go-around if their aircraft does not meet the stabilized approach criteria at the stabilization height or, if any of the stabilized approach criteria are not met between the stabilization height and the landing. Company guidance and training must be provided to flight crew for both cases."

2. "The aircraft operator should publish a standard operating procedure describing the pilot non flying duties of closely monitoring the flight parameters during the approach and landing. Any deviation from company stabilized approach criteria should be announced to the pilot flying using standard call outs."

3. "The aircraft operator must publish the company policy, procedure and guidance regarding the go-around decision. It should be clearly stated that a go-around should be initiated at any time the safe outcome of the landing is not assured. Appropriate training should be provided."

4. "The aircraft operator should publish the standard operating procedure regarding a touchdown within the appropriate touchdown zone and ensure appropriate training is provided."

On-board equipment

1. "The aircraft operator should consider equipping their aircraft fleet with technical solutions to prevent runway excursions."

2. "On-board real time performance monitoring and warning systems that will assist the flight crew with the land/go-around decision and warn when more deceleration force is needed should be made widely available."

3. "Develop rulemaking for the approval of on-board real-time crew alerting systems that make energy based assessments of predicted stopping distance versus landing distance available, and mandate the installation of such systems."

(21) http://www.bea.aero/docspa/2012/sx-v120411.en/pdf/sx-v120411.en.pdf

(22) http://www.skybrary.aero/index.php/European_Action_Plan_for_the_Prevention_of_Runway_Excursions_(EAPPRE)

D-ATIS

1. "Consider equipping for digital transmission of ATIS, as appropriate."

2. "The aircraft operator should consider equipping their aircraft fleet with data-link systems (e.g. ACARS) to allow flight crews to obtain the latest weather (D-ATIS) without one pilot leaving the active frequency."

Flight analysis

1. "The aircraft operator should include and monitor aircraft parameters related to potential runway excursions in their Flight Data Monitoring (FDM) program."

2. "Ensure aircraft operators as part of their Safety Management System identify and promote appropriate precursors for runway excursions that could be used from their flight monitoring data or safety data set as safety performance indicators that could be used to monitor the risk of a runway excursion. Encourage them to share safety related information based on agreed parameters."

The European Aviation Safety Plan[23] (EASP), managed by EASA, in its 2013-2016 version, asks that States examine the plan:

[23] http://easa.europa.eu/system/files/dfu/sms-docs-European-Aviation-Safety-Plan-%282013-2016%29--v1.0-Final.pdf

European Aviation Safety Plan 2013-2016

New actions

Runway Excursions

Runway excursions

There are at least two runway excursions each week worldwide. ICAO (Global Runway Safety Symposium 2011) has noted that the rate of runway excursions has not decreased in more than 20 years. A wide array of aviation stakeholders have requested to address the risk of runway excursions.

The European Action Plan for the Prevention of Runway Excursions (EAPPRE) developed by the European Working Group for the Prevention of Runway. Excursions (EWGPRE) under the aegis of ECAST is now available. The recommendations contained in the Plan stem from the findings of a Eurocontrol study of runway excursions in the European region. The study findings made extensive use of lessons from more than a thousand accident and incident reports.

Key findings:

- The risk of a runway excursion is increased by wet and contaminated runways in combination with gusts or strong cross or tail winds;
- Practices such as landing long and or late or ineffective deployment of braking devices are highly relevant to runway excursion risk;
- The majority of runway excursions occur on a dry runway;
- In the cases of both landing and take-off excursions, the primary opportunity to prevent a runway excursion is in the decision making of the flight crew to go around or, once at or approaching V1, continue a take-off.

Key enablers:

- Local Runway Safety Teams;
- Aeronautical Information publishers;
- Participation in lesson sharing;
- The uniform and consistent application of ICAO provisions and EU regulations;
- Training;
- Know your aircraft type performance limits for the aerodrome concerned;
- Communication of the recommendations and guidance materials contained in the European Action Plan for the Prevention of Runway Excursions to all operational staff.

Proposed action(s)

Two recommendations are proposed that encompass action at both Member States and Agency level.

A. On one hand Member States should address the recommendations made by the EAPPRE via their State Safety Programmes in coordination with service providers and industry organisations.

Page 22 of 65

ISO 9001:2008 Certified

European Aviation Safety Plan 2013-2016

B. On the other hand EASA should study possibilities for mitigating the risk of runway excursions through regulation, starting by evaluating the proposals made by the EAPPRE.

It has to be noted that as part of the second extension of the Agency's remits to ATM and aerodromes there are proposals in the process of being adopted that will contribute to this effort.

New Safety Actions						
No.	**Issue**	**Actions**	**Owner**	**Dates**	**Type**	**Deliverable (Measure)**
AER1.9	*Runway excursions*	Member States should address the recommendations made by the EAPPRE via their SSPs in coordination with service providers and industry organisations	MS	Per Plan	SP	Report on progress
AER1.10	*Runway excursions*	EASA should study possibilities for mitigating the risk of runway excursions through regulation, starting by evaluating the proposals made by the EAPPRE	EASA	Per Plan	R	Report on progress

1.18.3.2 Improved crew training

1.18.3.2.1 Implementation Pilot Training Group (IPTG)

EASA has also set up a working group (IPTG) aimed at reducing disparities in the level of pilot training in Europe by increasing standardization.

IPTG, among other things, defined eight priority areas for optimization of the following deficiencies:

- significant differences in the training of OPS/FTL inspectors;
- significant differences in the selection criteria for line flying supervisors and line check-pilots;
- lack of basic educational experience of the SFE/TRE, and their weakness in reliably establishing trainees' areas for improvement;
- the lack of robustness of the training and control process, and too great a share of resources dedicated to checks rather than training;
- inadequate SOPs, and deficiencies in their enforcement by the crews;
- the use of outside instructors and not using airline SOPs;
- a lack of consideration of the actual experience of trainees in training and the discrepancy between the actual experience of trainees and the experience needed in the operating environment of the airline.

1.18.3.2.2 Evidence Based Training (EBT)

Analysis of recent flight safety data brought to light the following points:

- human factors, in particular non-technical skills ,such as leadership/teamwork and communication are significant in the occurrence of undesirable events The quality of manual flying and the ability to monitor the flight parameters adequately are regularly mentioned as contributing factors in a large number of accidents and serious incidents on 4th generation aeroplanes;
- training time is not necessarily allocated to subjects dealing with the risks that are most frequently encountered in operational situations.

A change in the way training and recurrent training is handled was judged to be necessary by the industry, based on IATA initiatives.

Evidence Based Training (EBT) which has been part of ICAO documentation since 2013 resulted from the IATA initiative in the area of crew training and evaluation (ITQI Project). EBT provides an answer to these problems crew training and evaluation problems by:

- recommending that crews develop a wide range of operational skills in both technical and non-technical areas;
- recommending a choice of scenarios based on real events which are drawn from all events encountered in operations and the associated risks with them, EBT aims specifically to propose initial and recurrent training programmes based on:
  - an extended analysis of safety data available on a worldwide basis: all training subjects are thus justified by a need to attenuate an identified risk;
  - prioritisation of identified risks via safety management systems (SMS) for airlines based on their own operating conditions.

This was intended to ensure that crews are able to perform effectively when they are faced with realistic threats, that's to say close to those encountered in line operations.

EBT is thus a global crew training and evaluation system based on operational data. This system develops and evaluates a pilot's overall ability to employ a wide range of basic skills, rather than a measurement of individual ability to perform manœuvres of manage specific situations.

The conclusions of the IATA/IFALPA/ICAO group are available in three documents[24]:

- *Data report for Evidence-Based training (IATA);*
- *ICAO doc 9995 "Manual of Evidence-Based training";*
- *Evidence-Based Training Implementation Guide;*

[24] http://www.iata.org/whatwedo/ops-infra/itqi/Documents/ebt-implementation-guide.pdf

In the report *"Data Report for Evidence Based Training (EBT)"*, IATA specifically indicates that:

- **1 - Landing**

  The landing phase is highly complex and is the phase of flight that statistically involves the highest number of accidents. The current trend is upwards.

  According to the report, the pursuit of an unstable approach is the third most common source of discrepancies in the application of procedures; the same study indicates that for the time being pilot errors during landing are not adequately detected. The study also indicates that the ability of pilots to land is built up with experience, and deteriorates without sufficient practice. It highlights the need to improve training on the environmental and aerodynamic effects associated with landing. It recommends that the training conditions be realistic and show the time and the right way to decide to carry out a missed approach or balked landing.

- **2 - Unstabilised approaches**

  Unstabilised approaches are a global problem (3-4% of approaches). Statistically they lead to more serious events than those occurring after a stabilized approach. Pilots indicate that they pursue these approaches specifically because they think they are less in danger than if they carry out a go-around.

The report recommends targeted training of the *"EBT"* type on strengthening and stabilizing the quality of the interruption of the approach. It recommends improving the rigor in the application of procedures and the pilots' confidence in their ability to go around satisfactorily.

■ 3 - Missed approach and balked landing

The low rate of missed approaches due to an unstable approach generally finds its origin in a form of surprise, adverse conditions and altitudes and levels of energy different from those encountered during training.

The report highlights that Civil Aviation authorities in general do not currently have a strategy for an adaptation of training under realistic conditions close to operation.

■ 4 - Error management

The study indicates the importance of monitoring and error detection capabilities among crews. Error management capabilities degrade over time. These training courses are generally absent from airline training, and are not formally required by the authorities.

EASA has stated that in 2015 it will initiate two rulemaking tasks (RMT 0559 and 0600) relating to EBT. The results of these rulemaking tasks should be known in 2017.

1.18.3.3 EASA Rulemaking Task relating to on-board systems to prevent runway excursions

On-board systems to warn of a risk of a runway excursion are already available as an option on Airbus A319/A320/A321 - A330/340 - A380 aircraft.

Honeywell has also developed a similar system called Smartlanding.

EASA has launched a rulemaking task (NPA 2013-09 *"Reduction of runway excursions"* of 10 May 2013)[25], the objective of which is to define certification standards and possibly on mandatory installation of landing aids (Runway Overrun-Awareness and Avoidance Systems, ROAAS) on existing aeroplanes used in public transport (CS 25 and CS 26).

[25] http://easa.europa.eu/system/files/dfu/NPA%202013-09.pdf

On 16 April 2015, EASA published the responses to the NPA in a CRD[26](Comment-Response Document 2013-9 *"Reduction of runway excursions"*). It is planned to publish a new NPA. The work on this this regulatory are currently scheduled to be completed by 2017.

[26] https://www.easa.europa.eu/system/files/dfu/http://www.bea.aero/docspa/2012/sx-v120411/pdf/sx-v120411.pdf CRD%202013-09.pdf

1.18.3.4 LOSA (Line Operations Safety Audit) and TEM (Threat and Error Management) Concepts

The University of Texas, in partnership with Continental Airlines, developed a structured observation program for the operational activities of an operator LOSA). The program is based on observers specially trained to collect data on the behaviour of flight crews and contexts of regular flights.

During in-flight audits, observers record and encode potential safety threats, how these threats are addressed, the errors they cause, how the flight crew responds and specific behaviour patterns typically associated with accidents and incidents. Amongst other things, a LOSA audit can be used to:

- identify threats to the operational environment and operating conditions;
- assess the impact of training on operation;
- check the quality and usability of procedures;
- identify any deviations by pilots in operation.

This program can be used to implement measures facilitating the management of human errors in operational situations (TEM).

TEM is a philosophy designed to allow crews to:

- identify the threats they face and identify the errors that may be committed;
- determine one or more strategies suitable for the identified threats and errors;
- decide and implement the strategy that seems most appropriate;
- modify the strategy if it seems no longer suitable.

The briefing activates the crew’s short-term memory. They are therefore able to take into account the day’s threats and strategies for managing them.

In 1999, ICAO approved LOSA as a primary tool for developing counter-measures to manage human error in aviation operations (*Doc 9803 - LOSA (line operations safety audit*).

The document entitled *“LOSA Archive Report: 10 Target Areas for Evidence Based Training - IATA ITQI EBT Working Group report - April 2010“* deals in its first section with unstable approaches.

Statistics from the LOSA database based on 8,375 observations flights made between 2003 and 2010 show that 4% of approaches are unstable (according to the criteria of the operator). But the crew decided to continue the approach in 97% of the cases:

Unstable Approach Outcomes

Event	Outcome of the Event
4% of flights in LOSA Archive have an Unstable Approach	87% continued the approach and landed without issue
	10% continued the approach and landed long, short, or significantly off centerline
	3% executed a missed approach (9 of 337 unstable approaches observed)

LOSA audits show that the majority of the crews often begin an approach with the objective of stabilizing at 1,000 ft but confusion can be created in the cockpit when this goal is not achieved:

- unfamiliarity with the definitions of IMC or VMC conditions (choice of stabilisation heights of 500 or 1,000 ft);
- unfamiliarity or difficulties among crews in remembering the stabilisation criteria;
- difficulties among crews in interpreting procedures (SOP) when used to continue the approach if the corrections of deviations to be undertaken are deemed *“acceptable“*;

- lack of established operator procedures or unfamiliarity among crews of these procedures when they exist if the approach becomes unstable after crossing stabilisation heights (rejected landing procedure).

LOSA observations also indicate that the unstable approaches are mainly due to:

- insufficient integration of wind conditions (tailwind component, wind shear, wind gradient and turbulence);
- non-compliant approaches: ATC instructions and acceptance of these instructions by the crews (altitudes or speed constraints) does not leave them enough time to plan, prepare and perform a stabilised approach.

1.18.3.5 Measures taken in relation to A/THR behaviour

Airbus was first informed of an uncontrolled increase of the A/THR in September 1996 by Air Inter.

A correction was made during the introduction of the new FMGC standard[27] in 2001. This required a change of hardware equipment.

[27] The second generation (2G) Flight Guidance standard *"C8/I8"*.

In May 1997, a service information letter (SIL22-039 R1) was sent to all of the operators.

The latest R4 revision is dated October 2011. The letter lists the various FMGC standards and provides a description of functional changes (hardware and software) for each standard. In particular it states that the new standard solves the problem of uncontrolled increase of the A/THR below 150 ft when the aircraft is in an overspeed situation with A/THR engaged and the autopilot disengaged:

"Addresses thrust increase issues occurring below 150ft while aircraft is in overspeed situation, with autopilot off and Autothrust (A/THR) engaged".

When an operator is interested in replacing an FMGC, Airbus sends it a service bulletin. None of the previous operators of the SX-BHS (Swissair and Air Méditérannée) had taken this initiative. Hermes Airlines were unaware of the existence of the service information letter (SIL22-039 R4) because the previous operator had not forwarded it to them.

Approximately 385 aircraft used by about 90 operators in the world are equipped with the FMGC standard liable to produce this anomaly.

Following the accident, on 31 July 2013 Airbus issued a special bulletin (***appendix 10***) for the attention of operators whose aircraft were equipped with the FMGC in question. The bulletin proposed a commercial offer to facilitate and encourage the replacement of the equipment.

In June 2014, Airbus informed the BEA that the operators were studying the proposed replacement. This concerned about 250 aircraft. 36 aircraft were modified

EASA

On 14 November 2013, EASA published a safety information bulletin (SIB No. 2013-19) on the behaviour of the A/THR (***appendix 10***). The service information letter mentioned Airbus' proposal to replace the first-generation FMGC. The letter also provided information about the accident in Lyon and stated that the unwanted behaviour of the A/THR contributed to the accident. EASA issued the following three recommendations:

- ❐ crews must apply the normal and abnormal procedures in the aircraft flight manual (AFM) because they take into account the conditions that can affect landing;
- ❐ crews must remember that the decision to discontinue the approach when unstable is the safest decision. Landing in conditions of excessive overspeed, tailwind and contaminated runway is all the more difficult;
- ❐ operators should replace the old generation FMGC to prevent the occurrence of the identified abnormality in the behaviour of the A/THR.

1.18.3.6 Actions taken by DGAC

On 18 September 2013, the DGAC published safety information letter DGAC n°2013/09.

INFO SÉCURITÉ DGAC
N° 2013/09

Une info sécurité est un document diffusé largement par la DGAC, non assorti d'une obligation réglementaire dont le but est d'attirer l'attention de certains acteurs du secteur aérien sur un risque identifié.
Cette info sécurité est disponible sur : http://www.developpement-durable.gouv.fr/Info-securite-DGAC.html

Opérateurs concernés	• Exploitants d'avions en transport aérien commercial • Prestataires de services de navigation aérienne
Sujet	Vitesse en approche finale
Objectif	La DGAC : • attire l'attention des exploitants d'avions ainsi que des prestataires de services de navigation aérienne, sur les risques associés à une vitesse en finale trop élevée • recommande une vitesse maximale de 180kt en régression, à 8NM du seuil de la piste.
Contexte	De nombreux accidents en approche, à savoir des sorties de piste longitudinales, des pertes de contrôle en courte finale, voire des CFIT[1] peuvent être mis en relation avec des vitesses élevées en début d'approche finale. Ces vitesses peuvent être notamment la conséquence : - d'un souhait de l'équipage de limiter au maximum un retard ; - en amont de l'approche finale, d'une mauvaise estimation par l'équipage ou par l'ATC des possibilités de résorption d'énergie de l'appareil ; - d'une demande ou d'une sollicitation de l'ATC de maintenir une vitesse élevée dans l'objectif d'augmenter la capacité instantanée. La nécessité de fortement ralentir l'avion avant le plancher de stabilisation conduit à une importante diminution de la disponibilité des pilotes, favorable à la focalisation sur un paramètre en particulier. Les conséquences immédiates d'une telle situation sont principalement de deux ordres : **1) Difficulté de résorption de l'énergie :** Au-delà d'une certaine valeur, la réduction de vitesse devient délicate, la sortie des volets n'étant parfois plus possible au moment souhaité pour éviter un dépassement de vitesse maximale volets sortis (VFE). Cela est particulièrement vrai sur les avions modernes présentant une plus grande finesse. La nécessité de retarder certaines actions (sortie des volets…) et check-lists conduira ainsi à une approche d'autant plus précipitée que le temps disponible pour les réaliser sera plus court. La présence d'une composante de vent arrière en finale aggrave la situation. L'analyse de vol et les rapports d'incidents montrent que les critères de stabilisation[2] retenus par les exploitants ne sont pas toujours respectés, notamment lorsque la vitesse est en cours de régression vers la vitesse cible. Il convient donc de s'assurer que la gestion de la trajectoire en amont permettra de respecter ces critères de stabilisation : c'est l'objectif de cette info sécurité. Parmi les cas extrêmes, l'accident d'un Boeing 737-400, le 7 mars 2007 à Jogjakarta en Indonésie, illustre bien la problématique décrite dans ce paragraphe : au FAP, à 6,6NM du seuil de piste, la vitesse indiquée était de 254kt et la vitesse sol de 286kt, avec 950 pieds d'excès d'altitude. La suite de l'approche n'a pas permis de résorber cet excès initial de vitesse et l'avion est sorti de piste (voir lien en annexe). L'incident grave survenu à un A310 à Orly en 1994 (voir lien en annexe) est un autre exemple des conséquences possibles d'une approche initialement beaucoup trop rapide : la remise de gaz, initiée aux alentours de 1000 pieds sous une forte charge de travail, a conduit à un départ en chandelle puis à un décrochage récupéré de justesse.

[1] CFIT : Controlled Flight Into Terrain
[2] La Consigne Opérationnelle n° F-2008-01 (http://www.developpement-durable.gouv.fr/IMG/pdf/GUIDEBPDBLEFR.pdf) a rendu obligatoire pour les exploitants d'avions en transport aérien commercial la mise en place d'un plancher de stabilisation et d'une annonce positive au passage de celui-ci.

Toute remarque quant à la mise en œuvre des mesures proposées dans cette info sécurité DGAC est à adresser à : rex@aviation-civile.gouv.fr 1

Info Sécurité DGAC n° 2013/09 - *Version n°1 du 18/09/2013*

	2) Passage sous la vitesse d'évolution : Une vitesse élevée en amont de l'approche finale nécessite l'utilisation de tous les moyens de décélération disponibles, et notamment le maintien des moteurs au régime ralenti de façon prolongée afin de ralentir vers la vitesse d'approche. Or, dans une phase favorable au phénomène de focalisation et pendant laquelle la charge de travail s'intensifie (sortie des volets, changements de fréquences, check-lists…), la surveillance de cette vitesse en cours de régression peut être perturbée, menant ainsi à un passage non détecté sous la vitesse d'approche. Compte tenu du temps nécessaire à la remise en puissance des moteurs (notamment sur les avions à réaction), une perte de contrôle de l'avion peut en découler. Pour l'illustrer, et bien qu'une analyse de l'accident du Boeing 777 à San Francisco, le 6 juillet 2013, ne soit pas disponible à la date de parution de cette info sécurité, les données préliminaires rendues publiques par le NTSB font notamment état : - d'une demande par l'ATC de maintenir 180kt jusqu'à 5NM ; - de moteurs au régime ralenti ; - du passage à 500 pieds, 34 secondes avant l'impact, à 134 nœuds (la vitesse de référence était de 137kt) ; - de l'avancée des manettes 8 secondes avant l'impact, à 125 pieds et 112 nœuds. De façon similaire, l'accident d'un Boeing 737 à Amsterdam en 2009 résulte en particulier d'une approche avec moteurs au ralenti pour résorber la vitesse initiale élevée (voir lien en annexe). Par la perturbation de l'enchainement des actions et la diminution de la disponibilité des pilotes qu'il engendre, le maintien d'une vitesse élevée en début d'approche finale peut avoir de multiples conséquences que l'analyse des ASR reçus par la DGAC fait régulièrement apparaître.
Actions recom-mandées	**En conséquence, la DGAC recommande** ➢ **aux exploitants d'avions en transport aérien commercial :** • **d'établir des procédures et des limites opérationnelles en approche permettant de favoriser le respect des critères de stabilisation. La DGAC recommande un seuil de vitesse de 180kt à 8NM de la piste, <u>en régression</u> vers la vitesse d'approche.** • **d'adapter ces limites, notamment en cas de présence de composante de vent de face ou arrière significative ou d'approche exigeant une pente supérieure à 3° ;** • **de rappeler ces limites durant le briefing arrivée.** ➢ **aux prestataires de services de navigation aérienne :** • **pour un avion approchant à 3°, de considérer que toute clairance liée à la vitesse devrait être compatible avec un passage à 8NM du seuil à une VI maximale de 180kt <u>en régression</u> ;** • **en cas de présence de composante de vent arrière significative (10kt ou plus) durant la finale, de considérer ce même seuil pour la vitesse sol ; de même, en cas de vent de face significatif, ce même seuil sera acceptable pour la vitesse sol ;** • **de ne pas proposer de maintenir une vitesse élevée entre 8NM et la piste ;** • **pour une pente d'approche supérieure à 3°, de considérer que la gestion amont éventuelle de la vitesse par le contrôleur devrait permettre à l'équipage de pouvoir l'adapter à ses besoins à 8NM.** **NB : le seuil proposé couvre la plupart des turboréacteurs et turbopropulseurs utilisés en transport commercial, mais les marges de décélération réelles sont fonction du type d'avion et de sa masse à l'atterrissage. La valeur recommandée est un compromis visant une conduite sûre de l'approche connue à la fois des pilotes et des contrôleurs.**
Annexe	Accident survenu le 7 mars 2007 à l'atterrissage à Jogjakarta en Indonésie d'un B737-400 http://www.dephub.go.id/knkt/ntsc_aviation/baru/Final%20report%20PK-GZC%20Release.pdf Accident survenu le 25 février 2009 à l'approche d'Amsterdam Schiphol à un B737-800 http://www.onderzoeksraad.nl/en/onderzoek/1748/crashed-during-approach-boeing-737-800-amsterdam-schiphol-airport Incident grave survenu le 24 septembre 1994 pendant l'approche sur Paris Orly à un A310 http://www.bea.aero/docspa/1994/yr-a940924/pdf/yr-a940924.pdf

Toute remarque quant à la mise en œuvre des mesures proposées dans cette info sécurité DGAC est à adresser à : rex@aviation-civile.gouv.fr 2

Info Sécurité DGAC n° 2013/09 - *Version n°1 du 18/09/2013*

Local runway safety group at Lyon

The local runway safety team (LRST) is a working group made up of representatives of ATC, the airport operator, airline operators and Météo-France services. In 2013, the Lyon Saint-Exupery LRST took into account the recommendations of the EAPRE (European Action Plan for the Prevention of Runway Excursion). The LRST is not a decision-making body and can only make proposals. Its objectives are to:

❒ undertake risk analysis;
❒ review on measures taken since the last meeting;
❒ review events that have occurred since the previous meeting;
❒ propose and implement corrective measure, undertake a risk analysis.

On 27 September 2013, the introduction of the EAPPRE and, as a precursor, in the prevention of non-standard and unstabilised S approaches. The report from this meeting mentioned the following points:

- ❐ in relation to non-compliant and unstabilised approaches, the last meeting between ATC services and operators highlighted the importance of respecting 30 seconds in level flight before the FAF;
- ❐ a new method for speed management was implemented. The AIP was modified in October 2014 to ask pilots to expect sequencing at 160 kt down to 5 NM from the runway threshold.

The chapter on instructions relating to arrival procedures was modified and thus mentions:

4 GESTION TACTIQUE DES VITESSES	***4 TACTICAL MANAGEMENT OF AIRSPEEDS***
Les vitesses à l'approche sont gérées par l'ATC pour assurer la sécurité et la fluidité du trafic, elles sont donc à suivre précisément. Si les circonstances nécessitent une modification de vitesse pour des raisons de performance d'aéronef, les équipages doivent le signaler sans délai.	*Airspeeds on approach are managed by ATC to insure traffic safety and fluidity, they thus are to be strictly followed.* *If circumstances require a modification or airspeed for reasons of performance of aircraft, crews have to say it immediately .*
Au plus tard en début d'approche finale, les équipages doivent s'attendre à recevoir l'instruction de maintenir 160 kt jusqu'à 5 NM du seuil. Si des restrictions de vitesse ne sont pas nécessaires, il sera clairement indiqué par l'ATC : "Pas de restriction de vitesse".	*At the latest in the beginning of final approach, crews must expect to be asked to maintain 160 kt until 5 NM of the threshold.* *If airspeeds restrictions are not necessary, it will be clearly indicated by ATC : "No airspeed restriction".*

The DGAC in collaboration with the DSNA, Météo-France and airlines also set up a *"Tailwind"* working group.

Two experiments were undertaken at Marseille and Bordeaux between February and August 2014. These experiments consisted of providing controllers with an estimation of tailwind on final at 2000 ft based on a mathematical model developed by Météo-France. This information was then broadcasted on the ATIS and confirmed by crew reports at least once an hour if the intensity of the tailwind was higher than 10 kt. It is on the basis of this tailwind speed that aeroplane manufacturers estimate that it is more difficult to guarantee effective deceleration.

The DGAC explained that these experiments were positive overall and demonstrated that the model defined by Météo-France was relatively reliable.

1.18.3.7 Hermes Airlines

From May 2012 onwards, Hermes Airlines began implementing its safety management system (SMS). The SMS Manual was approved in early 2013 by the HCAA and its implementation was planned over four years. The operator explained that in the context implementation of its SMS, it intends to:

- ❐ implement the TEM concept (Threat and Error Management);
- ❐ adapt the CRM to operational specifics;
- ❐ implement a LOSA control;
- ❐ use a risk assessment methodology;
- ❐ implement a Fatigue Risk Management System (FRMS);
- ❐ share its flights analysis with Air Méditerranée.

Following the accident, Hermes Airlines distributed to all of its crews an information directive regarding the anomaly in the behaviour of the A/THR.

During the investigation, the BEA was informed that on the sole discretion of the accountable manager, the Captain was dismissed following the accident on the basis of information exchanged during the investigation.

2 - ANALYSIS

2.1 Scenario

Approach preparation

Descending towards FL 280, the PF listened to the ATIS before preparing the approach briefing. He did not understand the message indicating the presence of tailwind of 15 kt at 1,500 ft, which was based on reports given by crews having landed in the previous thirty minutes. The information recorded on the FDR indicate that at the time of the approach of SX-BHS, the actual wind conditions were more adverse than those provided by ATIS (30 kt at 2,000 ft for 15 kt announced).

A better level of English would certainly have helped the copilot to understand the message more precisely. Furthermore, the presence of a D-ATIS on Lyon airport and ACARS equipment on board SX-BHS would have enabled the crew to print the ATIS and therefore become aware of the presence of the tailwind and avoid the altimeter setting error.

Many pilots use the wind information displayed in the aeroplane as a decision-making aid. The crew of SX-BHS explained that, although this information was available on the navigation display (ND), they did not consult it at any point during the approach. The manufacturers' operational procedures do not provide guidance on the use of these displayed values, particularly on landing, considering that they are often quite inaccurate.

In the publication of its study on *"Aeroplane State Awareness during Go-Around (ASAGA)"* the BEA raised the issue of wind information provided to pilots: *"Wind is a key parameter taken into account in piloting and the strategies adopted. Without compromising the regulatory aspect of ATC wind, the BEA believes that information on aeroplane wind must be as accurate as possible and that the crew must also know the precision of the information presented."*

The CVR read-out indicated that the threats that should have been taken into account to perform this approach were not covered during the briefing. The crew did not therefore plan any specific action to mitigate the possible consequences, in particular relating to:

- managing potential fatigue after a flight duty period of nearly 15 hours;
- intended use of automation (managing speed in selected mode or managed mode);
- stabilisation altitude objective;
- the aeroplane's landing performance on a wet runway;
- the possibility of a go-around related to meteorological conditions close to the minima.

During the briefing, the PF did not clearly specify that he planned an ILS 36R approach Y or Z (FAP: respectively 10 NM/ 4,000ft or 6.9 NM/3,000 ft). Nevertheless he mentioned an altitude of 4,000 ft, which seemed to indicate that he was planning to make an ILS Y approach. However, the MEZIN 1D arrival includes an ILS Z approach. This confusion did not lead to any direct consequences on the management of the approach, but seemed to indicate that the PF prepared the arrival in an inadequate manner. This confusion was also not identified by the PM, although the aeroplane's FMS did not include the ILS 36R Z approach. During his radio communications with the crew, the controller did not specify which of the two approaches should be performed. The BEA, in a previous investigation[28] had already identified this risk and recommended that the controller call out without ambiguity the type of approach required. At the time of the publication of this report, Lyon air traffic control service has cancelled one of the two procedures.

[28]See Chapter 1.18.2 Previous Events- serious incident occurring on 7 September 2010 in Lyon(69) to the Boeing 737-400 registered TC-TLE operated by Tailwind Airline. http://www.bea.aero/docspa/2010/tc-e100907/pdf/tc-e100907.pdf

Descending through FL140, the crew were informed of deteriorating meteorological conditions and of the implementation of a low visibility procedure (LVP), visibility of 1,100 m and broken cloud at 100 ft[29]. The information caused the PM to doubt the possibility of landing but he did not call into question the continuation of the approach. The absence of confirmation of this doubt, as well as the error in altitude setting that remained undetected until the end of the flight seem to be indications of a considerable state of fatigue.

[29]The decision height for a CAT I approach is normally 200 ft, i.e. a DA in Lyon of 1,020 ft.

Throughout the approach, the crew's questions remained unanswered and did not lead them to establish a specific strategy for the possibility of a missed approach and a diversion.

Sloppy preparation of the arrival did not enable the crew to identify the various risks (threats) they could encounter during approach. At the time of the accident, Hermes Airlines did not require its crews to formally apply the concept of threat and error management (TEM).

Intermediate Approach

When low visibility conditions prevail at Lyon, the ATC procedure requires the controller to have the localizer intercepted at 160 kt and 10 NM from 36R threshold at the latest. On the day of the event, the controller did not apply this instruction and the aeroplane intercepted the localizer at about 12 NM at a speed of 220 kt. Air traffic control explained that this speed constraint is only useful for ensuring aircraft spacing and landing rate. In practice, it is not taken into account when there is little traffic.

It is the crew's responsibility to manage the speed of its aeroplane. Nevertheless, the application of the ATC speed regulation procedure by the controller would have provided the crew with the opportunity to anticipate speed reduction during approach.

In September 2013, the DGAC had drawn operators' and air traffic control service providers' attention to the risks related to excessive speed on final. It recommended a maximum speed of 180 kt, reducing, 8 NM from the runway threshold.

After the accident a new method of speed management was implemented at Lyon. In August 2014, the AIP was modified and now informs crews that they might have to maintain a speed of 160 kt until 5 NM from the threshold. This speed management is not, however, constantly applied and depends on the traffic.

This method enables pilots and controllers to share the same plan of action. The DGAC recommendation is not, however, applied at all French aerodromes whose traffic would require it.

During the radar vectoring of the previous aeroplane (A319 Air France flight AF-DD), the controller shared his doubts with the crew on the aeroplane's high ground speed (250 kt). The crew then answered that they were going to anticipate landing gear extension.

Four minutes later, the crew of SX-BHS were established on long final in the same conditions (4,000 ft / 250 kt). Unlike the previous flight, the controller did not share his doubts, explaining that the aircraft was the same type as the previous one and that their performance should be identical.

The controller's initiative of sharing his doubts with the Air France crew may have helped them to raise their awareness of the deceleration difficulties associated with their high ground speed. However, this radio communication in French could not be understood by the crew of SX-BHS. They were thus deprived of any chance of becoming aware of the difficulties on deceleration.

Final Approach

The manufacturer's standard procedures (FCOM) recommend ensuring that the aeroplane's speed decreases towards S on the glideslope. The aeroplane must reach S in the configuration *"conf 1"* at the latest on passing through 2,000 ft AGL. If the aeroplane has a speed that is significantly higher than S on the glideslope, extending the landing gear is then required as a priority before switching to configuration *"conf 2"*.

A short time before intercepting the glideslope at 3,820 ft QNH, the aeroplane was at 217 kt that is to say S+20 kt (S=197 kt). The PM asked the PF to keep the airbrakes extended and to try to reduce the speed. The PF selected a speed of 207 kt then 205 kt. This speed difference of 20 kt, with the airbrakes already extended, did not prompt the crew to extend the landing gear, nor to switch to managed speed.

The calculations made by the manufacturer based on the certified model of the aeroplane and in similar conditions to those of the event indicate that extension of the landing gear on interception of the glideslope would have enabled speed stabilisation (Vapp+9 kt at 1,000 ft and Vapp+1 kt at 500 ft).

After capturing the glideslope, the aeroplane's speed dropped and reached the selected speed of 205 kt. This deceleration, in accordance with that commanded by the crew, may have encouraged them to believe their representation of adequate speed management.

Only the awareness of the presence of a strong tailwind (wind gradient increasing from 20 towards 30 kt) could have then led the crew to anticipate any future difficulties in speed reduction and, consequently, to anticipate selecting landing gear extension before selecting *"conf 2"*.

At around 1,600 ft AAL the PF selected the *"conf 2"* configuration and selected a target speed of 180 kt but the aeroplane's speed did not decrease. This situation was specifically linked to the inversion of the tailwind gradient and to the retraction of the speedbrakes. The speed began to decrease 15 seconds later when the extension of the landing gear was commanded at 1,400 ft AAL.

Although he mentioned the difficulty of reducing the speed, the PM did not plan any corrective action, nor did he question the intention to land, yet another sign of a high state of fatigue.

Passing through 1,000 ft, the airspeed was significantly high (Vapp + 57 kt), the aeroplane was not in landing configuration and vertical speed was more than 1,000 ft/min. The stabilisation criteria required in IMC were therefore not met.

At about 900 ft, the PM asked the PF to engage the managed mode. The various configuration changes (*"conf 3"*, then FULL) modified the target speeds and the aeroplane's deceleration increased at 500 ft AAL, but the aeroplane was still not stabilised (Vapp + 38 kt).

Standard procedures (SOPs) require the PM to monitor the flight parameters in order to ensure the approach is stabilised at a height of 1,000 ft AAL in IMC conditions. When significant deviations are detected, it is expected that the crew perform a missed approach. In this particular case, the tacit decision to continue the approach indicates that the crew were apparently unaware of the risks incurred or that he does not feel able to make a missed approach. Testimony indicates that they never thought nor mentioned a go-around, except during the initial briefing.

Below 150 ft radio altitude, the anomaly in A/THR behaviour led to an increase in engine rpm. The crew, who were preoccupied with acquiring external visual references, did not detect this uncontrolled increase.

The calculations and simulations carried out during the investigation showed that, compared to the normal deceleration of an aeroplane, this increase in N1 contributed to an increase of about 5 kt of the aeroplane speed when reaching 50 ft and an increase in the runway overflight distance reaching 500 metres.

Flare Phase

The piloting technique and the late decrease in A/THR made it impossible for the PF to perform a nominal landing. The loss of external visual references and of the notion of remaining distance in the fog patch increased his difficulty in landing the aircraft.

The PMs' attempts to take over control were not effective, since they were not called out and resulted in a dual input phenomenon that increased the runway flyover distance prior to touchdown.

Application of the normal "Take over priority" procedure would have enabled the PM to take over the controls by inhibiting the PFs' inputs. In this situation, the aeroplane would probably have touched the runway at a lower distance than that of the event. It is however impossible to determine with certainty whether, under these conditions, the aeroplane could have stopped on the runway.

Training on taking over the controls is only carried out during initial training to obtain type rating. In recurrent training, it is limited to the case of pilot incapacitation. This does not make it possible to guarantee crews' maintaining competence in this area.

During the investigation by the BEA into the serious incident to the Airbus A320 registered SX-BHV on approach to 36L at Lyon Saint-Exupéry airport on 11 April 2012, a dual input phenomenon was also observed.

The investigation showed that taking over the controls leading to dual input occurs more frequently during the final approach phase or during flare when the copilot is PF. In many cases, the copilot is on line flying under supervision. It therefore appears that the scenarios for taking over the controls during training sessions are not in line with the most frequently encountered situations in operation.

The remaining runway distance after touchdown proved to be insufficient to allow the aeroplane to stop on the runway despite energetic braking by the crew.

At the time of the accident, there was no procedure for rejected landings in the manufacturer's FCOM. This aspect was mentioned in the FCTM and reminded crews that they could perform a go around as long as the thrust reversers were not deployed. The manufacturer considered that this situation was covered by the association of the FCOM "Go Around" procedure and the specific information provided in the FCTM.

Nevertheless a specific procedure is taught by the manufacturer in the syllabus of the *"Base Training"* instructor training. This procedure, although relevant in the event of go around after touchdown and until deployment of the thrust reversers, is not systematically taught to crews.

In the case of the event, it appeared that the crew had been trained to perform missed approaches down to 50 ft and never after the aeroplane had touched down on the runway. The partial loss of visual references after descending through 50 ft and the abnormally long duration of the flare phase (18 seconds) were factors which could have encouraged the crew to initiate a go around. Yet, the PM indicated that he had never considered this option because of the deteriorated visibility conditions, particularly on the ground, when he lost the notion of the remaining runway distance available.

In March 2014, the manufacturer amended its operational documentation (FCOM and FCTM) to introduce the specifics linked to a rejected landing.

This update draws crews' attention to the risk of a tail strike and recommends limiting the rotation rate. However, contrary to what is taught instructors, it does not provide a target pitch or a reminder to avoid dual inputs.

The crew's reaction during the event underlines the need for adequate training to rejected landings in the flare phase until the deployment of the thrust reversers, all the more so since the introduction of ROAAS systems could lead to increases in the number of go-around decisions.

Immobilisation of the aeroplane

Read-out of the CVR indicated that the crew were destabilised after the aeroplane was immobilised. This psychological state could explain why they did not initiate the first phase of the emergency evacuation procedure. The intervention of the controller prompted them, two minutes later, to switch off the engines. The PM then decided to start the APU without ensuring that there were no risks associated with the start-up (leaks, short-circuits, etc.).

During type rating training and recurrent training it is expected that the crew systematically apply the evacuation procedure in the event of serious failure, such as an engine fire. This training does not, however, take into account the occurrence of a runway excursion without apparent damage as a trigger for the emergency evacuation procedure.

The combination of the crew's psychological state after the runway excursion and their lack of training in this type of situation probably explain why they did not apply the procedure and in particular the first items to secure the aeroplane.

This investigation shows:

- **the importance of making crew aware of the fact that a state of shock related to a runway excursion may lead them to not carry out the first items of the emergency evacuation procedure which involves securing the aeroplane;**
- **the usefulness of an outsider intervening in order to remind the crew that after a runway excursion they must secure the aeroplane and, in particular, shut down the engines.**

2.2 A/THR Behaviour

Simulations have shown that the uncontrolled increase in N1 could contribute to increasing the distance of the air phase up to a value of about 500 metres. However it was not possible to determine with accuracy the influence of the phenomenon during the event as the PF's flare technique, the delayed A/THR reduction and the dual input phenomenon also contributed to increasing this distance.

Simulations showed that the application of a standard flare technique and a decrease to idle thrust at the latest at 20 ft (RETARD callout) limit the effects of this malfunction. However, the inevitable variability of flare techniques and the timing to set idle thrust exposes unaware crews to more significant effects of this malfunction in the event of an approach at excessive speed.

The service information letter published in 1997 by the manufacturer offered operators involved to replacing the FMGC as well as describing the features, evolutions and improvements to the various standards available. Only operators who accepted received a dedicated service bulletin in order to carry out the replacement.

The informative nature of this service letter probably did not sufficiently attract the attention of the previous operators of SX-BHS. When the aeroplane was taken over by Hermes Airlines, the airline was unaware of the existence of the document.

The SX-BHS accident as well as the runway excursion in Bamako in 2011 ***(see appendix 9)*** prompted the manufacturer to publish an information letter in July 2013. This letter, devoted to the functional anomaly of the FMGC concerned, was addressed to all operators (heads of fleet, FSOs and directors of operations) operating A320 family aeroplanes.

In November 2013, EASA also published a service information bulletin (SIB 2013-19) addressed to all the European Union member states civil aviation authorities. This bulletin recommends that the authorities ensure that its operators are actually aware of this FMGC failure and of the manufacturer's letter. The document was also the first to link the behaviour of the A/THR with the risk of runway excursion.

To date, despite these publications by the manufacturer and EASA, about 350 aircraft remain equipped with the old standard of FMGC.

The cost of the equipment, borne partly by the operator, may have been an obstacle to its replacement.

The large number of aircraft that are still equipped with this type of FMGC indicates the limited impact of publications from the manufacturer and EASA.

National civil aviation authorities are not systematically aware of the standards of FMGC equipping aeroplanes in service. It is consequently difficult for the authorities to ensure that the manufacturer's publications are properly taken into account by their operators.

Furthermore this type of FMGC also equips non-European Union operators' aeroplanes. The SIB issued by EASA do not therefore warn about safety issues in as obvious a manner as an AD. Thus, the issuing of the SIB did not make it possible to ensure that the information was actually taken into account by the operators involved.

2.3 Fatigue Assessment

The crew's flight duty period was close to 15 hours at the time of the event. Observation of their performance showed alterations which were symptomatic of fatigue.

The study carried out by the French army biomedical research institute (Institut de Recherche Biomédicale des Armées - IRBA) into the schedules of this crew did not identify any alterations in the sleep/wake cycle that might have led to fatigue during the day of the accident or the previous days. The accident did however happen at the time in the flight when the crew's performance risked being at its weakest.

Other more general studies suggest that fatigue, and the risk of accidents linked to fatigue, increase significantly when a crew's flight duty time exceeds 13 hours.

The European Regulation authorises a daily maximum flight duty period of 13 hours, but it also provides a waiver to this limitation in the event of *"unforeseen circumstances during actual flight operations"*.

EASA does not provide a definition of these *"unforeseen circumstances"*. It indicates that it is the operator's responsibility, within the context of its management system, to consider all of the aspects referred to in the paragraph. ICAO, in its FMRS – Fatigue Risk Management System document (Doc 9966) provides the following definition:

"Unforeseen operational circumstance. An unplanned event – unforecast weather, equipment malfunction or air traffic delay - that is beyond the control of the operator. In order to be considered unforeseen, the circumstance would occur or become known to the operator after the flight has begun (after the aeroplane first moves for the purpose of taking off)."

The day before the event flight, the Operations department of Air Méditerranée had advised Hermes Airlines to provide for an augmented crew because of possible extension of the flight time due to a possible technical stop. This stopover was therefore foreseeable and the use of the waiver for unforeseen circumstances was thus highly debatable.

Hermes Airlines crew scheduling service's not taking into account information and advice from the Operations department of Air Méditerranée, which had more experience that Hermes on this route, led to a predictable worsening of the risk of fatigue during this rotation.

According to the Captain, on the day before the flight, he had refused a crew change-over on the outbound leg as this solution seemed to him to be a last-minute fix.

However, the investigation showed that he had had to handle, without any controlled rest, a flight situation requiring sustained attention in the following domains:

- supervision of a young inexperienced copilot, a situation similar to line training;
- performance of a flight at the aeroplane's limit of endurance, requiring meticulous monitoring of fuel during the outbound leg;
- managing a stopover in Dakar with a delay and programming a technical stop in Agadir, increasing the duty period;
- arrival in Lyon, at night, in deteriorated meteorological conditions.

Refusal of extra payload from Dakar to avoid a technical stop in Agadir would in addition have incurred an increase in operating costs for the airline which the Captain was afraid he would be blamed for. Interviews with Hermes Airlines personnel indicated that they were concerned with limiting costs to a minimum. It seemed that some even feared losing their jobs in the event of an error incurring substantial additional costs. The decision of the manager in charge to dismiss the Captain after the accident was also likely to increase the employees' perception of this risk. The Captain's decisions were made in a context of adverse economic pressure.

Hermes Airlines' management seemed to accept, or indeed even favour this technique of applying a waiver for unforeseen circumstances that allow an extension of the flight duty period to 15 hours, in order to avoid resorting to augmented crews, a more expensive solution.

The event shows that an operator can thus invoke minor operational reasons to extend the flight duty period improperly.

The regulations in force stipulate that the use of flight duty period extension up to 15 hours remains, as a last resort, the Captain's responsibility. Nevertheless this accident shows that the latter is not always in a position to make the right decision.

The introduction of IR-OPS part ORO.FTL 205 in 2016 will require operators to set up specific procedures for captains in order to allow them to use the extension of flight duty period in the event of unforeseen circumstances that may lead to significant fatigue. The oversight authority will also be required to ensure that these specific procedures take into account a specific number of operational and environmental factors that may influence the crew's level of fatigue. Nevertheless it will still be the Captain's responsibility to decide on its use.

2.4 Crew performance

The investigation showed that crew performance on the day of the accident was below expected standards for an approach or landing.

The difficulties observed in this event contributed to worsening the crew's global performance. It appeared that the inadequate approach preparation, the application and partial knowledge of procedures, communication difficulties and inadequate management of the work load seriously disrupted the crew's monitoring of the flight. The latter never seemed to have had a clear awareness of the situation in which he found himself. He therefore continued an unstabilised approach and faced the risk of runway excursion.

The following factors adversely influenced this performance:

- ❐ both pilots had limited experience of both the aircraft type and their posts;
- ❐ the copilot's limited number of flying hours;
- ❐ the operator's conversion course, in the particular line flying under supervision, were not sufficient to compensate for the copilot's lack of experience when he was recruited by Hermes Airlines;
- ❐ the long break[30] during the copilot's line flying under supervision, which probably disrupted the normal acquisition process;
- ❐ the inappropriateness of the simulator training for the specific risks of this operation, although identified by the airline's safety department (dual inputs, unstabilised approaches, late thrust reduction, long landings);
- ❐ CRM training that was not representative of the specific conditions of operation and that was not adequate for raising crew awareness of potential risks;
- ❐ fatigue, related to a particularly long duty period on the day of the event.

[30]The future IR-OPS regulation will no longer allow this situation except where the copilot's skills are re-assessed after his line flying under supervision restarted.

2.5 Organisational Factors

2.5.1 Difficulties Encountered by the Operator

Hermes Airlines was founded in May 2011. At that time it operated a Boeing 737. In the first quarter of 2012, the fleet increased in number rapidly following the transfer of four Airbus previously operated by Air Méditerranée to its AOC.

The testimony of members of the management team indicated that they encountered difficulties in managing this rapid expansion, particularly as regards recruiting and training crews on Airbus. They added that because of the *"low cost"* profile selected for this operation, recruiting young inexperienced copilots was financially more rewarding. Thus in the first years of operation, roughly half the copilots hired only held a CPL and only totalled an average of 200 flying hours on piston-powered aeroplanes. The management team explained that they thought that recruiting experienced captains would compensate for their copilots' lack of experience. However most of the captains recruited had acquired experience on Boeing as copilots.

During the initial period of operation, the crews could consist of a copilot with low experience on Airbus and a captain lacking both experience on Airbus and with his/her new responsibilities.

Flight analysis identified a recurrence of the phenomenon of dual inputs that is typical of a lack of experience on Airbus. The FSO explained that the non-application by crews of the takeover procedure probably originated from the Captains' long experience on Boeing 737 on which this procedure does not exist. A simple verbal warning was transmitted during recurrent training. He added that the number of copilots under line flying under supervision had increased the recurrence of the phenomenon.

This situation had also been identified during the investigation conducted by the BEA into the serious incident that occurred to the Airbus A320 registered SX-BHV on approach to 36L at Lyon Saint-Exupéry airport on 11 April 2012. The BEA had at that time established that the Captain in training had only accumulated 25 flying hours on Airbus and that the low level of experience on type of both crew members had contributed to the event.

Hermes Airlines only has one Type Rating Examiner. To provide for its training requirements, the airline therefore uses contract instructors employed by ATOs based in Athens and the United Kingdom. It does not have a simulator in Greece and, more broadly, does not have a full and reliable vision of training and assessing the competence of its crews.

Furthermore, the business of charter flights requires the operator to have seasonal activity. In slack periods, the reduced number of flights does not allow for continuity in copilots' line flying under supervision. In this way, the copilot of the event flight had followed no specific training during the long interruption of his line flying under supervision.

The CRM training provided to Hermes Airlines crews was similar to that had been carried out at Olympic Airways, an established scheduled flight operator. Although mandatory, it is therefore not representative of the risks incurred by a recent operator using multicultural crews that are often inexperienced on Airbus or in their new posts. The operating risks detected by flight analysis were not incorporated (long landings, dual inputs) into the CRM course.

The crew's testimony and the data extracted from the flight analysis (delayed thrust reduction on landing, dual inputs, absence of missed approach) also seemed to highlight shortcomings in training.

2.5.2 Operator's Safety Organisation

At the time of the event, Hermes Airlines had begun implementing its Safety Management System (SMS). The SMS manual had been approved by the HCAA at the beginning of 2013. Its implementation was scheduled over a four-year period.

The FSO explained that the reduced number of reports transmitted by crews in 2012 and 2013 revealed that the latter were reluctant to report negative facts. The FSO's main objective was therefore to build up trust in order to create a culture of safety within the operator.

The geographical spread of the crews did not enable them to share a common base to receive and exchange safety information or to discuss in-flight experiences. Most information circulated by email and the FSO explained that it was not always easy to ensure that crews took it into consideration.

Furthermore, the decision by the manager responsible for dismissing the Captain after the accident by relying on specific elements of the investigation is not likely to encourage development of a fair safety culture within the airline.

The introduction of flight analysis in 2012 required many adjustments and configurations. The FSO was of course able to identify trends, for example the considerable number of copilots in training, the recurrence of dual input phenomena and unstabilised approaches, but without sufficient data, the FSO could not clearly assess the airline's global performance level.

When drawing up the 2012 annual report, the Hermes Airlines management team had identified that the priorities in terms of training and practice action were the prevention of unstabilised approaches and the phenomenon of dual inputs. In March 2013, the FSO sent a letter to the training centres in order to encourage instructors to emphasise the prevention of long landings and delayed thrust reduction on landing. During an audit conducted in April 2013, the HCAA had requested that Hermes Airlines swiftly put in place corrective actions in response to the risks detected by the flight analysis.

Thus, it seems that Hermes Airlines had not adequately taken into account the risks identified by the FSO and had not been able to implement the associated preventive measures, in terms of training, before the accident.

At the time of the event, safety organisation was based mainly on very weak crew feedback and on incomplete flight analysis.

During its first years of operation or when facing a major change in size, an operator may encounter difficulties in putting in place such structures. This investigation highlights the fact that a safety management system based only on crew feedback and incomplete flight analysis is not adequate in order to fully perceive the safety issues related to specific features of its operations.

Operating conditions when it was starting out exposed Hermes Airlines to the following difficulties simultaneously:

- ***recruiting copilots whose initial experience corresponded to the regulatory minimum and whose initial line training was sometimes interrupted, thus limiting this to the mandatory minimum;***
- ***operation of routes scheduled with maximum flight duty periods and aeroplanes' endurance;***
- ***partial outsourcing of crew training and checking, on the basis of programs inadequately adapted the operator's specific features;***
- ***the fleet's rapid expansion;***
- ***the seasonal nature of the business;***
- ***safety organisation based on few crew reports and on a flight analysis that did not reflect the actual performance of the operation.***

Generally speaking, although complying with the regulations in force, the management choices that limited to minimum conformity with the regulations exposed the airline to an increased risk of accident. This type of difficulty has already been identified by ICAO in its Safety Management Manual (doc 9859 chapter 2.7 "The Management Dilemma").

Hermes Airlines stated that the implementation of SMS by 2017 should enable the situation to improve, specifically by:

- ***implementing TEM (threat and error management);***
- ***adapting CRM to the operation's specific features;***
- ***carrying out a LOSA audit;***
- ***using risk assessment methodology (analysis and charting risks);***
- ***implementing a Fatigue Risk Management System;***
- ***raising awareness in the airline's management of the influence that economical flying can have on safety performance.***

2.6 Civil Aviation Authority and EASA

In 2012, the oversight authority had issued an AOC to Hermes Airlines without putting in place a suitable oversight programme which would have enabled it to detect operational weaknesses. It appears, however, that the conditions for recruitment, outsourced training and rapid expansion should have led the HCAA to establish an appropriate oversight programme.

EASA had detected inadequacies during an inspection of the oversight authority in 2012, specifically linked to its ability to ensure its oversight of its operators efficiently due to a drop in the number of staff members and an increase in the workload.

2.7 Prevention of Runway Excursions

The safety report published by IATA in April 2014 indicated that runway excursion is the most frequent accident category. Prevention of this type of event therefore appears to be a priority among international organisations responsible for safety. The studies and statistics conducted by these bodies also indicate that the interruption of approach or landing, which is the ultimate safety barrier to avoid this type of event, is rarely performed by crews. The BEA showed in its ASAGA[31] study that this manoeuvre can in itself raise safety issues.

The SX-BHS accident confirms the limits and failures of safety barriers currently in place to prevent a runway excursion resulting from an unstabilised approach. The final barrier depends on a decision by the crew to perform a missed approach when they become aware that their aircraft is not stabilised at a decision altitude of 1,000 or 500 ft, depending on meteorological conditions.

Many studies (statistical studies, observation flights) and the significant number of accident reports relating to runway excursions following unstabilised approaches confirm the fragility of this safety barrier. Thus, in-flight observations carried out by LOSA showed that nearly 97% of unstabilised approaches were continued by crews.

In this way LOSA indicated that continuing unstabilised approaches could specifically be explained by the fact that many crews:

- ***do not know or have forgotten the criteria for stabilisation during approach;***
- ***make a conscious decision to continue the approach despite the variations detected;***
- ***thought they would be stabilised before landing;***
- ***did not trust their ability to perform a go-around in different conditions from those they had been trained in.***

Studies also indicate that unstabilised approaches are mainly due to:

- ***inadequate management of wind conditions (tailwind component, wind shear, wind gradient and turbulence);***
- ***Performing a non-compliant approach: ATC instructions and acceptance of these instructions by crews (altitude or speed constraints) that do not allow sufficient time for the crew to plan, prepare and execute a stabilised approach.***

It would therefore seem necessary to put in place additional and more effective safety barriers.

[31] http://www.bea.aero/etudes/asaga/asaga.php

The European Action Plan for the Prevention of Runway Excursions (EAPPRE) published in January 2013 proposed recommendations addressed to all aviation stakeholders. A significant number of these measures would probably have made it possible to prevent the SX-BHS accident. They were mainly related to improving awareness of the crew's situation and to a better integration of the contribution of air traffic control services in the stabilisation of aircraft during approach.

Crew training and recurrent training

In parallel to the EAPPRE, the *"Implementation Training Group (IPTG)"* identified failures in current training and aims to reduce pilot training level disparities in Europe. The investigation showed that the weaknesses identified in the training given to flight crew at Hermes Airlines were characteristic of a general trend identified by the IPTG relating to some operators at the European level:

- inadequate SOPs and shortcomings in their application by crews;
- outsourced training with instructors not flying for the operator;
- a lack of consideration of the trainees' actual experience.

The scenarios proposed in EBT consist of materials designed to develop and assess crew performance in nine relevant areas of skill. This training enables the causes of failure or success to be identified more easily in order to allow more individualised and effective follow-up of trainees.

The storylines of the training scenarios are proposed by IATA document 9995, the *"Manual of Evidence-Based Training"*, and specifically addresses the following points:

- reinforcing respect for compliance with stabilisation criteria on approach;
- training the execution and management of go-around procedures, including N engine go-around down to the flare and until thrust reverser extension (rejected landing);
- reinforcing skills in detecting tailwind when it is not called out by ATC;
- increase the ability to establish the relationship between attitude, speed and thrust in an adequate manner.

All European and international plans have thus already identified the failures related to runway excursions and proposed corrective measures. The accident to SX-BHS confirms the need to implement these measures.

3 - CONCLUSIONS

3.1 Findings

- the crew held the valid licences and type ratings required to undertake the flight;
- Hermes Airlines possessed a valid Air Operator's Certificate;
- SX-BHS had a valid airworthiness certificate;
- the meteorological conditions were LVP (low visibility);
- ATIS *"Charlie"* for 19h36 contained information relating to the presence of a tailwind from 180° at 15kt at 15,000 ft. This information was not understood or integrated by the crew;
- in LVP conditions, controllers are asked to ensure localiser interception for aircraft at the latest 10 NM from the runway threshold, with maximum convergence of 30° and maximum speed of 160 kt;
- the aeroplane intercepted the localiser at a speed of 217 kt at 12.5 NM;
- the crew did not carry out level-off stabilisation between the IF and the FAF;
- at the stabilisation height of 1,000 ft in IMC, the aeroplane was not stabilised. Its speed was 57 kt higher than the approach speed (VAPP=141 kt);
- during approach, no call out of deviations was made by the PM;
- an anomaly, known to the manufacturer but not known to the operator, in A/THR behaviour when the aeroplane's speed is more than 10 kt higher than the VAPP, occurred below 150 ft and contributed to lengthening the runway overflight;
- the crew indicated that on crossing the runway threshold, they lost the notion of remaining runway distance because of the presence of a localised fog bank over the opposite runway threshold;
- the aeroplane's excess energy at the flare and the PF's inputs prolonged the flare phase before touchdown;
- after nine seconds of flying over the runway, the PM took over control without applying the procedure for taking over control. The PF continued to apply inputs on his side-stick and a dual input phenomenon occurred for nine additional seconds;
- the crew disengaged A/THR with a delay after the triggering of the RETARD announcement;
- the main landing gear touched the runway about 1,600 metres from the runway threshold. The aeroplane ground speed was 154 kt. The remaining distance meant that it was no longer possible for the crew to stop before the end of the runway;
- the aeroplane left the runway at a speed of 70 kt and came to a stop 300 metres after the threshold;
- at the time of the event, the crew had been on flight duty for almost 15 hours;
- Hermes Airlines is a recent operator and the size of its fleet had increased significantly during the course of the year previous to the accident;
- before the accident, the operator had identified safety weaknesses that contributed to the accident (captains and copilots that were inexperienced on type and in the post held, dual inputs, unstabilised approaches) but had not adapted the training and the recurrent training to these risks and did not yet have the tools required to determine the true safety performance of its operation;
- The HCAA had not put in place oversight specific to Hermes Airlines' particular situation.

3.2 Causes of the Accident

Continuing an approach below the stabilisation height with a speed significantly higher than the approach speed shows that the crew were not adequately aware of the situation, even though they mentioned several times their doubts on the marginal meteorological conditions and on the difficulties in reducing the aeroplane's speed.

Continuing this unstabilised approach at an excessive approach speed triggered, below 150 ft, an uncommanded increase in engine thrust. The crew's delayed A/THR reduction below 20 ft made it impossible for the aeroplane to slow down sufficiently for about 15 seconds after passing the threshold.

After descending through 20 ft, the copilot's inappropriate flare technique and the dual input phenomenon caused by the Captain significantly lengthened the flare phase. The remaining runway distance after the touchdown made it impossible for the aeroplane to stop before the end of the runway.

The following factors contributed to continuing the unstabilised approach and the long flare:

- a flight duty period of nearly 15 hours which likely led to crew fatigue;
- incomplete preparation of the approach which meant the crew was not aware of the risks on the day (tailwind, wet runway);
- the non-application of ATC procedures that require controllers to ensure aircraft are provided with localiser interception at the latest 10 NM from the runway threshold, with a maximum convergence of 30° and a maximum speed of 160 kt;
- partial application of standard procedures (SOP), impaired task sharing and degraded CRM, which meant the crew was unable to manage optimally the aeroplane's deceleration. These factors contributed to a progressive deterioration in situational awareness that meant that they could not envisage rejecting the approach and landing;
- the A/THR anomaly which maintained the aeroplane at a high energy level during the landing phase;
- an inadequate procedure for taking over the controls that led to the dual input phenomenon.

The following organisational factors contributed to the crew's poor performance:

- the choice of flight crew recruitment profiles by the operator, motivated by economic considerations, and inadequate airline conversion, led to operating aeroplanes with crews that were relatively inexperienced on type and in their roles as captain or copilot;
- improper and inappropriate application of the regulatory provisions that allow an extension of flight duty time in case of *"unexpected circumstances"* without taking into account the predictable risk of excessive fatigue for the crew;
- the absence of suitable initial oversight which made it impossible for the HCAA to focus on the predictable potential operational weaknesses of Hermes Airlines.

4 - SAFETY RECOMMENDATIONS

Note: In accordance with Article 17.3 of European Regulation (EU) 996/2010 of the European Parliament and Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation shall in no case create a presumption of blame or liability for an accident, a serious incident or an incident. The addressee of a safety recommendation shall inform the safety investigation authority which issued the recommendation of the actions taken or under consideration, under the conditions described in Article 18 of the aforementioned Regulation.

4.1 Raising Crews' Situational Awareness on Approach

4.1.1 ATIS Message Broadcasting Using Data-Link

One of the recommendations of the European plan deals with the implementation of D-ATIS. Reception and printing of ATIS using Data-Link enables a crew to avoid misinterpretations and omissions of important information, particularly during critical flight phases requiring a heavy work load.

A D-ATIS would likely have made it possible for the crew of SX-BHS to be aware of the presence of a high tailwind.

Consequently the BEA recommends that, in accordance with the EAPPRE recommendations:

- **DGAC give high priority to the implementation of D-ATIS at aerodromes receiving significant commercial air transport traffic. [Recommendation FRAN-2015-020]**

4.1.2 Speed Management on Approach

This investigation highlights the close relationship between the risk of longitudinal runway excursion and high speed on initial or intermediate approach. The DGAC in its September 2013 publication (Info Sécurité DGAC N°2013/09) recommends:

- that commercial air transport operators:
  - put in place procedures and operational limits on approach to foster compliance with stabilisation criteria. The DGAC recommends a speed threshold of 180 kt at 8 NM from the runway, reducing towards the approach speed;
  - adapt these limits, particularly in the event of the presence of a significant head or tailwind component or approach requiring an angle of more than 3°;
  - reiterate these limits during the arrival briefing.
- that air traffic control service providers:
  - for an aeroplane approaching at 3°, to consider that any clearance related to speed should be compatible with passing 8NM from the threshold at a maximum VI of 180 kt and decreasing;
  - in the event of presence of a significant tailwind component (10 kt or more) during final, to consider this same threshold for ground speed; in the same way, in the event of considerable headwind, this same threshold would be acceptable for ground speed;
  - do not propose maintaining high speed between 8 NM and the runway;
  - for an approach angle of more than 3°, to consider that possible upstream speed management by the controller should enable the crew to adapt it to their needs at 8 NM.

Consequently the BEA recommends that:

- **EASA in cooperation with national civil aviation authorities and air traffic control service providers encourage publication throughout Europe of procedures and operational limits on initial or intermediate approach enabling compliance with stabilisation criteria to be facilitated on final approach, in the spirit of the document published by the DGAC. [Recommendation FRAN-2015-021]**

4.1.3 Assistance to Crews

After the SX-BHS runway excursion, it appeared that only the controller's intervention enabled the crew to recover from their state of stupor and helped them to take the first steps to secure the aircraft by switching off the engines.

Consequently the BEA recommends that:

- **DGAC study ways to for a third person to intervene (controller, RFFS agent) in order to remind crews that they must secure the aeroplane after a runway excursion. [Recommendation FRAN-2015-022]**

4.2 Crew Training

The investigation identified weaknesses in training within Hermes Airlines, specifically taking into account the recruitment profiles adopted. In addition it appeared that this type of failure had already been identified in crew training in general at a European level by many international organisations.

More specifically, the investigation showed that the crews were not trained or trained adequately in specific procedures such as rejecting a landing below 50 ft or emergency evacuation. Indeed, the training provided was not in line with operational situations encountered in service.

Implementation of training including the principles of evidence-based-training (EBT) should correct these failures by defining programmes that are more appropriate to the risks encountered in operations.

Consequently the BEA recommends that:

- **EASA in coordination with the international working groups in charge of implementation of EBT ensure that future training programmes and recurrent training make it possible for crews to better manage the following situations:**
  - managing the energy during transition from the initial and final approach phases;
  - rejecting landings in the flare phase until deployment of the thrust reversers;
  - emergency evacuation (carrying out the first items in order to secure the aeroplane). **[Recommendation FRAN-2015-023]**

4.3 Training on Taking over Priority on Aeroplanes Equipped with Non-coupled Control Sticks

The investigation showed that training on taking over control on non-coupled control sticks as currently undertaken during initial and recurrent training does not guarantee maintaining crew competence in this area.

It therefore seems to be necessary, within the context of OSD, to take into account the specific procedures relating to taking over control of aeroplanes equipped with non-coupled control sticks.

Consequently the BEA recommends that:

- **EASA, in coordination with manufacturers, ensure that future programmes defined in the context of OSD include initial and recurrent training relating to taking over control of aeroplanes equipped with non-coupled control sticks. [Recommendation FRAN-2015-024]**

4.4 Behaviour of the A/THR

The manufacturer published a service information letter in July 2013. This letter, devoted to an anomaly in some FMGCs that led to an increase in thrust commanded by the A/THR when the approach speed was higher than Vapp + 10 kt below 150 ft, was addressed to all operators (heads of fleets, FSOs and Flight Operations post holders) operating A320 family aeroplanes. In November 2013, EASA also published a safety information bulletin (SIB 2013-19) addressed to all European Union member state civil aviation authorities. This information recommends that the authorities ensure that their operators are actually aware of this FMGC failure and of the manufacturer's letter. This publication was also the first to identify the A/THR behaviour anomaly as contributing factor to a runway excursion.

At the time of this report's publication, roughly 350 aircraft were still equipped with the old FMGC standard likely to have this anomaly. The considerable number of aeroplanes still equipped with this type of FMGC shows the relative ineffectiveness of the manufacturer's and EASA's publications.

National civil aviation authorities are not aware of the standards of FMGCs equipping aeroplanes in service. Consequently it is difficult for them to ensure that the manufacturer's publications are properly taken into account by their operators. This difficulty is even greater for authorities outside Europe as they are not recipients of the information bulletin published by EASA.

Consequently the BEA recommends that:

- **EASA in coordination with the manufacturer, ensure that all civil aviation authorities whose airlines are likely to operate the aeroplanes in question are effectively informed of the A/THR behaviour anomaly. [Recommendation FRAN-2015-025]**

To ensure a positive improvement in this situation, the BEA recommends that:

- **EASA, in coordination with the manufacturer, define a period following which it determines the effectiveness of the actions undertaken. Without feedback from operators on their decision to replace the FMGCs concerned, it could then consider issuing an airworthiness directive. [Recommendation FRAN-2015-026]**

4.5 Oversight of an Operator by its Authority

The investigation showed that in the operating conditions under which Hermes Airlines began its activities in public air transport exposed it simultaneously to difficulties in crew recruitment, training and skill checks. These difficulties were also accentuated by the rapid growth in the fleet and the seasonal nature of its activities. The operator had identified some safety weaknesses that contributed to the accident (captains and copilots with little experience on type and in the position, dual inputs, unstabilised approaches), but had not adapted its training and recurrent training to these risks and did not yet have the tools required to really determine the safety performance of its operations.

The HCAA was unable to set up an oversight programme that would focus on Hermes Airlines predictable potential weaknesses.

Consequently the BEA recommends that:

- **Hermes Airlines, in the context of putting in place its risk management system, take appropriate steps in order to correct the weaknesses identified during the investigation, in particular in the fields of flight crew recruitment and training, as well as the risk linked with fatigues of its crews. [Recommendation FRAN-2015-027]**

- **The HCAA implement an appropriate oversight programme for Hermes Airlines, specifically based on the risks identified during the investigation. [Recommendation FRAN-2015-028]**

List of Appendices

Appendix 1
Airbus A 321 Systems and Procedures

Managing speed in selected mode or managed mode during an approach

In Approach mode, with the A/THR engaged, speed management consists in providing a target speed to the A/THR. The target speed can be:

- *"managed"* when the target is calculated by an on-board system (FMGS);
- *"selected"* when the target is manually selected by the crew on the Flight Control Unit (FCU).

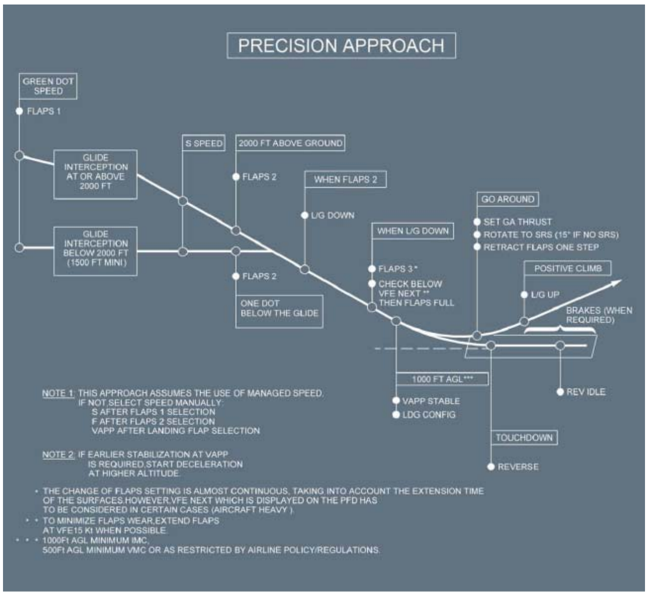
In the conditions on the day of the event (weight of 72 tonnes), the characteristic speed targets were as follows:

- Green dot for *"conf 0"* = 218 kt;
- S for *"conf 1"* = 197 kt;
- F for *"conf 2"* and *"conf 3"* = 153 kt;
- Vapp for *"conf FULL"* = 141 kt.

In the case of speed management in managed mode during an approach, the FMGS will automatically and successively change the target speed with each change in configuration.

In the case of speed management in selected mode, the manufacturer recommends manually selecting speed S after selecting *"conf 1"*, selecting speed F after selecting *"conf 2"* and Vapp after selecting the landing configuration (*"conf 3"* or *"conf FULL"*).

In some circumstances (strong tailwind or significant weight), the deceleration rate may be insufficient. In this case, the manufacturer recommends extending the landing gear at less than 220 kt, and before selecting *"conf 2"*.



During a precision approach, the manufacturer recommends using the managed mode for speed management. Once the Approach Mode has been engaged, the A/THR mode manages the speed of the aeroplane.

Aborting the approach below the minima - Aborting the landing

On the date of the accident, there was no ''Rejected Landing'' procedure in the operational procedures manual provided by the manufacturer (FCOM). A *''Rejected Landing''* paragraph was included, however, in the training document (FCTM), stating that the crew could abort the landing at any time, provided the thrust reversers were not deployed. This paragraph was not the subject of a specific, supplementary procedure in the FCOM because the manufacturer considered that a rejected landing was only a missed approach *''Go Around''* in a specific phase of flight. According to the manufacturer, this particular operation was therefore covered by the combination of the *''Go Around''* procedure in the FCOM and the information specific to the flight phase described in the FCTM.

REJECTED LANDING

Ident.: NO-180-00005598.0001001 / 24 APR 08
Applicable to: ALL

A rejected landing is defined as a go-around manoeuvre initiated below the minima.
Once the decision is made to reject the landing, the flight crew must be committed to proceed with the go-around manoeuvre and not be tempted to retard the thrust levers in a late decision to complete the landing.
TOGA thrust must be applied but a delayed flap retraction should be considered. If the aircraft is on the runway when thrust is applied, a CONFIG warning will be generated if the flaps are in conf full.
The landing gear should be retracted when a positive climb is established with no risk of further touch down. Climb out as for a standard go-around.
In any case, if reverse thrust has been applied, a full stop landing must be completed.

In November 2013, the manufacturer's operational documentation was amended. The manufacturer explained that the FCTM paragraph entitled *''Rejected Landing''* was modified and amended in the paragraph *''Consideration about Go-Around''* with a sub-paragraph *''Go-Around near the Ground''*. The *''Go-Around''* FCOM procedure was also amended in March 2014 by introducing a short, specific note to the *''Go-Around near the Ground''* sub-paragraph.

HERMES A318/A319/A320/A321 FLIGHT CREW TRAINING MANUAL	NORMAL OPERATIONS GO AROUND

PREFACE

Ident.: NO-180-00005592.0001001 / 28 MAR 08
Applicable to: ALL

Failure to recognize the need for and to execute a go-around, when required, is a major cause of approach and landing accidents. Because a go-around is an infrequent occurrence, it is important to be "go-around minded". The decision to go-around should not be delayed, as an early go-around is safer than a last minute one at lower altitude.

CONSIDERATION ABOUT GO-AROUND

Applicable to: ALL

Ident.: NO-180-A-00005593.0001001 / 08 NOV 13

1 2 **DECISION MAKING**

A go-around must be considered if:

- There is a loss or a doubt about situation awareness
- If there is a malfunction which jeopardizes the safe completion of the approach e.g. major navigation problem
- ATC changes the final approach clearance resulting in rushed action from the crew or potentially unstable approach
- The approach is unstable in speed, altitude, and flight path in such a way that stability will not be obtained by 1 000 ft IMC or 500 ft VMC.
- Any GPWS, TCAS or windshears alert occur
- Adequate visual references are not obtained at minima or lost below minima.

3 Ident.: NO-180-A-00015224.0001001 / 22 OCT 13

GO-AROUND NEAR THE GROUND

If the PF initiates a go-around, the flight crew must complete the go-around maneuver. The PF must not initiate a go-around after the selection of the thrust reversers.

If the flight crew performs a go-around near the ground, they should take into account the following:

- The PF should avoid excessive rotation rate, in order to prevent a tailstrike
- A temporary landing gear contact with the runway is acceptable. For more information *Refer to NO-170 TAIL STRIKE AVOIDANCE*
- In the case of bounce, the flight crew must consider delaying flap retraction
- The PF should order landing gear retraction when the aircraft reaches and maintains positive climb with no possibility of subsequent touchdown.

Excerpt from the November 2013 FCTM

HERMES A318/A319/A320/A321 FLIGHT CREW OPERATING MANUAL	PROCEDURES NORMAL PROCEDURES STANDARD OPERATING PROCEDURES - GO-AROUND

GO AROUND WITH FD

Ident.: PRO-NOR-SOP-20-A-00011578.0001001 / 04 MAR 14
Applicable to: MSN 0666

Apply the following three actions simultaneously:

THRUST LEVERS .... TOGA

If TOGA thrust is not desired, set the thrust levers to TOGA detent then retard the thrust levers as required. This enables to engage the GO-AROUND phase, with associated AP/FD modes.
The flight crew may use CL detent to have benefit of ATHR.

Note: *If the thrust levers are not set briefly to TOGA detent :*
- *The FMS does not engage the GO-AROUND phase, and flying over, or close to the airport will sequence the Destination waypoint in the F-PLN.*
- *When descending at minimum speed with AP and A/THR engaged, the speed may go below VLS if APPR mode is deselected, and/or if OP CLB or V/S mode is engaged.*

ROTATION .... PERFORM

Initiate rotation towards 15 ° of pitch with all engines operative (approximately 12.5 ° if one engine is out) to get a positive rate of climb, then follow the SRS Flight Director pitch bars orders.
When near the ground, avoid excessive rotation rate in order to prevent a tail strike.

GO AROUND .... ANNOUNCE
FLAPS lever .... SELECT AS RQRD

Retract one step of flaps.

FMA .... ANNOUNCE

The following modes are displayed: MAN TOGA / SRS / GA TRK / A/THR (in blue).

POSITIVE CLIMB .... ANNOUNCE
L/G UP .... ORDER
L/G .... SELECT UP
NAV or HDG mode .... AS RQRD

Reselect NAV or HDG, as required (minimum height 100 ft).

AP .... AS RQRD

Note: *Go-around may be flown with both autopilots engaged. Whenever any other mode engages, AP 2 disengages.*

FCOM Procedure - Go-Around dated 4 March 2014

Manufacturer's new training program associated with the update of the FCOM

During initial type rating training, the manufacturer's programme includes conducting a missed approach under the following conditions:

- ❒ At night in VMC conditions;
- ❒ Wet runway;
- ❒ Engine Anti Ice on;
- ❒ AP off;
- ❒ FD/ATHR engaged;
- ❒ Go-around initiated under 50 ft.

The manufacturer adds that its new recurrent training programme includes, as part of the 5 usual scenarios, the following *''Go-Around near the ground''* exercises:

- ❒ Either runway blocked at 100 ft;
- ❒ Or windshear at around 300/400ft;
- ❒ Or runway incursion;
- ❒ Or LVO failure, or weather conditions degraded to CAT II/III.

Furthermore, the *''immediate go from touch''* abort landing procedure after touchdown is taught by the manufacturer as part of the FLIGHT FIF SESSION GUIDE *''base training''* Airbus pilot instruction course *''Airborne phase''* E F11. It indicates:

- ❒ that the control take-over by the instructor must be made clear (*''I have control''*, and by pressing the P/B instinctive disconnect on the sidestick);
- ❒ select TOGA;
- ❒ maintain the configuration (ignoring the non-configuration alarm on take-off);
- ❒ select a pitch attitude of 10° until a safe altitude is reached;
- ❒ select the configuration 3 above the VLS speed and then continue with the standard go-around procedure.

The manufacturer has also published the following two documents:

- ❒ FOBN (Flight Operations Briefing Notes – Being prepared for Go-Around)

"Go-Around below the Minimums When the need for go-around is identified, the decision should not be delayed. Go-around can be decided until the selection of the reverse thrust. If the go-around has been initiated, it must be completed. Reversing a go-around decision can be hazardous (e.g. F/O initiating a late go-around; Captain overriding and trying to land the aircraft). Also refer to the Flight Operations Briefing Note Bounce Recovery, for expanded information."

Training recommendations:

- ■ Go-around below minimums not called by ATC;
- ■ Destabilization of the approach;
- ■ Loss of appropriate visual references;
- ■ Runway incursion.

- ❒ Safety first The Go-Around published in July 2011

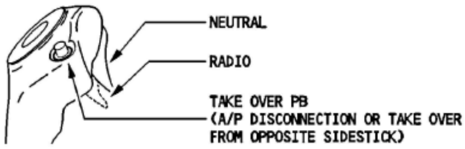
"Go Around Close to the Ground If you are close to the ground, initiate a standard Go-Around", and avoid rapid rotation and excessive pitch. This low Go-Around may result in a runway contact, If it does, continue with the standard Go-Around.

Conclusion

We must train for different Go-Arounds.

Description of the operation of sidesticks, associated procedure and training

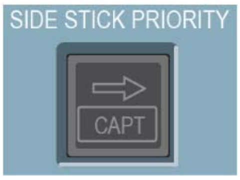
The two sidesticks are used for manual control of the aircraft in pitch and roll. Each sidestick has, among other things, a push button used to disconnect the autopilot and/or take precedence over the other sidestick.

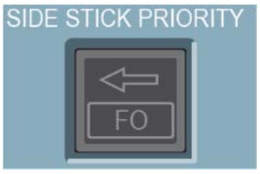


When one pilot makes inputs on the sidestick, the inputs are sent to the flight control computers. When both pilots make inputs on their sidestick, whether in the same or in opposite directions, the inputs are algebraically added and sent to the computers[(1)].

[(1)]The sum is limited to the equivalent of a full nose-up input applied on the sidestick of a single pilot.

Dual input is detected when deflections of more than 2° are applied on each of the two sidesticks for a time period called the confirmation time. The two lights *"SIDE STICK PRIORITY"* light up green and the voice message *"DUAL INPUT"* is called out. There may be a two-second period between the detection of the simultaneous deflections of more than 2° and the *"DUAL INPUT"* callout. This is due to the confirmation time and the calculation time required by the computers.





By pressing the button on the sidestick, the pilot takes over control as long as he maintains the pressure. When the Captain takes over control, the light *"SIDE STICK PRIORITY"* lights up green before him, and the arrow of the same light turns red in front of the co-pilot. The voice message *"PRIORITY LEFT"* is generated.

The pilot who takes control must make the following call-out: *"I have control"*. The other pilot accepts by calling out *"you have control"* before leaving the controls.

Teaching how to take over control

Teaching how to take over control takes place in several phases only during type rating. The trainee first acquires theoretical knowledge about the operation of the system and the procedure, and then sees an analytical demonstration on the simulator. S/he then puts it into practice during two other sessions.

Theoretical instruction

The principles of design, priority logic and control take-over are set out in two phases. The first during ground training on the first day of type rating. The second when learning how to use the systems (computer-based training (CBT). The documents available to the trainee are the FCOM and the FCTM.

Field instruction

In the first simulator session (session 1), the exercise is carried out at FL120, at level flight AP/FD OFF and A/THR ON. The instructor indicates the interfaces to the trainee (takeover P/B on the control column, visual indications with associated arrows and colours). In particular, the instructor shows the algebraic addition of the control column inputs. The purpose is to demonstrate to the trainee that only one pilot must act on the controls at a time and the importance of priority take-over by continuously pressing the *''disconnect P/B''* together with the call-out *''I have control''*.

During the two other sessions (sessions 5 and 6), control take-over is taught during an exercise simulating the incapacity of a pilot. Only one of the two trainees is briefed on the nature of the error to commit in order to create a sufficiently startling effect on the other. The objective is to practice control take-over during a dynamic, critical phase of the flight. During the exercise, which is carried out on take-off, one of the two pilots applies an excessive nose-up input during the 5th session, and forgets to turn during the 6th session. In both cases, the other trainee must adequately take over control. The manufacturer indicated that during these exercises, approximately 75 % of the trainees perform the procedure correctly the first time.

Emergency evacuation procedure

The *''EMERGENCY EVACUATION''* procedure is an emergency procedure described in the manufacturer's and operator's FCOM, FCTM and QRH.

This procedure is in two stages. The first phase does not formally instruct the crew to evacuate the aeroplane. It allows the crew to perform the first items necessary to secure the aircraft (in particular, cutting the engines and the APU, and informing the cabin crew members and the ATC of the situation). The second phase describes the procedure to follow once the crew has decided to evacuate the aeroplane or not.

Simulator instruction

During type rating, the procedure is taught during a simulator session (FFS 6). The scenario provides for a rejected take-off (RTO), followed by an evacuation procedure.

During recurrent training, the evacuation procedure among operators generally follows:

- ❒ A rejected take-off after a serious failure of the engine fire type;
- ❒ A landing, in particular with an uncontrolled engine or APU fire or an on-board fire/smoke exercise.

The evacuation training scenarios do not include the case of a runway excursion triggering the emergency evacuation procedure.

appendix 2
CVR Transcript

```
                                       A321_SX-BHS_29 Mars 2013_Transcript V09
=====================================  TRANSCRIPTION  CVR  ======================================================
------------------------------   05/06/2013
------------------------------   TRANSCRIPTION FINALE
********************************************************************************
------------------------------   DOCUMENT RESERVE A L'ENQUETE DE SECURITE
------------------------------   CONFIDENTIEL
********************************************************************************
------------------------------   A321 / SX-BHS / Sortie de piste à l'atterrissage / Aéroport Lyon Saint-Exupéry / 29
Mars 2013


-----------------------------------------------------------------------------------------------------------------------
------------------------
AVERTISSEMENT
-------------
```

Ce qui suit représente la transcription des éléments qui ont pu être compris au cours de l'exploitation de l'enregistreur phonique (CVR). Cette transcription comprend les échanges entre les membres de l'équipage, les messages de radiotéléphonie et des bruits divers correspondant par exemple à des manœuvres de sélecteurs ou à des alarmes.

L'attention du lecteur est attirée sur le fait que l'enregistrement et la transcription d'un CVR ne constituent qu'un reflet partiel des événements et de l'atmosphère d'un poste de pilotage. En conséquence, l'interprétation d'un tel document requiert la plus extrême prudence.
Les voix des membres d'équipage sont placées dans des colonnes séparées par souci de clarté. Deux autres colonnes sont dédiées aux autres voix, bruits et alarmes également entendus.

GLOSSAIRE

```
Temps FSK  Temps obtenu à partir d'un temps UTC enregistré au format FSK sur le CVR
Temps UTC  Temps Universel Coordonné
(F/)       Mots ou groupes de mots prononcés par le copilote
(C/)       Mots ou groupes de mots prononcés par le commandant de bord
(E/)       Mots ou groupes de mots prononcés par le mécanicien navigant
(G/)       Mots ou groupes de mots prononcés par l'équipe technique au sol
(O/)       Mots ou groupes de mots prononcés par un autre intervenant (ATC, PNC, autre avion, ...)
(?/)       Locuteur non identifié
(*)        Mots ou groupes de mots non compris
( )        Les mots ou groupes de mots placés entre parenthèses n'ont pu être établis avec certitude
(...)      Mots ou groupes de mots n'ayant pas de lien avec la conduite du vol
(!)        Interjection, juron
(@)        Bruit, alarme
(>)        Communication en direction du contrôle, du sol ou du PNC par l'interphone
(VS)       Voix synthétique.
(xxx)      Mots ou groupes de mots prononcés en langue native
```

Pae p

```
-----------------------------------------------------------------------------------------------------------------------------
-- Référence horaire: Paramètre FDR --

*********************************************************
Temps:
*********************************************************

17 h 50 min 53,886              Début de transcription
17 h 51 min 28,884              C/Vers PNC/ (XXX) (Remarque: conversation en grec)
17 h 51 min 29,980              P/(XXX)
17 h 51 min 40,429              C/(*)
17 h 51 min 44,737              F/Thank you, thank you
17 h 51 min 56,139              C/(*)
17 h 52 min 10,292              F/After that in (*), it gonna to be in (Malaga), it' gonna to be heu...to the (five
point five) (*)
17 h 52 min 23,291              C/Well
17 h 52 min 24,284              F/In Malaga
17 h 52 min 25,703              C/Malaga?
17 h 52 min 26,588              F/Yes
17 h 52 min 27,391              C/But you (*) in Malaga now?
17 h 52 min 28,787              F/Yeah, no, no, (we have not Malaga but we gonna be in Malaga)
17 h 52 min 33,387              C/We are approaching Malaga
17 h 52 min 34,939              F/Yeah
17 h 53 min 10,570              @/Double bip
17 h 53 min 58,604              @/Bruit
17 h 54 min 18,568              @/Bruit
17 h 54 min 31,261              @/Bruit
17 h 54 min 56,098              @/Bruit
17 h 54 min 59,232              C/(*)
17 h 55 min 01,030              F/(*)
17 h 55 min 06,181              @/Bruit de sélecteur
17 h 55 min 06,776              @/Bruit de sélecteur
17 h 55 min 10,687              C/(Nice) (*)
17 h 56 min 26,612              @/Sonnerie poste pilotage
17 h 57 min 57,254              O/CASABLANCA ENR/Méditerranée seven eight one seven, contact Seville, one three four
decimal eight
17 h 58 min 02,153              C/>Three four eight, Méditerranée seven eight one seven, bye
17 h 58 min 07,629              C/(*)
17 h 58 min 08,534              F/Yeah
17 h 58 min 12,351              F/Do you want I speak in spanish?
17 h 58 min 17,490              C/>Sevilla Control, buenas tardes, Méditerranée seven eight one seven, flight level
three four zero
17 h 58 min 23,106              O/SEV ENR/Méditerranée seven one eight seven, buenas tardes, radar contact at three
```

four zero, and the squawk one zero five two
17 h 58 min 31,904 C/>Squawking one zero five two, Méditerranée seven eight one seven
17 h 58 min 39,174 F/One zero five two (selected)
18 h 02 min 24,086 @/Bruit
18 h 02 min 25,390 @/Bruit de sélecteurs
18 h 02 min 29,779 @/Bruit de sélecteur
18 h 04 min 28,740 @/Bruit
18 h 04 min 36,998 @/Bruit de sélecteur
18 h 05 min 09,927 C/(*)
18 h 05 min 37,040 @/Bruit
18 h 05 min 43,041 @/Bruit de sélecteur
18 h 06 min 27,992 @/Bruit de sélecteur
18 h 06 min 38,175 @/Bruit de sélecteur
18 h 07 min 00,885 @/Bruit
18 h 07 min 47,019 @/Bruit de sélecteur
18 h 08 min 13,998 @/Sonnerie poste pilotage
18 h 08 min 17,739 C/Vers PNC/>(XXX) (Remarque: conversation en grec)
18 h 08 min 18,292 P/(XXX)
18 h 08 min 34,154 @/(Remarque: fin de conversation)
18 h 08 min 41,160 @/Bruit
18 h 08 min 43,685 @/Bruit
18 h 09 min 59,307 C/(...) (Remarque: conversation non relative à la conduite du vol)
18 h 10 min 00,472 F/(...)
18 h 11 min 50,705 C/(*)
18 h 11 min 55,141 F/No
18 h 11 min 56,230 C/One six four five
18 h 11 min 58,450 F/One six four five, yes
18 h 12 min 01,492 @/Bruit de sélecteur
18 h 12 min 32,701 F/(So)
18 h 12 min 35,576 C/We (*) thirty five minutes (*)
18 h 12 min 44,061 @/Bruit
18 h 12 min 59,742 F/(...) (Remarque: conversation non relative à la conduite du vol)
18 h 15 min 04,492 @/Sonnerie
18 h 15 min 05,980 F/(...) (Remarque: conversation non relative à la conduite du vol)
18 h 15 min 06,799 C/(...)
18 h 16 min 24,756 O/SEV ENR/Méditerranée seven one eight seven, call now (*) one three two six seven five, adios
18 h 16 min 31,255 C/>Three two six seven five, Méditerranée seven eight one seven, adios
18 h 16 min 37,726 F/(*)
18 h 16 min 42,339 C/It's heu...
18 h 16 min 43,811 F/Sevilla
18 h 16 min 44,844 C/>Sevilla Control, buenas tardes, Méditerranée seven eight one seven, flight level three four zero
18 h 16 min 49,844 O/SEV ENR/Méditerranée seven eight one seven, buenas tardes, identified

18 h 16 min 59,563 F/(...) (Remarque: conversation non relative à la conduite du vol)

A321_SX-BHS_29 Mars 2013_Transcript V09

```
18 h 19 min 25,793            @/Appel PNC
18 h 22 min 05,510            @/Appel PNC
18 h 22 min 12,998            F/(...) (Remarque: conversation non relative à la conduite du vol)
18 h 22 min 22,692            C/(...)
18 h 25 min 01,101            O/SEV ENR/Méditerranée seven eight one seven, Madrid on one three three decimal
seven five five
18 h 25 min 06,018            C/>Three three seven five five, Méditerranée seven eight one seven, adios

18 h 25 min 22,132            C/>Madrid Control, buenas tardes, Méditerranée seven eight one seven, flight level
three four zero
18 h 25 min 27,627            O/?/Méditerranée seven zero one eight (*)
18 h 25 min 33,260            C/(*)
18 h 25 min 37,469            F/(...) (Remarque: conversation non relative à la conduite du vol)
18 h 28 min 13,290            @/Buit de sélecteur
18 h 28 min 13,928            @/Buit de sélecteur
18 h 28 min 36,530            F/(*)
18 h 30 min 21,679            O/?/Méditerranée seven eight one seven, Madrid calling on one two one decimal five,
=
18 h 30 min 27,430            O/?/=Méditerranée seven eight one seven, do you read?
18 h 30 min 31,176            C/>Yes, hear you five five five
18 h 30 min 37,962            O/?/Méditerranée seven eight one seven, Madrid calling on one two one decimal five

18 h 30 min 44,045            C/>(*)
18 h 30 min 45,867            O/?/(*)
18 h 30 min 47,632            C/>(*)
18 h 30 min 51,285            O/?/Méditerranée seven eight one seven, call Madrid on one three three decimal two,
one three three decimal two
18 h 31 min 01,582            C/>Ok, one three three decimal two, but we have contact with one three three decimal
seven five five, right now
18 h 31 min 19,652            C/>Madrid, buenos dias, buenas tardes, Méditerranée seven eight one seven, flight
level three four zero. =
18 h 31 min 29,497            C/>Madrid, buenas tardes, Méditerranée seven eight one seven, flight level three
four zero.
18 h 31 min 33,718            O/MAD ENR/Méditerranée seven eight one seven, buenas tardes, radar contact

18 h 31 min 41,052            C/Why... why (they hear) two hundred decimal five?
18 h 31 min 42,925            F/I don't know why
18 h 31 min 44,215            C/But we had (*) to that.
18 h 31 min 45,780            F/Yes
18 h 31 min 47,110            C/(*)
18 h 31 min 50,691            F/They heu...they had going to (call out), they are (stupid) so (*)  I don't know
why (*)
18 h 34 min 43,124            C/One hundred knots (*)
18 h 35 min 04,712            F/I think they...they have (something in the weather in Dakar) beacause they don't
give us a negative weather
18 h 35 min 17,796            C/(*)
```

Pge p

18 h 35 min 33,133 F/Yeah
18 h 35 min 38,915 @/Bruit de sélecteur
18 h 36 min 03,478 C/(*) (Lyon)
18 h 36 min 06,910 F/Heu...
18 h 36 min 08,105 C/(*)
18 h 36 min 11,412 F/(*)
18 h 36 min 11,910 C/Yes
18 h 36 min 15,425 F/(*)
18 h 36 min 39,648 O/MAD ENR/Méditerranée seven eight one seven, call Madrid on one three two decimal nine eight zero, bye bye
18 h 36 min 47,000 C/>Three two décimal eight zero, Méditerranée seven eight one seven
18 h 36 min 50,769 O/MAD ENR/One three two nine eight zero, one three two nine eight zero, please.

18 h 36 min 55,729 C/>Three two nine eight zero, Méditerranée seven eight one seven, bye
18 h 36 min 58,583 O/MAD ENR/Bye
18 h 37 min 08,694 C/>Madrid Control, buenas tardes, Méditerranée seven eight one seven, flight level three four zero
18 h 37 min 14,042 O/MAD ENR/Méditerranée seven eight one seven, buenas tardes, radar contact

18 h 37 min 22,367 F/Heu (!) six, six degrees.
18 h 37 min 28,269 C/(*)
18 h 37 min 29,517 F/No
18 h 38 min 25,600 F/(...) (Remarque: conversation non relative à la conduite du vol)
18 h 38 min 33,985 C/(...)
18 h 40 min 09,943 F/You remember where we'll find the... the one three and two point five, (*) two point five, yeah, where do you find it?
18 h 40 min 22,761 C/Heu...
18 h 40 min 30,577 F/Because (*) the limitations, (*) limitation
18 h 40 min 52,121 F/(*) one point three left, two point five, right
18 h 40 min 56,206 C/(*)
18 h 40 min 57,987 F/Two point five left
18 h 40 min 58,687 @/Sonnenie
18 h 40 min 59,374 F/One point three right
18 h 41 min 04,357 C/Vers PNC/>(XXX) (Remarque: conversation en Grec)
18 h 41 min 05,085 P/(XXX)
18 h 42 min 00,392 @/(Remarque: fin de conversation)
18 h 42 min 02,639 @/Bip
18 h 43 min 10,513 O/MAD ENR/Méditerranée seven eight one seven, Madrid
18 h 43 min 14,641 C/>Go ahead
18 h 43 min 16,125 O/MAD ENR/Méditerranée seven eight one seven, call Madrid one one nine decimal six three zero
18 h 43 min 21,838 C/>One one nine six three zero, Méditerranée seven eight one seven, adios

18 h 43 min 31,173 C/Six three zero
18 h 43 min 32,257 F/Six three zero
18 h 43 min 39,981 C/>Madrid Control, buenas tardes, Méditerranée seven eight one seven, flight level

three four zero
18 h 43 min 44,962 O/MAD ENR/Méditerranée seven eight one seven, Madrid, buenas tardes, identified at three four zero, continue as cleared
18 h 43 min 58,200 C/(*)
18 h 45 min 05,013 C/You release the (*) now
18 h 45 min 07,317 F/Ok
18 h 45 min 07,868 C/(*)
18 h 45 min 08,688 F/No (*) limitations... (*) (CAT) two, (CAT) three
18 h 45 min 22,971 @/Bruit de sélecteur
18 h 45 min 38,573 C/(Five) (*)
18 h 45 min 40,767 @/Bruit
18 h 45 min 41,981 F/(Why)
18 h 45 min 43,954 C/(*)
18 h 45 min 44,359 F/Why..., why
18 h 45 min 45,832 C/(Why)
18 h 45 min 46,047 F/Why you will asking me) (*)
18 h 45 min 47,600 C/(*)
18 h 45 min 49,501 F/Ah yes (*)
18 h 45 min 55,498 C/(*)
18 h 45 min 57,735 F/Yeah (*)
18 h 46 min 05,077 F/(*)
18 h 48 min 59,512 @/Bruit
18 h 49 min 03,325 O/MAD ENR/Méditerranée seven eight one seven, Madrid, one two seven decimal two two five, adios
18 h 49 min 09,976 C/>Two seven two two five, Méditerranée seven eight one seven, adios.
18 h 49 min 21,636 C/Madrid
18 h 49 min 22,537 F/Yeah
18 h 49 min 23,554 C/>Madrid Control, buenas tardes, Méditerranée seven eight one seven, flight level three four zero
18 h 49 min 29,403 O/MAD ENR/Méditerranée seven eight one seven, buenas tardes, radar contact at zero three four zero.
18 h 49 min 48,189 F/(*)
18 h 53 min 17,011 @/Bruit de sélecteur
18 h 54 min 37,373 @/Bruit
18 h 54 min 52,685 C/(*) one one (wide) (*)
18 h 55 min 31,430 F/(Three) (*)
18 h 55 min 54,410 C/(*)
18 h 56 min 50,231 @/Bruit de sélecteur
18 h 59 min 21,986 O/MAD ENR/Méditerranée seven eight one seven, contact Bordeaux one two one three four zero, good day
18 h 59 min 29,068 C/>Two one three four zero, Méditerranée seven eight one seven, adios
19 h 00 min 38,385 C/>Bordeaux Contrôle bonjour, Méditerranée seven eight one seven, flight level three four zero on cruise for (LATIC)
19 h 00 min 43,823 O/BDX ENR/Méditerranée seven eight one seven, maintain three four zero, Mike Echo November
19 h 00 min 50,043 F/Mike Echo November, direct

A321_SX-BHS_29 Mars 2013_Transcript V09

```
19 h 00 min 51,480            C/>Direct Mike Echo November, level three four zero, Méditerranée seven eight one
seven
19 h 01 min 17,384            F/(Mike Echo November) (*)
19 h 03 min 35,779            @/Sonnerie PNC
19 h 03 min 39,703            C/Look, (*) (pressure), (*) (pressure), maximum take off weight, thirty eight,
eighty, eighty three, eighty five, eighty nine
19 h 03 min 54,033            F/Nine
19 h 03 min 55,180            C/Ninety three, ninety three point five
19 h 03 min 57,727            F/Yes
19 h 03 min 59,132            C/(*)
19 h 04 min 00,343            F/Yeah (*) (it depends on what you pay) (*)
19 h 04 min 24,117            C/(...)
19 h 04 min 27,654            F/Ok
19 h 04 min 28,983            C/(...)
19 h 04 min 48,910            C/Ninety three point five, maximum take off weight
19 h 04 min 51,910            F/Ninety three point five
19 h 04 min 59,735            C/That's why you haven't to calculate the (sum) ninety one, ninety three...

19 h 05 min 03,331            F/Yeah
19 h 05 min 03,827            C/Ninety one
19 h 05 min 05,023            F/Yeah, it's not... it's not possible avoid the (*)
19 h 05 min 07,526            C/Did you have the schedule (*) ?
19 h 05 min 18,164            @/Bruit
19 h 05 min 30,663            VS: (*)
19 h 05 min 47,470            @/Double bip
19 h 05 min 48,340            @/Bip
19 h 05 min 53,488            @/Sonnerie PNC
19 h 06 min 00,922            F/Yeah, almost the top of the cloud (*)
19 h 06 min 06,991            C/On top
19 h 06 min 07,700            F/Yeah
19 h 06 min 14,396            C/(*)
19 h 06 min 15,445            F/Yeah
19 h 06 min 23,625            C/(*)
19 h 06 min 32,654            F/Thank you (*)
19 h 07 min 14,041            F/(...)
19 h 07 min 16,838            C/(...) (Remarque: l'equipage cherche à savoir si Marseille Radio diffuse l'ATIS de
Lyon)
19 h 08 min 34,269            C/Marseille, one two seven decimal four
19 h 08 min 39,292            F/Two seven decimal four
19 h 08 min 42,872            O/Marseille Radio/Visibility, more than ten thousand meters,
19 h 08 min 46,303            F/(*)
19 h 08 min 46,332            O/Marseille Radio/Few cloudy at three six zero zero feet, temperature one four (*)

19 h 09 min 02,409            C/You have the same (data) on this (*)
19 h 09 min 04,567            O/Marseille Radio/Visibility eight thousand meters, (light) rain, cloud scattered at
two zero zero feet =
```

Pge p

19 h 09 min 05,053 F/(*)
19 h 09 min 11,717 O/Marseille Radio/=cloud broken at one eight zero zero feet, cloud broken at six six zero zero feet =
19 h 09 min 18,672 C/(*)
19 h 09 min 20,037 O/Marseille Radio/=temperature eight, due point seven
19 h 09 min 20,873 F/(*)
19 h 09 min 22,672 O/Marseille Radio/Q N H one zero zero four
19 h 09 min 27,016 O/Marseille Radio/Geneva one eight five zero, (bearing) wind zero two knots, visibility three five zero zero meters =
19 h 09 min 36,046 O/Marseille Radio/=light rain, mist, cloud scattered at four zero zero feet, cloud broken at thousand feet, =
19 h 09 min 45,432 O/Marseille Radio/=temperature three, due point two, Q N H one zero zero five

19 h 09 min 51,991 O/Marseille Radio/De Gaulle, one nine zero zero, wind zero five zero degrees, one zero knots =
19 h 09 min 59,665 O/Marseille Radio/=visibility eight thousand meters, few cloudy at four thousand feet, =
19 h 10 min 05,784 O/Marseille Radio/=cloud scattered at one three thousand feet, temperature two, due point minus four, Q N H one zero zero six.
19 h 10 min 16,523 O/Marseille Radio/Roma one eight five zero, wind one six zero degrees, zero eight knots, visibility more than ten thousand mete
19 h 10 min 27,316 O/Marseille Radio/=few cloudy at one two zero zero feet, temperature one four, due point one two =
19 h 10 min 34,087 O/Marseille Radio/=Q N H one zero zero nine.
19 h 10 min 38,573 O/Marseille Radio/Milano one eight five zero, (bearing) wind zero two knots, visibility three thousand meters, light drizzle =
19 h 10 min 48,202 O/Marseille Radio/=cloud scattered at thousand feet, cloud broken at three thousand feet, temperature six, due point five =
19 h 10 min 56,796 O/Marseille Radio/=Q N H one zero zero five
19 h 11 min 01,023 O/Marseille Radio/Palma de Majorqua one eight three zero, wind two two zero degrees, one two knots (*)
19 h 11 min 23,669 O/Marseille Radio/Barcelona one eight three zero, wind two two zero degree, zero seven knots =
19 h 11 min 32,365 O/Marseille Radio/=visibility more than ten thousand meters, few cloudy at three thousand feet =
19 h 11 min 38,633 O/Marseille Radio/=temperature one six, due point one three, Q N H one zero zero four
19 h 11 min 45,880 O/Marseille Radio/All station this is Marseille Radio
19 h 11 min 50,591 O/Marseille Radio/Marseille one nine zero zero, wind one four zero degrees, zero four knots =
19 h 11 min 58,988 O/Marseille Radio/=visibility more than ten thousand meters, few cloudy at two three zero zero feet (*)
19 h 12 min 17,147 O/Marseille Radio/Nice one nine zero zero, wind two three zero degrees, one four knots =
19 h 12 min 25,383 O/Marseille Radio/=Visibility more than ten thousand meters, few cloudy at three six zero zero feet

19 h 12 min 32,527 O/Marseille Radio/=temperature one four, due point one one, Q N H one zero zero two.

19 h 12 min 41,017 O/Marseille Radio/Catana one nine zero zero, wind (*), visibility eight thousand meters, light rain =
19 h 12 min 50,912 O/Marseille Radio/=cloud scattered at two zero zero feet, cloud broken at one eight zero zero feet =
19 h 12 min 58,205 O/Marseille Radio/=cloud broken at six six zero zero feet, temperature eight, due point five
19 h 13 min 03,449 O/BDX ENR/Méditerranée seven eight one seven, say mach number.
19 h 13 min 05,231 O/Marseille Radio/Q N H one zero zero four
19 h 13 min 08,847 C/>Point seven six, Méditerranée seven eight one seven
19 h 13 min 09,539 O/Marseille Radio/(*) one eight five zero
19 h 13 min 11,399 O/BDX ENR/Copied
19 h 14 min 03,069 F/(*)
19 h 14 min 07,870 C/(*)
19 h 14 min 14,811 F/So Marseille it's heu... one one zero, four knots, ten kilometers or more (*) broken at (nine) thousand feet, =
19 h 14 min 26,728 F/=and (*) two hundred. And heu...Lyon (wind)... wind calm, eight kilometers

19 h 14 min 33,012 C/Eight kilometers
19 h 14 min 33,859 F/Yes it's heu...some rain but little... just few rain, broken at one thousand eight hundred feet =
19 h 14 min 40,817 F/=scatttered two hundred and heu... (*) eight degrees
19 h 16 min 56,733 O/ATIS Lyon/U T C, good evening. Approach I L S three six right, runway in use landing three six right, =
19 h 17 min 02,648 O/ATIS Lyon/=take off three six left, standard departure four November, Echo, Romeo. Runway is wet. =
19 h 17 min 08,902 O/ATIS Lyon/=Transition level six zero. =
19 h 17 min 11,894 O/ATIS Lyon/=Caution wind at one thousand five hundred feet is reported one eight zero degrees, one five knots. =
19 h 17 min 18,353 O/ATIS Lyon/=Wind one four zero degrees, three knots, visibility four hundred meters, =
19 h 17 min 24,917 O/ATIS Lyon/=R V R are above two thousand meters, light wind and fog
19 h 17 min 27,379 O/BDX ENR/Méditerranée seven eight one seven, (*) level two eight zero
19 h 17 min 33,865 F/>(*) flight level two eight zero Méditerranée seven eight one seven
19 h 17 min 40,092 F/Two eight zero (*)
19 h 17 min 54,445 O/BDX ENR/Méditerranée seven eight one seven, I confirm, descend level two eight zero initially
19 h 17 min 58,338 C/>Two eight zero initially, Méditerranée two zer...seven eight one seven

19 h 18 min 01,714 O/BDX ENR/Roger, I think... your read back was cut by an other traffic
19 h 18 min 07,938 F/We have to check the... we have to check the ATIS... of Lyon
19 h 18 min 15,306 O/ATIS Lyon/...is reported one eight zero degrees, one five knots. =
19 h 18 min 20,117 O/ATIS Lyon/=Wind one four zero degrees three knots, visibility four hundred meters, R V R above two thousand meters =
19 h 18 min 28,838 O/ATIS Lyon/=(slight) wind and fog, scattered two thousand, correction scattered two

Pge p

hundred, =
19 h 18 min 35,004 O/ATIS Lyon/=broken one thousand eight hundred feet, broken six thousand six hundred feet
19 h 18 min 39,955 O/ATIS Lyon/=temperature plus eight degrees, due point plus eight degrees, =

19 h 18 min 42,560 O/ATIS Lyon/=Québec Novembre Hotel, one zero zero four, Québec Fox-Trot Echo available on ground frequency =
19 h 18 min 50,029 O/ATIS Lyon/=acknowledge information Alpha first contact.
19 h 18 min 54,325 O/ATIS Lyon/This is Lyon Saint-Exupéry information Alpha record one nine one two U T C, good evening. =
19 h 18 min 59,248 O/ATIS Lyon/=Approach I L S three six right, runway in use landing three six right, take off three six left
19 h 19 min 05,132 O/ATIS Lyon/=standard departure four November, Echo, Romeo, runway is wet, transition level six zero. =
19 h 19 min 07,826 O/BDX ENR/Méditerranée seven eight one seven, at level two eight zero, you will take two eighty knots maximum
19 h 19 min 12,590 O/ATIS Lyon/=Caution wind at one thousand five hundred feet is reported one eight zero degrees, one five knots. =
19 h 19 min 15,334 C/>At flight level two eight zero, two eighty knots maximum speed, Méditerranée seven eight one seven
19 h 19 min 20,376 O/ATIS Lyon/=Wind one four zero degrees three knots, visibility four hundred meters, R V R are above two thousand meters =
19 h 19 min 29,011 O/ATIS Lyon/=(slight) wind and fog.
19 h 19 min 33,080 F/Ok I'm with you
19 h 19 min 35,581 C/Yes
19 h 19 min 36,445 F/I'm with you
19 h 19 min 38,318 C/(*) flight level two eight zero, speed two eight zero knots
19 h 19 min 41,376 F/Ok check
19 h 19 min 42,786 C/So we have speed set at two eight zero
19 h 19 min 45,404 F/Check. Hey... after the... the I...I L S landing three six right (who is) expected, =
19 h 19 min 53,533 F/=(that is said that), flight level one eight zero, (it's gonna) to be windy so one...one five zero eighteen knots =
19 h 20 min 01,626 F/=at flight level one eight zero
19 h 20 min 03,665 C/Eighteen?
19 h 20 min 04,740 F/(Eighty), pass.., aft..., passing (*) one four zero three knots and the visibility four hundred meters =
19 h 20 min 13,560 F/=and the R V R is two kilometers, two thousand meters
19 h 20 min 17,025 C/Ah it's heu...low visibility
19 h 20 min 19,289 F/Yeah and it's foggy, rain, (*) and (local mist)
19 h 20 min 22,586 C/Raining?
19 h 20 min 23,402 F/And (*) little, and it's broken one thousand eight hundred and six thousand six hundred broken also
19 h 20 min 31,968 F/Local temperature and due point, eight, eight
19 h 20 min 35,277 C/Eight
19 h 20 min 35,850 F/Eight eight

19 h 20 min 36,630 C/Eight eight, that's why that's...
19 h 20 min 37,821 F/That's foggy yeah, and we are in the limits, four hundred meters, the limits for the CAT two (*) (CAT one)
19 h 20 min 47,186 C/(*) what is (the visibility)
19 h 20 min 48,789 F/Heu... the visibility, four hundred meters
19 h 20 min 52,216 C/We don't care about visibility, we care about the R V R
19 h 20 min 54,242 F/R V R sorry, yes
19 h 20 min 55,349 C/(*)
19 h 20 min 56,166 F/Heu... two thousand meters
19 h 20 min 58,817 C/Visibility (*) five thous...heu... eight thousand meters, if you have R V R it's (five thousand fifty) (*)
19 h 21 min 42,461 F/So runway is three six
19 h 21 min 47,073 C/So... runway, runway is three six
19 h 21 min 53,683 F/Yeah the three six right (*).Short briefing, the weather is checked, status checked, four knots, heu... notams checked, =
19 h 22 min 17,903 F/=(elevation is) (*) eight hundred feet on Lima, (*) MEZIN one Delta, (*) to Bravo but we waiting for that, (*)=
19 h 22 min 33,600 F/=after MEZIN, we go to Lima Sierra Echo forty five, two fifty (flight level) (*) flight level one four zero (*), =
19 h 22 min 48,236 F/=and heu after that, NELEN (*) at flight level one two zero (*) after that ROLIR

19 h 23 min 02,884 F/And then to (*) at Lima Sierra Echo (*)
19 h 23 min 09,119 C/Ok
19 h 23 min 09,676 F/Maximum two two zero knots, (the) speed (constraint). After that (ARBON)...(ARBON), after that (thirty) (D M E) Lima Sierra E
19 h 23 min 20,422 F/=maximum two hundred. And then for the I L S heu... three six right (*) three five five (*) =
19 h 23 min 32,228 F/= (this is the (*)) eleven five five =
19 h 23 min 35,426 F/=and it said it's heu... four thousand feet (*) one one one point five at (*) =

19 h 23 min 44,168 F/= Lima Sierra November (waiting) (*) and the minimals
19 h 23 min 53,732 C/What they (said)? (*)
19 h 24 min 15,802 F/Lima Sierra Echo (above the place) (*) (missed approach) is going to the (head) to one thousand two hundred and right =
19 h 24 min 22,376 F/=maximum one hundred fifty five knots to intercept and follow radial zero two zero Lima Sierra Echo(*)
19 h 24 min 28,733 C/Zero two zero
19 h 24 min 31,770 F/And heu... climbing up to five thousand
19 h 24 min 35,220 C/(Well)
19 h 24 min 35,437 F/(*) five thousand
19 h 24 min 37,593 C/Yes
19 h 24 min 38,265 F/And after twenty seven D M E, Lima Sierra Echo turn right to join holding (maximum)
19 h 24 min 43,872 C/Ok
19 h 24 min 45,168 F/And the missed approach (it's here...) (*) and then (they said) (*)
19 h 24 min 52,928 O/BDX ENR/Méditerranée seven eight one seven, report speed to Marseille one three

two decimal three six five, bye bye
19 h 24 min 59,678 C/>Three two three six five with speed, Méditerranée seven eight one seven bye

19 h 25 min 06,284 F/(*)
19 h 25 min 13,406 C/>Marseille Contrôle bonjour, Mediterrannée seven eight one seven, flight level two eight zero, speed two eight zero
19 h 25 min 20,853 O/MAR ENR/Méditerranée seven eight one seven bonjour, identified
19 h 25 min 30,127 F/(*) (Lima Fox) (*) and it's three six right (*) minimal descent altitude (*) M D A one thousand twenty one =
19 h 25 min 43,928 F/=config full, auto brake low, gross weight seventy two tonnes, below maximum landing weight =
19 h 25 min 51,506 F/=(*) the approach is one four one, (fuel) five point seven =
19 h 25 min 57,509 F/=and destination with two point three (that's extra), fifty three minutes. The secondary... nothing (*) =
19 h 26 min 08,329 F/=Hey... we expect to vacate heu... via...heu
19 h 26 min 15,229 C/(*)
19 h 26 min 16,221 F/Whisky four...not Whisky four Bravo four, Bravo three =
19 h 26 min 20,626 F/=heu... cross the runway at...Alpha three or Alpha four and then heu Tango Charlie, Tango Bravo, Tango Delta=
19 h 26 min 28,129 F/= to the Bravo something (*)
19 h 26 min 30,285 C/(Where we stay for this time?)
19 h 26 min 33,185 F/(After) also we have heu...runway three six right, we have heu... =
19 h 26 min 44,801 F/=high intensity in the center line, no, high intensity in runway light and center line. We have heu... have PAPI, no. Yes =
19 h 27 min 00,786 F/=That's it.
19 h 27 min 04,260 @/Bruit de sélecteur
19 h 27 min 06,898 F/Anything else?
19 h 27 min 09,616 @/Bruit
19 h 27 min 10,595 @/Bruit
19 h 27 min 41,071 F/(*) have to maintain two eight zero?
19 h 27 min 58,372 C/I don't get it, we have this guy here
19 h 28 min 00,584 F/Yeah
19 h 28 min 00,757 C/(*) descend
19 h 28 min 02,780 F/Hum hum
19 h 28 min 02,951 C/(You know) (*)
19 h 28 min 05,285 F/Yeah
19 h 28 min 26,629 O/MAR ENR/Méditerranée seven eight one seven, descend level two zero zero, indicated airspeed two height zero knots or less
19 h 28 min 34,490 C/>Descending flight level two zero zero, indicated speed two eight zero or less, Méditerranée seven eight one seven
19 h 28 min 42,910 F/Ok, two eight zero speed, thrust idle, descend flight level two zero zero

19 h 28 min 47,359 C/(Right) check (Remarque:test micro)
19 h 28 min 51,269 F/I hear you really well (*)
19 h 29 min 34,447 VS:(*)
19 h 29 min 49,824 F/So we are twenty five (*) open descent

Pge p

19 h 30 min 05,898 O/MAR ENR/Méditerranée seven eight one seven, contact Marseille one two eight three two five, au revoir.
19 h 30 min 12,017 C/>One two three two five, Méditerranée seven eight one seven, bye
19 h 30 min 15,434 O/MAR ENR/One two eight three two five
19 h 30 min 17,776 C/>Two eight three two five, Méditerranée seven eight one seven, bye
19 h 30 min 26,734 C/>Marseille Contrôle bonjour Méditerranée seven eight one seven, descending two zero zero, speed two eight zero knots
19 h 30 min 36,349 O/MAR ENR/Méditerranée seven eight one seven bonjour, descend two zero zero

19 h 30 min 39,520 C/>Descending two zero zero, Méditerranée seven eight one seven.
19 h 31 min 13,976 @/Sonnerie poste pilotage
19 h 31 min 16,621 C/Vers PNC/Yes
19 h 31 min 17,062 P/(*) for landing
19 h 31 min 19,402 C/Vers PNC/(XXX) (Remarque: conversation en Grec)
19 h 31 min 23,177 P/(XXX)
19 h 32 min 05,272 @/(Remarque: fin de conversation)
19 h 32 min 08,138 F/(*)
19 h 32 min 15,731 F/We have heu... to maintain two eighty? No hein?
19 h 32 min 18,949 C/(Reduce)
19 h 32 min 45,373 O/MAR ENR/Méditerranée seven eight one seven, descend level one six zero

19 h 32 min 49,049 C/>Descending flight level one six zero, Méditerranée seven eight one seven

19 h 32 min 54,669 C/(*)
19 h 32 min 56,256 F/Alpha
19 h 32 min 59,115 O/MAR ENR/Méditerranée seven eight one seven, descend level one six zero

19 h 33 min 03,013 C/>Descending one six zero, Méditerranée seven eight one seven
19 h 33 min 04,001 F/(Five) thousand, open descent flight level one six zero blue
19 h 33 min 06,281 C/Check
19 h 33 min 08,512 O/MAR ENR/Méditerranée seven eight one seven, descend level one six zero

19 h 33 min 12,666 C/>Did you copy descending flight level one six zero, Méditerranée seven eight one seven
19 h 34 min 35,220 O/MAR ENR/Méditerranée seven eight one seven, descend level one four zero, =

19 h 34 min 37,953 O/MAR ENR/=contact Lyon Approche, one three six zero seven five, au revoir.

19 h 34 min 41,961 C/>Descending one four zero, three six zero seven five, Méditerranée seven eight one seven, au revoir.
19 h 34 min 49,748 C/One four zero blue
19 h 34 min 51,996 F/Checked, flight level one four zero blue.
19 h 35 min 10,526 C/>Lyon Approche bonjour Mediterrannée seven eight one seven, descending one four zero, information Alpha
19 h 35 min 16,990 O/APP/Mediterrannée seven eight one seven bonjour, descend level seven zero heu... =

19 h 35 min 24,156 O/APP/=and vectoring I L S three six right, =

19 h 35 min 26,977 O/APP/=correction descend level one hundred, Mediterrannée seven one seven, seven eight one seven

19 h 35 min 31,452 C/>Ok descending one hundred, vector for runway three six right, Mediterrannée seven eight one seven

19 h 35 min 36,738 O/APP/Mediterrannée seven eight one seven, continue present heading and it's information Bravo =

19 h 35 min 40,783 O/APP/=low visibility procedures in progress due to heu... due to cloud.

19 h 35 min 46,007 C/>Roger descending heu ...one zero zero, present heading, Mediterrannée seven eight one seven

19 h 36 min 02,437 F/So heading, flight level one zero zero (blue)

19 h 36 min 06,193 C/Check

19 h 36 min 23,631 C/This ATIS information Bravo ?

19 h 36 min 27,977 O/ATIS Lyon/Lyon Saint-Exupéry information Charlie, recorded at one nine three five U T C, good evening.

19 h 36 min 33,962 O/ATIS Lyon/=Approach I LS three six right, runway in use landing three six right, =

19 h 36 min 37,810 O/ATIS Lyon/=take off three six left, standard departure four November, Echo, Romeo, runway is wet =

19 h 36 min 43,429 O/ATIS Lyon/=transition level six zero, wind at one thousand five hundred feet reported southerly one five knots =

19 h 36 min 52,058 O/ATIS Lyon/=low visibility procedures in force, wind one four zero degrees, four knots, =

19 h 36 min 56,336 O/ATIS Lyon/= visibility one thousand one hundred meters, light wind and mist, broken one hundred feet, broken...

19 h 37 min 04,582 C/Why we have low visibility in force? With one thousand one hundred meters.

19 h 37 min 08,000 F/Yes

19 h 37 min 12,768 C/So... we cannot go there.

19 h 37 min 16,203 O/APP/Méditerranée soixante dix-huit dix-sept, contactez Lyon radar, cent vingt decimal deux cent vingt cinq, au revoir

19 h 37 min 25,696 O/APP/Méditerranée soixante dix-huit dix-sept, contactez Lyon radar, cent vingt decimal deux cent vingt cinq, au revoir

19 h 37 min 30,458 C/>Did you call, Méditerranée seven eight one seven?

19 h 37 min 32,542 O/APP/Méditerranée seven eight one seven, correction, contact Lyon Radar one two zero decimal two two five, bye bye

19 h 37 min 38,389 C/>Two zero two two five Méditerranée seven eight one seven, bye

19 h 37 min 48,457 C/We will down (*) on the way to the I L S so descent as fast as possible

19 h 37 min 53,269 F/Yeah that's what I'm doing

19 h 37 min 57,117 C/>Lyon bonjour, Méditerranée seven eight one seven, heading zero seven zero, down to flight level one zero zero

19 h 38 min 04,000 O/LYON/Seven eight one seven bonjour, turn left heading zero three zero, intercept localizer three six right

19 h 38 min 09,845 C/>Left heading zero three zero, intercept localizer three six right, Méditerranée

seven eight one seven.
19 h 38 min 17,316 C/Well, it's going to shake
19 h 38 min 18,965 F/Yeah
19 h 38 min 19,235 C/Be prepared. Anti ice ON
19 h 38 min 22,381 F/Checked, speed alt star.
19 h 38 min 24,393 C/Yes
19 h 38 min 26,270 F/ Intercept the localizer, four thousand checked, we have to be prepared

19 h 38 min 30,116 C/Ok
19 h 38 min 44,121 C/>Lyon for Méditerranée seven eight one seven, requesting ten degrees to the left to avoid weather
19 h 38 min 49,418 O/LYON/Méditerranée seven eight one seven, that's approved, descend five thousand feet, one zero zero four
19 h 38 min 54,840 C/>Five thousand with one zero zero four, Méditerranée seven eight one seven, deviation approved thank you
19 h 39 min 04,926 C/One zero one four... one zero one four
19 h 39 min 08,876 F/One zero one four
19 h 39 min 10,282 C/One zero one four
19 h 39 min 11,429 F/(*)
19 h 39 min 12,151 O/LYON/Méditerranée seven eight one seven for information, low visibility procedures in force
19 h 39 min 15,734 F/One zero one four
19 h 39 min 17,484 O/LYON/The ceiling is broken one hundred
19 h 39 min 18,000 F/One... ten thousand now
19 h 39 min 19,000 O/LYON/And heu...latest R V R, more than two thousand meters everywhere

19 h 39 min 22,796 C/>Thank you
19 h 39 min 25,952 C/So
19 h 39 min 26,565 C/>Copied
19 h 39 min 27,507 C/Vers PNC/>Cabin crew prepare for landing
19 h 39 min 29,262 C/So Q N H one zero one four, passing nine thousand six hundred now
19 h 39 min 32,900 F/Cross check
19 h 39 min 34,070 C/Approach checklist, briefing
19 h 39 min 36,134 F/Confirm
19 h 39 min 36,646 C/(ECAM status)
19 h 39 min 38,118 F/(ECAM status) checked
19 h 39 min 39,600 C/Seat belt
19 h 39 min 41,000 F/ON
19 h 39 min 42,160 C/Baro ref
19 h 39 min 43,788 F/Baro ref, one zero one four set
19 h 39 min 48,287 C/One zero one four set and minimums?
19 h 39 min 52,580 F/One thousand twenty one set
19 h 39 min 54,140 C/One thousand twenty one set and engine mode selector?
19 h 39 min 57,840 F/Normal
19 h 39 min 58,236 C/(Procedure) completed
19 h 39 min 59,133 F/Thank you very much

19 h 40 min 04,285 C/We are clear for the approach, yes?
19 h 40 min 05,766 F/Yes
19 h 40 min 09,210 C/>Lyon for Méditerranée seven eight one seven, can we intercept localizer with that heading?
19 h 40 min 14,352 O/LYON/Seven eight one seven, that's approved, reduce speed two two zero knots.

19 h 40 min 18,486 C/>Two two zero knots, we have already, Méditerranée... seven eight one zero, clear for the approach runway three six right
19 h 40 min 24,808 O/LYON/Seven eight one seven, descend four thousand feet and you're cleared I L S =

19 h 40 min 27,540 F/We're cleared I L S, right?
19 h 40 min 27,662 O/LYON/=three six right, leave four thousand feet on the glide.
19 h 40 min 30,421 C/>Ok, four thousand, clear for the I L S and (leave them on) the glide, Méditerranée seven eight one seven.
19 h 40 min 36,200 C/Yes
19 h 40 min 36,253 F/(CAT) two
19 h 40 min 36,704 F/Auto (pilot), plus two
19 h 40 min 39,445 C/Four thousand
19 h 40 min 40,178 F/Four thousand sorry... descending four thousand feet
19 h 40 min 43,740 C/Checked
19 h 40 min 44,253 F/Four thousand to blue
19 h 40 min 45,876 C/Ok
19 h 40 min 48,160 F/So (*)
19 h 40 min 48,798 C/It was a bit yellow, that's why I'm making the left turn just to avoid because we heading in
19 h 40 min 54,763 F/So... I don't want this....
19 h 40 min 58,770 F/So activate approach phase
19 h 41 min 01,115 C/Activate approach phase, you can do something else
19 h 41 min 04,233 C/You can use flaps
19 h 41 min 05,328 F/Yes
19 h 41 min 05,484 C/Flap one
19 h 41 min 05,832 F/Flap one, yes
19 h 41 min 06,637 C/Speed check, flap one
19 h 41 min 08,826 F/Thanks you very much
19 h 41 min 08,986 C/With speed two two zero
19 h 41 min 10,571 F/Thank you very much
19 h 41 min 11,025 C/It's increasing the rate
19 h 41 min 13,623 F/After maintain two twenty, CAT three (dual)
19 h 41 min 17,189 C/Yes
19 h 41 min 18,102 F/But we can reduce our speed
19 h 41 min 19,572 C/Why?
19 h 41 min 19,832 F/Right?
19 h 41 min 20,566 F/No after (*) maintain two two zero
19 h 41 min 23,838 C/Leave it like this, you need to (have) a high rate of descent
19 h 41 min 28,275 F/No, (I L S approach) because we need that yes (we have) (glide slope) is above

```
19 h 41 min 33,154              F/(I L S) below
19 h 41 min 34,358              C/You have to descent so (further)
19 h 41 min 36,292              F/Yes
19 h 41 min 38,282              C/And now you can use speed brakes because now the I L S go lower because you have
flaps
19 h 41 min 43,649              F/Hum hum
19 h 41 min 53,899              C/Localizer alive
19 h 41 min 55,846              F/Checked
19 h 41 min 59,793              @/vérification audio moyen radionav / ILS
19 h 42 min 04,500              F/LOC STAR
19 h 42 min 05,288              @/vérification audio moyen radionav / ILS (indicatif LSN)
19 h 42 min 05,788              C/Check
19 h 42 min 09,116              C/I L S identified
19 h 42 min 10,133              F/Thank you very much
19 h 42 min 11,347              F/So just to be prepared, it's said head two five five, (engage the go around and
then) (*) zero two zero
19 h 42 min 17,739              C/Yes
19 h 42 min 18,177              F/To five thousand feet
19 h 42 min 22,285              C/Yes
19 h 42 min 27,121              C/LOC
19 h 42 min 27,135              F/LOC
19 h 42 min 27,783              O/LYON/Seven eight one seven, continue descent three thousand feet (wind's up) call
me back when you established
19 h 42 min 32,552              C/>Three thousand feet (follow) the glide Méditerranée seven eight one seven

19 h 42 min 36,202              F/LOC
19 h 42 min 37,315              C/Three thousand, ok?
19 h 42 min 38,806              F/Three thousand blue
19 h 42 min 39,928              C/Check
19 h 42 min 42,996              C/You have very good rate
19 h 42 min 44,683              F/(You're nice)
19 h 42 min 44,922              C/Thanks
19 h 42 min 45,847              F/(*)
19 h 42 min 46,043              C/Very, very, very, very, very, very, very, very, very
19 h 42 min 50,902              F/So when intercept the glide slope we going to reduce the speed.
19 h 42 min 53,928              C/As soon as you get... glide slope?
19 h 42 min 56,461              F/Yes
19 h 42 min 56,787              C/Yes you can do
19 h 43 min 01,796              F/Speed...
19 h 43 min 01,912              C/Ok, leave the speed brakes and the thrust drive to reduce the speed
because...leave the speed brakes=
19 h 43 min 07,333              C/=and try to reduce the speed, because with this attitude we are not going to
reduce speed
19 h 43 min 13,424              F/Hum hum
19 h 43 min 14,860              C/You can use whatever speed you need now
19 h 43 min 17,234              F/Ok
```

Pge p

A321_SX-BHS_29 Mars 2013_Transcript V09

19 h 43 min 17,412 C/Glide slope
19 h 43 min 18,102 F/Glide slope
19 h 43 min 18,252 C/This approach is five thousand
19 h 43 min 20,553 F/Check (*) five thousand is put, reducing to two zero five
19 h 43 min 37,584 C/>Established on the I L S three six right, Méditerranée seven eight one seven

19 h 43 min 42,504 O/LYON/Ok seven eight one seven, call tower one two zero four five bye bye

19 h 43 min 46,140 C/>One two zero four five, Méditerranée seven...eight one seven bye
19 h 43 min 53,513 F/Flap two when you can
19 h 44 min 00,600 C/>Tower bonjour Mediterrannée seven eight one seven, six miles final runway three six right
19 h 44 min 14,471 C/Speed checked, flaps two
19 h 44 min 15,111 O/TWR/Mediterrannée seven eight one seven bonjour, clear to land runway three six right, =
19 h 44 min 19,543 O/TWR/=wind one three zero degrees, six knots, report on ground.
19 h 44 min 24,300 C/>We'll report on ground Mediterrannée seven eight one seven
19 h 44 min 27,757 F/Landing gear down, yeah, I want to reduce speed
19 h 44 min 28,510 @/Bruit de sortie du train
19 h 44 min 29,306 O/TWR/>Confirm, clear to land three six right, seven eight one seven
19 h 44 min 32,629 C/>Clear to land three six right, Mediterrannée seven eight one seven
19 h 44 min 35,828 C/Vers PNC/>Oui allô?
19 h 44 min 36,505 P/>Cabin secured for landing
19 h 44 min 37,317 C/Vers PNC/>Thank you
19 h 44 min 42,979 C/(*)
19 h 44 min 44,010 F/Yes
19 h 44 min 45,113 C/(It's your turn)
19 h 44 min 49,684 C/You cannot reduce the speed. Look!
19 h 44 min 51,310 F/No
19 h 44 min 54,914 C/Managed speed
19 h 44 min 56,707 F/Thank you very much. Flaps three, (heu no) (*)
19 h 44 min 59,543 C/Speed checked, flaps three
19 h 45 min 01,532 F/In the limits...
19 h 45 min 05,323 C/Speed checked
19 h 45 min 06,299 F/Flaps full
19 h 45 min 07,035 C/Flaps full, last checklist
19 h 45 min 10,304 F/Yes
19 h 45 min 10,430 C/Heu...cabin crew
19 h 45 min 12,339 F/Advised
19 h 45 min 12,645 C/Auto thrust
19 h 45 min 13,541 F/Speed
19 h 45 min 13,897 C/Auto brake
19 h 45 min 15,427 F/Heu...
19 h 45 min 16,733 VS:(Four hundred)
19 h 45 min 18,053 F/Auto brake low
19 h 45 min 19,238 C/ECAM memo

Pge p

A321_SX-BHS_29 Mars 2013_Transcript V09

19 h 45 min 20,070	F/Land...landing no blue
19 h 45 min 21,229	VS:Three hundred
19 h 45 min 22,157	C/(*) is completed (one hundred above)
19 h 45 min 24,530	F/(*)
19 h 45 min 24,684	C/(No that's not yet)
19 h 45 min 26,932	F/(*) disconnect auto pilot?
19 h 45 min 28,381	C/Yes
19 h 45 min 28,816	VS:Two hundred
19 h 45 min 29,304	F/Auto pilot OFF
19 h 45 min 30,501	@/Cavalry charge
19 h 45 min 31,223	F/Single
19 h 45 min 32,459	C/Yes
19 h 45 min 33,105	@/Triple click
19 h 45 min 34,433	F/(CAT) one ?
19 h 45 min 35,560	C/Yes
19 h 45 min 38,328	VS: One hundred
19 h 45 min 43,060	F/Pull down
19 h 45 min 44,958	VS: Fifty
19 h 45 min 46,041	VS: Fourty
19 h 45 min 46,943	VS: Thirty
19 h 45 min 49,690	C/(We are too high)
19 h 45 min 50,670	F/Yes
19 h 45 min 50,822	VS: Twenty
19 h 45 min 51,379	VS:Retard
19 h 45 min 52,521	VS:Retard
19 h 45 min 53,526	VS:Retard
19 h 45 min 55,411	C/Come on
19 h 45 min 56,250	F/Come on
19 h 45 min 56,540	C/Leave it
19 h 45 min 58,235	VS:Ten
19 h 46 min 00,143	VS:Dual input
19 h 46 min 00,950	C/Lea... leave it!
19 h 46 min 02,165	@/Bruit de vibrations
19 h 46 min 04,459	@/Bruit similaire au toucher des roues
19 h 46 min 05,443	F/(!)
19 h 46 min 07,884	@/Bruit similaire aux reverses en fonction
19 h 46 min 14,355	C/(*) (!)
19 h 46 min 15,900	F/Sorry
19 h 46 min 16,841	C/(*)
19 h 46 min 17,377	F/(...) sorry (...)
19 h 46 min 27,248	F/Sorry
19 h 46 min 28,201	C/Where are we going ?
19 h 46 min 30,403	F/(...) (*)
19 h 46 min 34,461	O/TWR/Mediterrannée seven eight one seven?
19 h 46 min 36,951	F/>(Yeah we stop) (*) Mediterrannée seven eight one seven
19 h 46 min 40,251	O/TWR/Yeah, you still on the runway?

Pge p

19 h 46 min 41,421 C/No!
19 h 46 min 41,649 F/>Heu no we are not...
19 h 46 min 42,049 C/Negative
19 h 46 min 42,569 F/>Negative, we are not on the runway
19 h 46 min 44,528 O/TWR/Ok we're calling the firemen
19 h 46 min 46,272 F/>Ok
19 h 46 min 48,198 F/(...)
19 h 46 min 50,110 C/(*) (!)
19 h 46 min 51,120 F/Sorry (...)
19 h 46 min 53,168 C/Contact the crew, they remain seated, they remain seated
19 h 46 min 56,155 O/TWR/Mediterrannée seven eight one seven any injuries or problems with the engines?

19 h 46 min 57,983 C/(Stop it)
19 h 47 min 01,896 C/>Actually we're...run out of the...run out of the runway... we didn't pass the runway

19 h 47 min 08,841 O/TWR/Any problems with passengers or technical problems?
19 h 47 min 10,994 C/>Negative we don't have technical problems but we are out of the runway =

19 h 47 min 14,659 C/>=probably we have prob...problems with the airbrakes here
19 h 47 min 18,507 O/TWR/Ok the firemen will be here in about heu... one or two minutes
19 h 47 min 27,123 C/That's it (!) ...and we are above the...we have... we were exceded... we exceding the (*). =
19 h 47 min 35,780 C/=Why you do that? Why?
19 h 47 min 38,278 F/No this is not my fault
19 h 47 min 39,735 C/Why? Why... why... why you did that? Why?
19 h 47 min 42,482 VS:(*)
19 h 47 min 43,555 F/This is... (...)
19 h 47 min 45,414 C/Why you did that?
19 h 47 min 46,410 F/We still...
19 h 47 min 46,590 C/We are above the...the... the limits you know what I mean?
19 h 47 min 50,163 @/Appel PNC
19 h 47 min 50,907 F/Yes
19 h 47 min 51,315 C/That mean we would lose... we lo... we lost our licence
19 h 47 min 55,888 F/(*) (is landing), (*) (is landing)
19 h 48 min 05,562 P/(*)
19 h 48 min 05,589 @/Appel PNC
19 h 48 min 07,903 P/(XXX)
19 h 48 min 08,978 C/(XXX)
19 h 48 min 10,167 P/(XXX)
19 h 48 min 14,813 O/TWR/Mediterrannée seven eight one seven, have you switch off the engines?

19 h 48 min 17,933 @/Sonnerie d'accès porte cockpit
19 h 48 min 19,696 C/>I was shutting down the engine now... we shutting down the engines now

19 h 48 min 25,831 O/TWR/Ok roger
19 h 48 min 28,880 P/(XXX) (Remarque :conversation en background avec le captain)

A321_SX-BHS_29 Mars 2013_Transcript V09

19 h 48 min 36,328 C/(XXX) (Remarque :conversation en background avec le captain)
19 h 48 min 45,916 O/TWR/Mediterrannée seven eight one seven, if possible, give me number of souls on board
19 h 48 min 51,146 C/>Heu one seventy four
19 h 48 min 55,558 O/TWR/One seventy four with... crew included?
19 h 48 min 58,637 C/>Heu plu... negative, one seventy four plus seven
19 h 49 min 03,098 O/TWR/Ok one seventy four plus seven thank you
19 h 49 min 09,463 O/TWR/Mediterrannée seven eight one seven any dangerous goods on board?

19 h 49 min 14,947 C/>Say again
19 h 49 min 16,099 O/TWR/Dangerous goods on board?
19 h 49 min 18,192 C/>Everybody is well, no...no injured what we are on the grass after the runway =

19 h 49 min 23,278 C/>=and we need stairs or something like that to evacuate
19 h 49 min 29,159 O/TWR/Ok you need stairs, all right, ok... we... we'll thing of you for further information
19 h 49 min 37,070 @/ discussions entre le captain et la chef de cabine jusqu'à 19:49:55
19 h 50 min 24,395 O/TWR/Mediterrannée seven eight one seven, how many liters of fuels on board?

19 h 50 min 30,563 C/>Six thousand kilos
19 h 50 min 32,938 O/TWR/Ok thank you
19 h 51 min 07,553 F/(*) appologize for this (strategy)
19 h 51 min 09,926 C/You don't have to appologize, now it's (*)
19 h 51 min 25,228 @/Appel PNC
19 h 51 min 27,483 C/Why (you did) that why?
19 h 51 min 31,207 C/Vers PNC/>Yes?
19 h 51 min 31,718 P/(XXX)
19 h 51 min 36,999 C/Vers PNC/>(XXX)
19 h 51 min 44,980 @/(Remarque: fin de conversation)
19 h 51 min 45,150 O/TWR/Méditerranée seven eight one seven, an other question please
19 h 51 min 48,584 C/>Yes
19 h 51 min 49,757 O/TWR/Ok heu...would... do you like the passengers to depart heu... as soon as possible or can they stay on board =
19 h 51 min 56,734 O/TWR/=heu...as soon as the stairs arrives?
19 h 51 min 59,906 C/>We can stay on board, we can... can wait because actually without... =

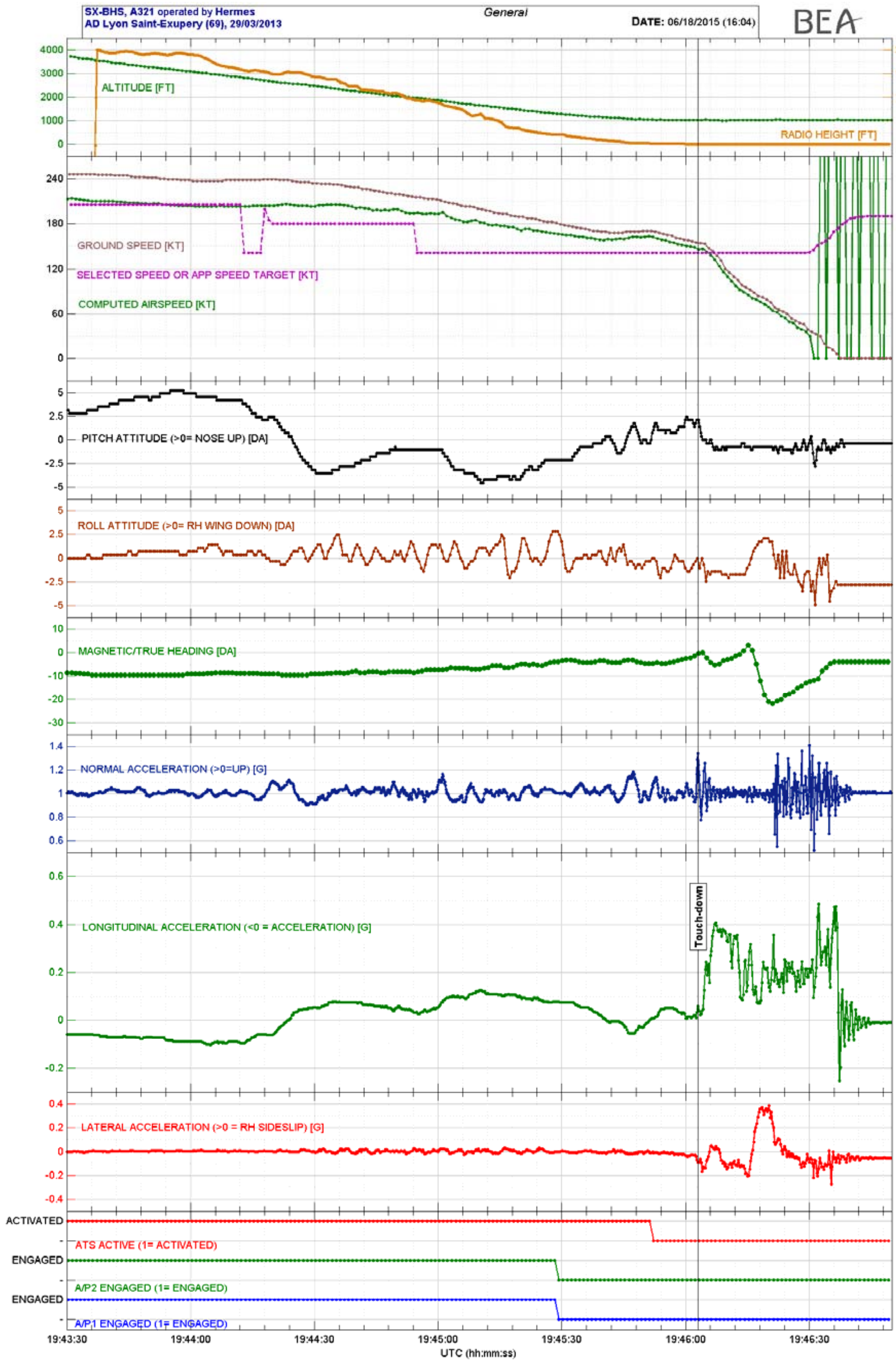
19 h 52 min 04,613 C/>=we don't have any problems with fire or something like that.
19 h 52 min 08,532 O/TWR/Ok, they can stay heu... on board the aircraft...ok =
19 h 52 min 12,380 O/TWR/=the stairs heu... we have called for stairs for the passengers and heu... ok thank you.
19 h 52 min 27,975 F/Sorry again, sorry
19 h 52 min 28,777 C/>Could you check the fire brigade any...any fire or something like that, because we can't see anything, to confirm
19 h 52 min 37,125 P/Vers les passagers/(*) pour le débarquement merci, mais restez assis s'il vous plait, merci.
19 h 52 min 37,190 O/TWR/Ok they... they going to make a visual check of the aircraft

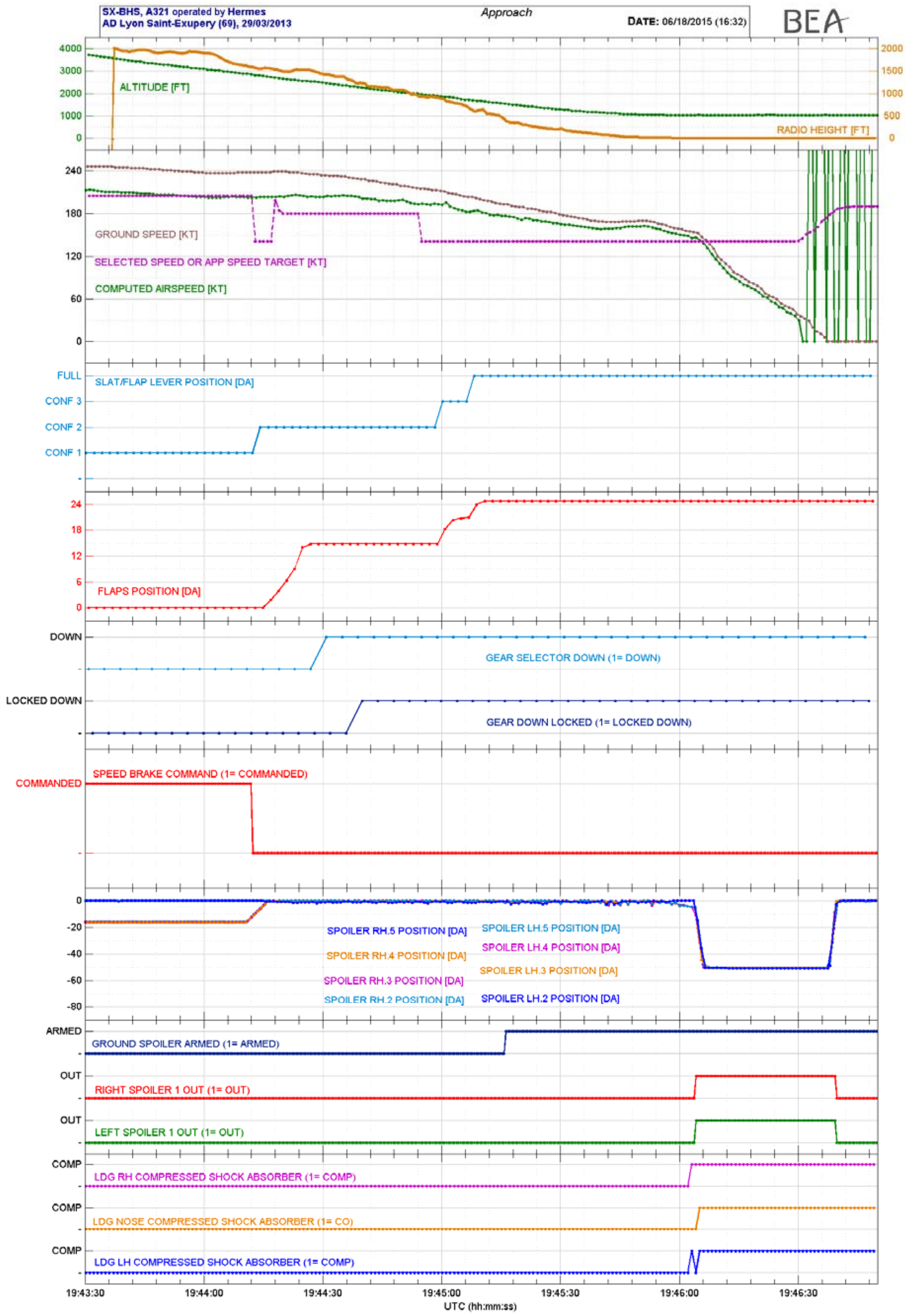
Pge p

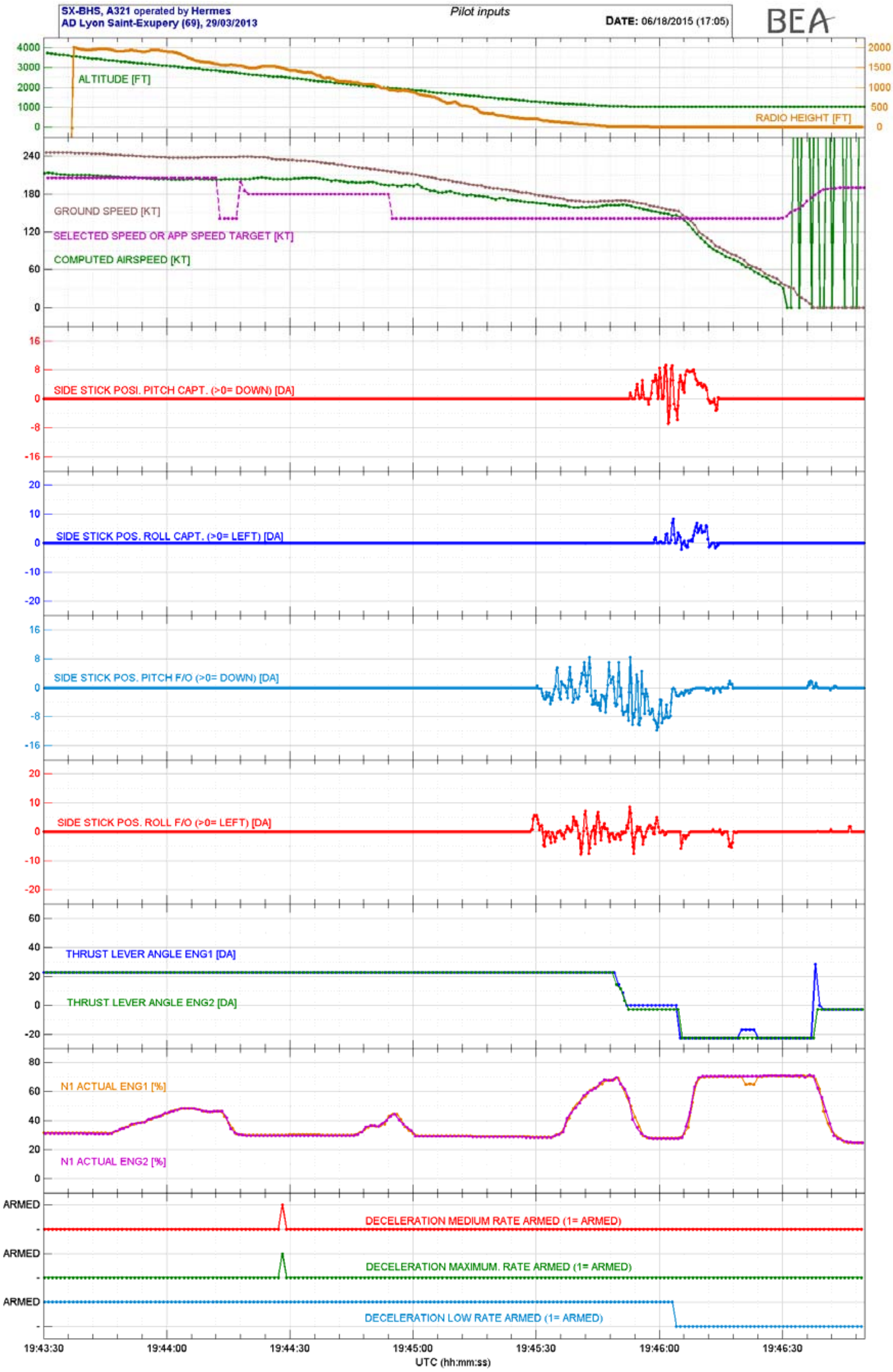
19 h 52 min 47,508	F/(...) (Remarque: conversation non relative à la conduite du vol)
19 h 52 min 58,113	C/I made a mistake, we should make a go around.
19 h 52 min 58,874	O/TWR/Méditerranée seven one seven, the firemen heu... just only heu...=
19 h 53 min 02,548	O/TWR/=there is no problem visually with the aircracft, no problem at all.
19 h 53 min 08,691	C>Thank you very much Sir
19 h 53 min 12,838	F/(...) (Remarque: conversation non relative à la conduite du vol)
19 h 53 min 16,598	P/Vers les passagers/Restez assis s'il vous plait avec vos ceintures attachés.
19 h 53 min 22,331	F/Can I put the flaps on (*)?
19 h 53 min 23,448	C/No no no no no don' t touch anything
19 h 53 min 37,306	@/Single chime
19 h 53 min 42,128	Fin de transcription

****
------------------------------ DOCUMENT RESERVE A L'ENQUETE DE SECURITE
------------------------------ CONFIDENTIEL
****

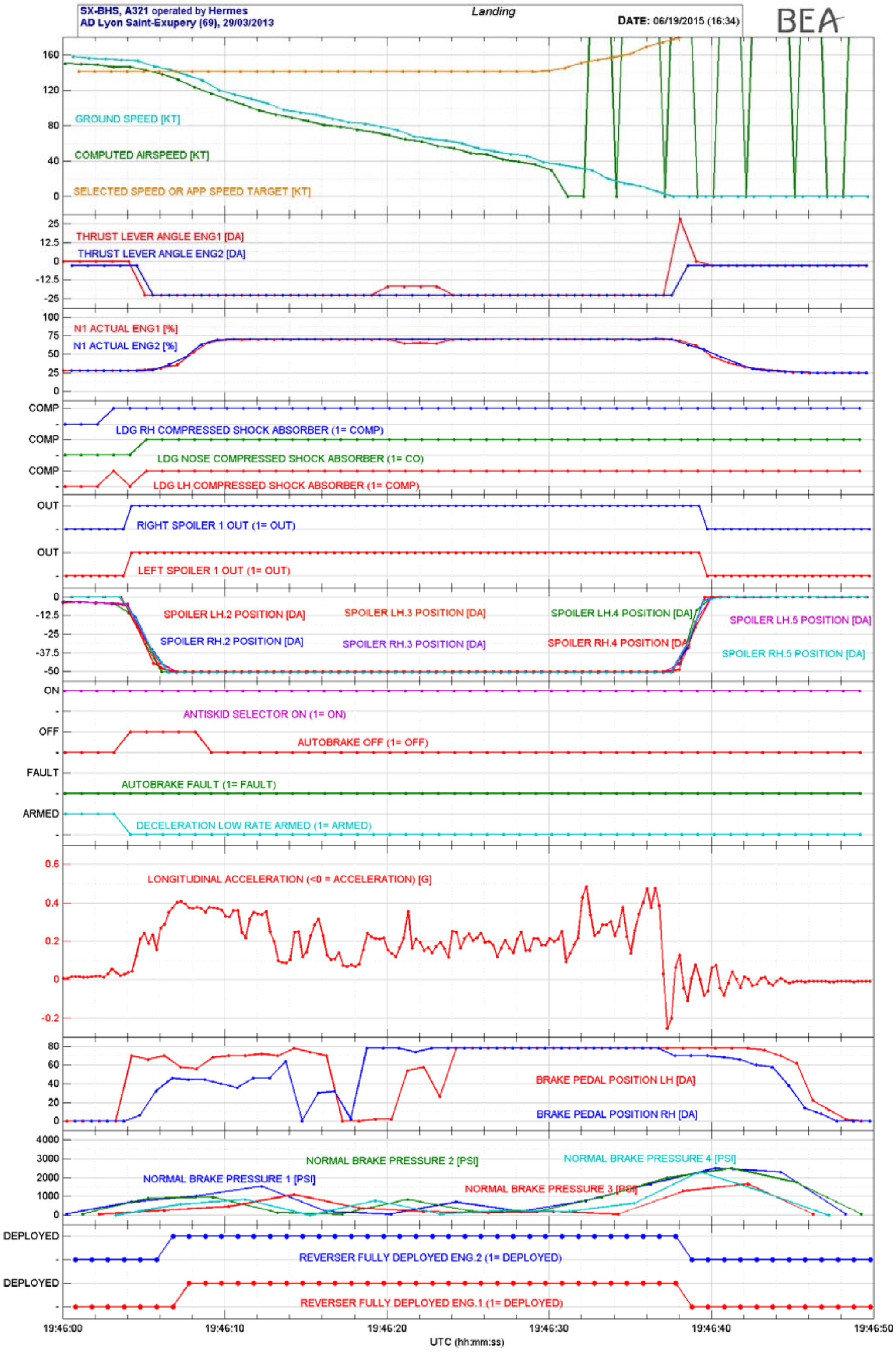
Appendix 3
Graphs of FDR parameters




SX-BHS, A321 operated by Hermes
AD Lyon Saint-Exupery (69), 29/03/2013
Approach
DATE: 06/18/2015 (16:32)
BEA
ALTITUDE [FT]
RADIO HEIGHT [FT]
GROUND SPEED [KT]
SELECTED SPEED OR APP SPEED TARGET [KT]
COMPUTED AIRSPEED [KT]
SLAT/FLAP LEVER POSITION [DA]
FULL
CONF 3
CONF 2
CONF 1
FLAPS POSITION [DA]
DOWN
GEAR SELECTOR DOWN (1= DOWN)
LOCKED DOWN
GEAR DOWN LOCKED (1= LOCKED DOWN)
COMMANDED
SPEED BRAKE COMMAND (1= COMMANDED)
SPOILER RH.5 POSITION [DA]
SPOILER RH.4 POSITION [DA]
SPOILER RH.3 POSITION [DA]
SPOILER RH.2 POSITION [DA]
SPOILER LH.5 POSITION [DA]
SPOILER LH.4 POSITION [DA]
SPOILER LH.3 POSITION [DA]
SPOILER LH.2 POSITION [DA]
ARMED
GROUND SPOILER ARMED (1= ARMED)
OUT
RIGHT SPOILER 1 OUT (1= OUT)
OUT
LEFT SPOILER 1 OUT (1= OUT)
COMP
LDG RH COMPRESSED SHOCK ABSORBER (1= COMP)
COMP
LDG NOSE COMPRESSED SHOCK ABSORBER (1= CO)
COMP
LDG LH COMPRESSED SHOCK ABSORBER (1= COMP)
19:43:30
19:44:00
19:44:30
19:45:00
19:45:30
19:46:00
19:46:30
UTC (hh:mm:ss)



SX-BHS, A321 operated by Hermes
AD Lyon Saint-Exupery (69), 29/03/2013
Pilot inputs
DATE: 06/18/2015 (17:05)
BEA
ALTITUDE [FT]
RADIO HEIGHT [FT]
GROUND SPEED [KT]
SELECTED SPEED OR APP SPEED TARGET [KT]
COMPUTED AIRSPEED [KT]
SIDE STICK POSI. PITCH CAPT. (>0= DOWN) [DA]
SIDE STICK POS. ROLL CAPT. (>0= LEFT) [DA]
SIDE STICK POS. PITCH F/O (>0= DOWN) [DA]
SIDE STICK POS. ROLL F/O (>0= LEFT) [DA]
THRUST LEVER ANGLE ENG1 [DA]
THRUST LEVER ANGLE ENG2 [DA]
N1 ACTUAL ENG1 [%]
N1 ACTUAL ENG2 [%]
DECELERATION MEDIUM RATE ARMED (1= ARMED)
DECELERATION MAXIMUM. RATE ARMED (1= ARMED)
DECELERATION LOW RATE ARMED (1= ARMED)
19:43:30
19:44:00
19:44:30
19:45:00
19:45:30
19:46:00
19:46:30
UTC (hh:mm:ss)



SX-BHS, A321 operated by Hermes
AD Lyon Saint-Exupery (69), 29/03/2013
Landing
DATE: 06/19/2015 (16:34)
BEA
GROUND SPEED [KT]
COMPUTED AIRSPEED [KT]
SELECTED SPEED OR APP SPEED TARGET [KT]
THRUST LEVER ANGLE ENG1 [DA]
THRUST LEVER ANGLE ENG2 [DA]
N1 ACTUAL ENG1 [%]
N1 ACTUAL ENG2 [%]
LDG RH COMPRESSED SHOCK ABSORBER (1= COMP)
LDG NOSE COMPRESSED SHOCK ABSORBER (1= CO)
LDG LH COMPRESSED SHOCK ABSORBER (1= COMP)
RIGHT SPOILER 1 OUT (1= OUT)
LEFT SPOILER 1 OUT (1= OUT)
SPOILER LH.2 POSITION [DA]
SPOILER LH.3 POSITION [DA]
SPOILER LH.4 POSITION [DA]
SPOILER LH.5 POSITION [DA]
SPOILER RH.2 POSITION [DA]
SPOILER RH.3 POSITION [DA]
SPOILER RH.4 POSITION [DA]
SPOILER RH.5 POSITION [DA]
ANTISKID SELECTOR ON (1= ON)
AUTOBRAKE OFF (1= OFF)
AUTOBRAKE FAULT (1= FAULT)
DECELERATION LOW RATE ARMED (1= ARMED)
LONGITUDINAL ACCELERATION (<0 = ACCELERATION) [G]
BRAKE PEDAL POSITION LH [DA]
BRAKE PEDAL POSITION RH [DA]
NORMAL BRAKE PRESSURE 2 [PSI]
NORMAL BRAKE PRESSURE 4 [PSI]
NORMAL BRAKE PRESSURE 1 [PSI]
NORMAL BRAKE PRESSURE 3 [PSI]
REVERSER FULLY DEPLOYED ENG.2 (1= DEPLOYED)
REVERSER FULLY DEPLOYED ENG.1 (1= DEPLOYED)
19:46:00
19:46:10
19:46:20
19:46:30
19:46:40
19:46:50
UTC (hh:mm:ss)

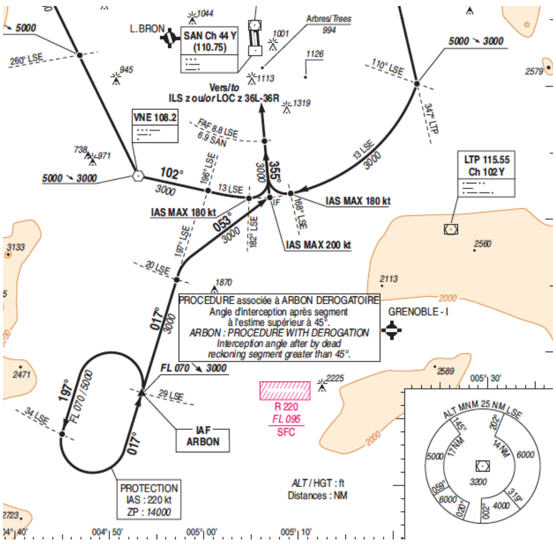
Appendix 4

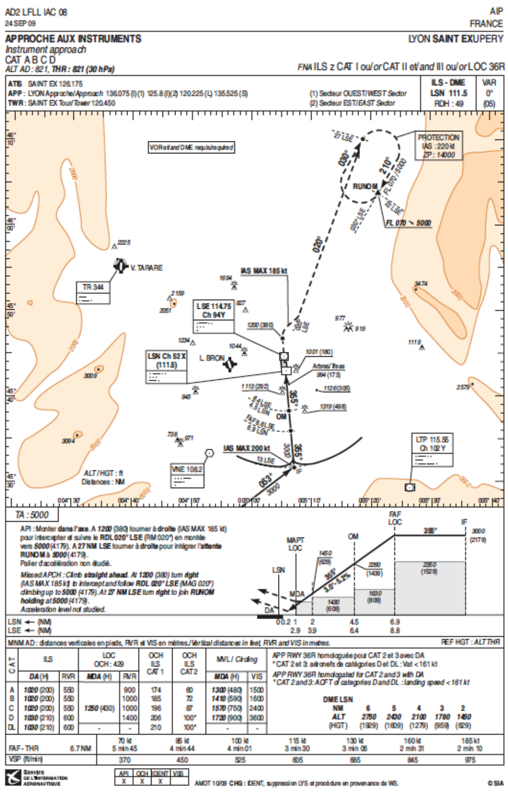
ILS approach to runway 36R (IAF ARBON) after STAR MEZIN 1D

The following information is based on the Tower/Approach Operations Manual of Lyon Saint-Exupéry and on an interview with the Service Quality Manager of the airport air navigation services.

ILS approach to runway 36R (IAF ARBON) after STAR MEZIN 1D

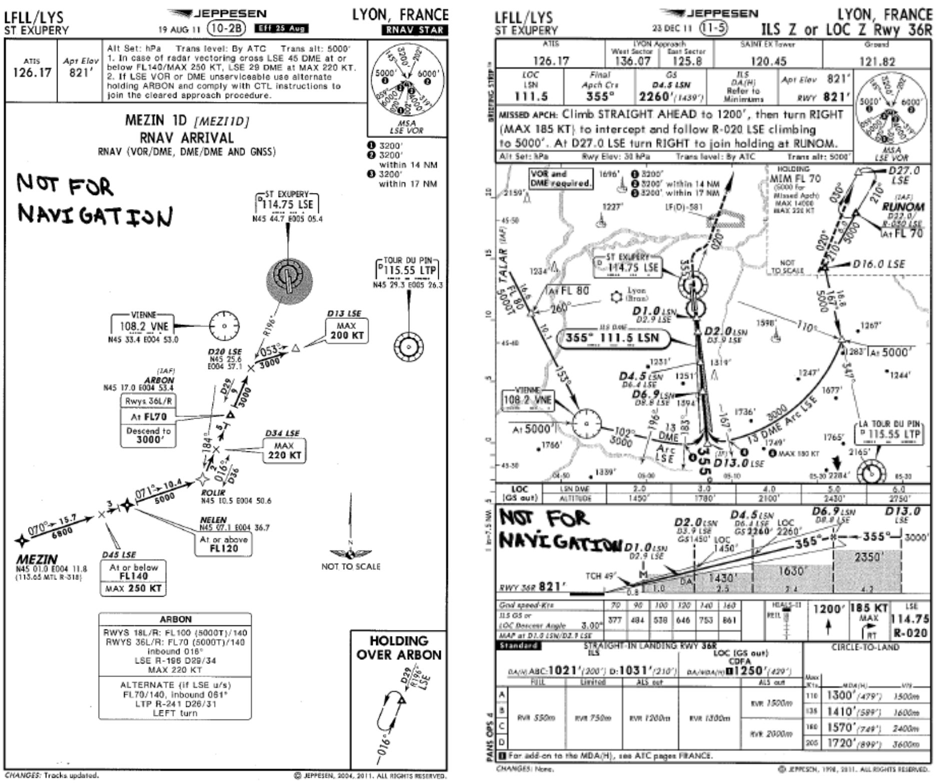
AIP France file AD2 LFLL IAC 03 describes the flight paths required to align with the approach centreline from the initial approach fix ARBON. The initial approach is followed by an intermediate and final approach using procedure ILS Z or LOC 36 R.





The FAF used during an approach via ARBON (by radar vectoring or normal procedure) is the FAP of the ILS 36R Z approach, located at 6.9 NM / 3,000ft.

Note: Only the approaches via GOMET (approach ILS 36R Y) use the FAP located at 10 NM / 4,000 ft. In the short term the FAF for the approach via GOMET will also be positioned at 3,000 ft (i.e. a single FAP for all of the approaches).



Jeppesen charts in effect and available to the crew of the SX-BHS

Listening to the CVR indicates that the PF’s briefing uses the path as described on the Jeppesen data. It only mentions an altitude of 4,000 ft suggesting that the crew was not using the right approach chart and had scheduled an ILS 36R Y approach for which the FAP is at 10 NM and 4,000 ft (instead of approach chart ILS 36R Z).

Appendix 5

Airbus Manual of Core Competencies

APPENDIX 1

CORE COMPETENCIES AND BEHAVIOURAL INDICATORS

Note.— Demonstration of the competencies can be assessed using the behavioural indicators, which should meet the required level of performance, as established by the operator for its specific operation.

Competency	*Competency description*	*Behavioural indicator*
Application of Procedures	Identifies and applies procedures in accordance with published operating instructions and applicable regulations, using the appropriate knowledge.	Identifies the source of operating instructions Follows SOPs unless a higher degree of safety dictates an appropriate deviation Identifies and follows all operating instructions in a timely manner Correctly operates aircraft systems and associated equipment Complies with applicable regulations. Applies relevant procedural knowledge
Communication	Demonstrates effective oral, non-verbal and written communications, in normal and non-normal situations.	Ensures the recipient is ready and able to receive the information Selects appropriately what, when, how and with whom to communicate Conveys messages clearly, accurately and concisely Confirms that the recipient correctly understands important information Listens actively and demonstrates understanding when receiving information Asks relevant and effective questions Adheres to standard radiotelephone phraseology and procedures Accurately reads and interprets required company and flight documentation Accurately reads, interprets, constructs and responds to datalink messages in English

Competency	*Competency description*	*Behavioural indicator*
		Completes accurate reports as required by operating procedures Correctly interprets non-verbal communication Uses eye contact, body movement and gestures that are consistent with and support verbal messages
Aircraft Flight Path Management, automation	Controls the aircraft flight path through automation, including appropriate use of flight management system(s) and guidance.	Controls the aircraft using automation with accuracy and smoothness as appropriate to the situation Detects deviations from the desired aircraft trajectory and takes appropriate action Contains the aircraft within the normal flight envelope Manages the flight path to achieve optimum operational performance Maintains the desired flight path during flight using automation whilst managing other tasks and distractions Selects appropriate level and mode of automation in a timely manner considering phase of flight and workload Effectively monitors automation, including engagement and automatic mode transitions
Aircraft Flight Path Management, manual control	Controls the aircraft flight path through manual flight, including appropriate use of flight management system(s) and flight guidance systems.	Controls the aircraft manually with accuracy and smoothness as appropriate to the situation Detects deviations from the desired aircraft trajectory and takes appropriate action Contains the aircraft within the normal flight envelope Controls the aircraft safely using only the relationship between aircraft attitude, speed and thrust Manages the flight path to achieve optimum operational performance Maintains the desired flight path during manual flight whilst managing other tasks and distractions Selects appropriate level and mode of flight guidance systems in a timely manner considering phase of flight and workload Effectively monitors flight guidance systems including engagement and automatic mode transitions

Competency	*Competency description*	*Behavioural indicator*
Leadership and Teamwork	Demonstrates effective leadership and team working.	Understands and agrees with the crew's roles and objectives. Creates an atmosphere of open communication and encourages team participation Uses initiative and gives directions when required Admits mistakes and takes responsibility Anticipates and responds appropriately to other crew members' needs Carries out instructions when directed Communicates relevant concerns and intentions Gives and receives feedback constructively Confidently intervenes when important for safety Demonstrates empathy and shows respect and tolerance for other people[1] Engages others in planning and allocates activities fairly and appropriately according to abilities Addresses and resolves conflicts and disagreements in a constructive manner Projects self-control in all situations
Problem Solving and Decision Making	Accurately identifies risks and resolves problems. Uses the appropriate decision-making processes.	Seeks accurate and adequate information from appropriate sources Identifies and verifies what and why things have gone wrong Employ(s) proper problem-solving strategies Perseveres in working through problems without reducing safety Uses appropriate and timely decision-making processes Sets priorities appropriately Identifies and considers options effectively.

Competency	*Competency description*	*Behavioural indicator*
		Monitors, reviews, and adapts decisions as required Identifies and manages risks effectively Improvises when faced with unforeseeable circumstances to achieve the safest outcome
Situation Awareness	Perceives and comprehends all of the relevant information available and anticipates what could happen that may affect the operation.	Identifies and assesses accurately the state of the aircraft and its systems Identifies and assesses accurately the aircraft's vertical and lateral position, and its anticipated flight path. Identifies and assesses accurately the general environment as it may affect the operation Keeps track of time and fuel Maintains awareness of the people involved in or affected by the operation and their capacity to perform as expected Anticipates accurately what could happen, plans and stays ahead of the situation Develops effective contingency plans based upon potential threats Identifies and manages threats to the safety of the aircraft and people. Recognizes and effectively responds to indications of reduced situation awareness.
Workload Management	Manages available resources efficiently to prioritize and perform tasks in a timely manner under all circumstances.	Maintains self-control in all situations Plans, prioritizes and schedules tasks effectively Manages time efficiently when carrying out tasks Offers and accepts assistance, delegates when necessary and asks for help early Reviews, monitors and cross-checks actions conscientiously Verifies that tasks are completed to the expected outcome Manages and recovers from interruptions, distractions, variations and failures effectively

KNOWLEDGE *(Source: Airbus technical competencies)*

Competency description

Knowledge and understanding of relevant information, operating instructions, aircraft systems, and the operating environment

Performance indicators

- ❒ Demonstrates practical and applicable knowledge of limitations and systems and their interaction;
- ❒ Demonstrates required knowledge of published operating instructions;
- ❒ Demonstrates knowledge of the physical environment, the air traffic environment including routings, weather, airports and the operational infrastructure;
- ❒ Demonstrates knowledge of the applicable legislation;
- ❒ Knows where to source required information.

Appendix 6

IRBA

MINISTÈRE DE LA DÉFENSE

Service de santé des armées

Direction Centrale du Service de Santé des Armées

Institut de **R**echerche **B**iomédicale des **A**rmées

Pôle Facteurs Humains

Département Neurosciences & contraintes opérationnelles (NCO)

Unité Fatigue et Vigilance

Rapport d'expertise

Titre

Etude « Fatigue – BEA » accident A321 SX-BHS

Rédacteurs du rapport :

MP SAUVET Fabien, M. CHENNAOUI Mounir

DIFFUSION RESTREINTE

Service de Santé des Armées

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
MINISTÈRE DE LA DÉFENSE

Service de santé des armées

Direction Centrale du Service de Santé des Armées

IRBA

Institut de Recherche Biomédica

Pôle Facteurs Humains

Département Neurosciences & contraintes opérationnelles (NCO)

Unité Fatigue et Vigilance

Rapport d'expertise

Titre

Etude « Fatigue – BEA » accident A321 SX-BHS

Rédacteurs du rapport :

MP SAUVET Fabien, M. CHENNAOUI Mounir

LE DIRECTEUR DE L'IRBA

Le Médecin général inspecteur Didier LAGARDE
Directeur
de l'Institut de recherche biomédicale des armées

LE CHEF DE LA DIVISION RECHERCHE

SYNTHÈSE

ORGANISME	DEPARTEMENT	N° DE L'ÉTUDE
IRBA Brétigny sur Orge	NCO, Unité Fatigue et Vigilance	2014/DRS/NCO/Vigilance/01
RESPONSABLE SCIENTIFIQUE		CLASSIFICATION
M. Mounir CHENNAOUI (IRBA/NCO/Fatigue et Vigilance) Institut de recherche biomédicale des armées BP 73 91223 Brétigny sur Orge		DIFFUSSION RESTREINTE : IRBA/DIR, IRBA/DRS/NCO, IRBA/DRS/ACSO, BEA
TITRE DE L'ETUDE		TYPE D'ETUDE
Etude « Fatigue – BEA » accident A321-SX BHS		Expertise
PARTENAIRE		TYPE PARTENARIAT
Bureau d'Enquêtes et d'Analyse pour la sécurité civile, Aéroport du Bourget, 200 rue de Paris, 93352 Le Bourget Cedex.		Contrat de prestation
		VERSION / DATE
		Version 4 /24avril 2014

Contexte.

Dans le cadre de l'enquête de sécurité ouverte à la suite de la sortie de piste de l'Airbus A321 immatriculé SX-BHS survenue le 29 mars 2013 sur l'aéroport de Lyon (LYS), le Bureau d'Enquête et d'Analyse (BEA) pour la sécurité civile a sollicité l'Institut de recherche biomédicale des armées (IRBA) afin de lui fournir une évaluation du niveau de fatigue de l'équipage.

Objectif de l'étude.

L'objectif de cette expertise était d'évaluer l'impact des altérations du cycle veille/sommeil et des activités aéronautiques sur le risque de fatigue, dans cette situation.

Descriptif des travaux.

L'expertise a été réalisée à partir des documents présentés par les enquêteurs du BEA (activités aéronautiques, horaires de travail, conditions de sommeil, enquête technique…) des pilotes le jour de l'accident et les 2 mois précédents). Les données présentées ont été comparée à celles décrites dans la littérature scientifique et aux valeurs obtenues avec un modèle bio-mathématique de gestion du risque fatigue (Modèle SAFTE^{TM}) (Hursch *et al.* 2004).

Résultats.

Les enquêteurs du BEA ont relevé, au cours du vol, des erreurs techniques et non techniques, pouvant être imputées à une dégradation des performances cognitives, caractérisée notamment par des troubles de la mémoire de travail, de la prise de décision et de la conscience de la situation, évocatrices d'un état de fatigue de l'équipage.

Nous n'avons pas identifié d'altérations du cycle veille/sommeil (dette aigüe ou cumulée, modification du rythme circadien) susceptibles de favoriser à elles seules l'apparition d'un tel état de fatigue. La modélisation bio-mathématique, ne met pas en évidence de score à risque de fatigue au cours de la journée de l'accident ou au cours des jours précédents (score d'efficacité minimal de 86 % à la fin du 3ème vol et moyenne pour les 3 vols à 91,9 % ± 0,9 %).

Par contre, le temps de service en vol particulièrement long (14h30) est compatible avec une augmentation importante du risque d'accidents (Goode et al. 2013) et de fatigue ressentie par les équipages. Cet état a pu être notamment majoré par le nombre de vols réalisés au cours de la journée, des durées d'escale courtes ne permettant pas de période de repos et une charge de travail importante.

Conclusion.

Le principal facteur de fatigue identifié au cours de la journée de l'accident est un temps de service particulièrement long. Cette expertise illustre l'intérêt de mieux prendre en compte le temps de service en vol et le nombre d'escales dans les modèles bio-mathématiques de prédiction du risque fatigue en aéronautique.

Signatures :

Chef de la division Recherche Scientifique

Directeur de l'IRBA

Le Médecin général inspecteur Didier LAGARDE
Directeur
de l'Institut de recherche biomédicale des armées

TABLE DES MATIERES

I. INTRODUCTION

I.1. LE MANDAT

Dans le cadre de l'enquête de sécurité, ouverte à la suite de la sortie de piste de l'Airbus A321 immatriculé SX-BHS survenue le 29 mars 2013 sur l'aéroport de Lyon Saint Exupéry (LYS), le Bureau d'enquête et d'analyse (BEA) pour la sécurité civile a sollicité le directeur de l'Institut de recherche biomédicale des armées (IRBA) (courrier du 04/07/2013, annexe 1) afin de lui fournir une évaluation du niveau de fatigue de l'équipage, liée en particulier aux activités aéronautiques le jour de l'accident et les éventuelles dettes de sommeil induites par les activités aéronautiques au cours des jours précédents. L'unité Fatigue et Vigilance de l'IRBA (département Neurosciences et Contraintes Opérationnelles du Pôle Facteurs Humains) a été désignée pour répondre à cette demande d'expertise. Cette expertise a été réalisée dans le cadre d'un contrat de prestation entre l'IRBA et le BEA pour la sécurité civile.

Figure 1. Photographies parues dans la presse relative à l'accident

I.1. PRESENTATION DU GROUPE D'EXPERTS

Cette demande rentre dans le périmètre de recherche et d'expertise de l'unité Fatigue et Vigilance de l'IRBA, créé en septembre 2011 pour répondre aux questions des forces et des états-majors relatives aux conséquences et à la gestion de la fatigue induite par les situations opérationnelles.

L'unité Fatigue et Vigilance, dirigée par Mounir Chennaoui, est composée de 14 personnels (médecin, chercheurs, ingénieurs, techniciens, doctorants …). Ses personnels conduisent depuis plus de dix ans des projets de recherche et d'expertise sur les conséquences physiologiques des altérations du cycle veille/sommeil et du temps passé à la tâche, en laboratoire ou sur le terrain en situation opérationnelle. Ils étudient principalement les effets de ces altérations sur les réponses endocriniennes, immuno-inflammatoires, cardio-vasculaires et cognitives. Ils évaluent aussi l'efficacité de contremesures (stratégies nutritionnelles et pharmacologiques, sieste, luminothérapie…) dans ces situations dégradées.

L'unité Fatigue et Vigilance est notamment experte pour la France pour le STANAG 3527 *aircrew fatigue management* et assure le suivi de l'instruction N° 744/DEF/DCSSA/AST/TEC relative à « l'utilisation des substances modifiant la vigilance en opération ». Ses personnels dispensent les cours relatifs à la gestion de la vigilance en opération dans le cadre des brevets de médecine aéronautique et spatiale (BMAS, BMAS+, brevet européen), interviennent lors des journées sécurité des vols et dans la formation des moniteurs de sport militaire, des personnels navigants au profit de compagnies aériennes civiles. L'unité est également un terrain de stage pour les étudiants du diplôme universitaire « Facteurs Humains pour la conception de systèmes homme-machine en aéronautique de l'université Paris Descartes».

Les spécificités et le caractère unique de l'unité sont ses compétences scientifiques et techniques multidisciplinaires et transversales (neurosciences, physiologie, psychologie et biologie). L'unité dispose également de plusieurs plateaux techniques : un plateau de biologie moléculaire et biochimie, un appartement de sommeil équipé en polysomnographie et en surveillance vidéo (6 chambres), un plateau technique ambulatoire de monitorage en électrophysiologie, température, actimétrie, GPS et exploration cardiovasculaire et un plateau un plateau d'explorations neurophysiologiques (cage de Faraday).

L'unité Fatigue et Vigilance est labélisée E.A. (Equipe d'accueil) par l'Agence d'évaluation de la recherche et de l'enseignement supérieur (AERES) à compter du 01/01/2014 avec le Centre du Sommeil et de la Vigilance de l'Hôtel Dieu (APHP). L'unité collabore avec l'Ecole supérieure de physique et de chimie de la ville de Paris (ESCPI), avec le Laboratoire de Physiologie de l'Exercice de l'Université de Saint-Etienne et avec la *Military Performance Division* de l'*United States Army Research Institute of Environmental Medicine* (USARIEM. Natick, USA). Elle participe également à des travaux au profit des fédérations françaises de football (FFF), d'athlétisme (FFA) et de cyclisme (FFC), le Paris Saint Germain football club (PSG), l'Institut National du Sport, de l'Expertise et de la Performance (INSEP) et le *Qatar Orthopaedic and Sports Medicine Hospital* (ASPETAR, Doha, Qatar).

L'expertise a été réalisée par :

- **Mounir Chennaoui.** Docteur en sciences, titulaire d'une Habilitation à Diriger la Recherche (HDR), il dirige l'unité Fatigue et Vigilance depuis sa création. Ancien officier supérieur du service de santé des armées, il travaille depuis plus de 19 ans dans le Pole Facteurs Humains de l'Institut de médecine aérospatiale du service de santé des armées (IMASSA) puis de l'IRBA. Il a publié plus de 40 articles internationaux et chapitres de livres dans le domaine de la fatigue et de la performance.

- **Fabien SAUVET.** Docteur en médecine, praticien certifié de recherche du Service de santé des armées, titulaire d'une thèse d'université en physiologie, spécialiste du sommeil et de médecine et biologie du sport. Après une première partie de carrière dans les forces il exerce depuis 2007 à l'IMASSA puis à l'IRBA où il a mené des travaux de recherche portant principalement sur les effets de la privation de sommeil.

Le docteur Mounir CHEANNAOUI et le médecin principal Fabien SAUVET n'ont aucun conflit d'intérêt de type commercial, scientifique ou réglementaire pouvant interférer avec la réalisation de ce travail. Ils ne bénéficient d'aucun intérêt financier personnel.

I.2. DEFINITION DES CONCEPTS UTILISES

I.2.2. LA SOMNOLENCE ET LA VIGILANCE

La vigilance désigne la capacité du système nerveux central à répondre à un stimulus ou à un évènement, à maintenir une surveillance attentive, sans défaillance (Wright et McGown 2001; Caldwell *et al.* 2009). Classiquement, on entend par état de vigilance, l'état d'éveil de l'organisme.

Le déclin de la vigilance au cours de la journée constitue un phénomène physiologique normal qui dépend principalement de la durée de l'éveil et de l'heure de la journée (Akerstedt and Folkand 1986) mais aussi de caractéristiques individuelles, familiales, de la qualité du sommeil la nuit précédente, de la nature des tâches accomplies… (Wegmann *et al.* 1986, Coroenne *et al.* 2013b). L'état de vigilance est physiologiquement au plus bas entre 1 heure et 5 heures du matin (Akerstedt and Folkand 1986).

La diminution de la vigilance, notamment observée au cours de périodes de travail prolongées ou nocturnes, est fréquentes dans le milieu aéronautique (Caldwell *et al*. 2009; Yen *et al*. 2009). Les variations du niveau de vigilance au cours de la journée sont aussi accompagnées de fluctuations de la performance. Or, le pilotage est une tâche complexe qui requiert un niveau optimum d'éveil pour garantir la sécurité (Wright *et al.* 2005). Ainsi, la diminution de la vigilance, est un facteur de risque majeur d'accident dans l'aviation (Caldwell *et al.* 2009; Yen *et al.* 2009), d'augmentation du temps de réaction et d'erreurs (Bourgeois-Bougrine *et al.* 2003a).

La somnolence se définit comme un état intermédiaire entre la veille et le sommeil caractérisé par une tendance irrésistible à l'assoupissement si la personne n'est pas stimulée. La somnolence correspond donc à une diminution de l'éveil physiologique manifestée par un besoin de dormir (Billiard et Deauvilliers 2009).

La probabilité de s'endormir à un moment donné est la résultante de 2 pressions : la pression de sommeil qui dépend de facteurs homéostatiques et du facteur circadien, la pression de veille, dépendant de stimuli internes (horloge biologique) et externes (exposition à la lumière, synchroniseurs sociaux, stimuli psychophysiologiques…) (Billiard et Deauvilliers 2009). En pratique, l'augmentation de la somnolence est corrélée à une diminution de la vigilance (Caldwell *et al.* 2008 ; Wright et McGown 2001, Chennaoui *et al.* 2011). Cependant, la somnolence diminue avec la prise de sommeil mais pas après le repos. Le seul traitement efficace de la somnolence est un sommeil proportionné (Caldwell *et al.* 2009 ; Philip *et al.* 2005).

1.2.3. LA FATIGUE

Définition de la fatigue

Actuellement, il n'y a pas de définition de la fatigue universellement acceptée. Néanmoins, le terme « fatigue », fait référence à une combinaison de signes fonctionnels, tels que l'altération des performances physiques ou mentales, la sensation subjective de somnolence, une diminution de la motivation… La fatigue est favorisée par de nombreux facteurs tels que la privation de sommeil, les activités prolongées, la perturbation des rythmes circadiens, la réalisation de taches complexes et prolongée, d'effort physiques (Chennaoui et Lagarde 2013) mais aussi par l'âge, des maladies, les pathologies du sommeil, des troubles psychiques... (Philip *et al.* 2005). En aéronautique, la fatigue est une problématique majeure du fait de ses conséquences sur la sécurité (Caldwell *et al.* 2009). 25% des accidents dans l'US Air Force ont été attribués à la fatigue des pilotes (Caldwell *et al.* 2009).

Ainsi, l'Organisation de l'Aviation Civile Internationale (OACI) a retenue dans la convention relative à l'aviation civile internationale (annexe 6, 15 juin 2011), la définition suivante de la fatigue : *« état physiologique de capacités mentales ou physiques réduites résultant d'une perte de sommeil ou d'une période d'éveil prolongée qui peut affecter la vigilance d'un membre d'équipage et sa capacité de travailler dans un avion ou effectuer des taches de sécurité de manière efficace* ».

Cependant, il est difficile de mesurer la fatigue réelle des pilotes et il n'y a pas actuellement de méthode de mesure directe de l'apparition de l'état de fatigue d'un pilote (Good 2003 ; Caldwell *et al.* 2009).

Néanmoins, fatigue et somnolence coexistent lors d'activité de conduite prolongée, de pilotage ou après privation de sommeil (Philip *et al.* 2005 ; Caldwell *et al*. 2009). Dans le milieu aéronautique et dans de nombreuses publications scientifiques, les mots fatigue/hypersomnolence/hypovigilance sont même souvent associés ou confondus (Caldwell *et al.* 2009). En pratique, de nombreux auteurs (Barth et Holding 1976, Bougrine *et al.* 2003, Colqhoun 1976, Lille *et al.* 1980, Jackson *et al.* 2013, Ballenky *et al.* 2003) ont développé à partir d'étude portant sur les modifications de l'état d'éveil en vol, des relations empiriques entre les horaires et amplitudes de travail et la dégradation des performances.

La fatigue en vol, évaluée par la sensation de diminution de l'éveil, est observée dans 20% des vols moyens courrier et dans 40% des vols long-courriers (Bourgeois-Bougrine *et al.* 2003a). Entre 41% et 5% des pilotes reconnaissent que la « fatigue a sévèrement impacté la sécurité d'un vol au moins une fois dans leur carrière » (Yen *et al.* 2009) et 50% des pilotes de l'US Air Force admettent être tombé de sommeil involontairement en vol, au moins une fois, pendant une mission (Caldwell et Gilreath 2002). Des enregistrements du sommeil en vol ont mis en évidences des périodes de micro-sommeil chez 40 à 50% des pilotes au cours de vols prolongés de nuit, notamment entre 1 et 5 heures du matin (Wright et McGown 2001, Wright *et al.* 2005, Cabon *et al.* 2003, Coroenne *et al.* 2013b).

Ces résultats confirment de récents travaux menés dans le transport automobile qui ont mis en évidence que le principal facteur de somnolence n'était pas lié à la durée de conduite mais aux perturbations du cycle veille/sommeil et à l'heure de la journée (Philip *et al.* 2005 ; Valent *et al.* 2010). De nombreux travaux ont mis en évidence que la privation de sommeil diminue le temps de réaction, les performances mentales et augmente le nombre d'erreurs (Pikker et Huffcutt 1996) et ce, dès deux heures de privation de sommeil (Belenky et Bissel 1994).

La fatigue dans l'aéronautique peut être favorisée par 3 composantes principales (Hursh 2005, Powell *et al*. 2010) :

- la composante circadienne (l'heure de la journée),
- les dettes de sommeil (dette cumulée de sommeil au cours des jours précèdent, durée d'éveil continue),
- le temps de service.

Dans l'aviation, les causes de la fatigue sont multiples tels que l'accumulation de décalages horaires, de réveils précoces successifs, de vols de nuits répétés, de repos insuffisants entre les vols, les vols successifs au cours d'une même journée qui concourt à la survenue de niveau élevés, voire inacceptables de fatigue et de somnolence pendant les vols (Powell *et al.* 2002, Caldwell *et al.* 2009).

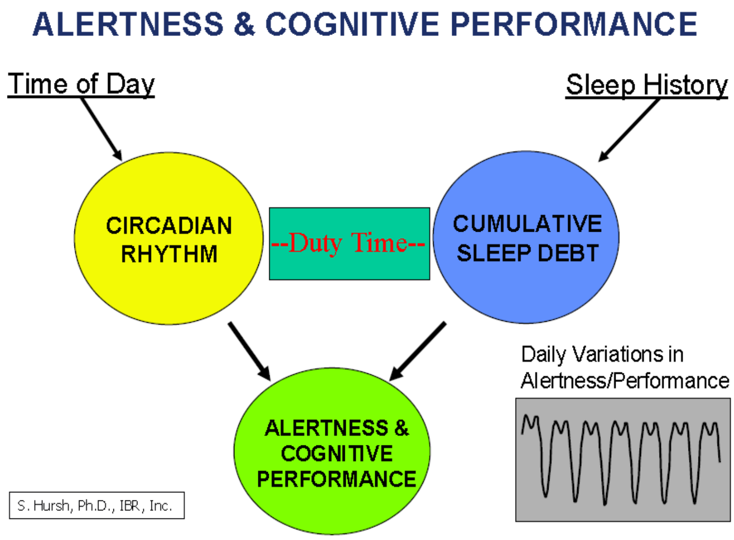


Figure 2. Facteurs influençant l'éveil et la performance cognitive (Hursh 2005)

I.3. LA PROBLEMATIQUE

Dans l'aviation, la question de la fatigue est un problème facteur humain majeur (Caldwell *et al*. 2009). Ne pas prendre en compte ou sous-estimer le signal d'alarme qu'est la fatigue ressentie expose les personnels navigants à ne pouvoir mettre en œuvre leurs capacités au meilleur niveau et à se situer en deçà de l'attente de performance et de sécurité. Il y a là un réel enjeu d'arbitrage dans la gestion de la fatigue d'un équipage et le maintien d'un niveau élevé de performance et de rentabilité pour une compagnie aérienne. En conséquence, de nombreux états et organisations ont développé des règles et des normes, qui fixent des durées minimales de repos et maximales d'emploi des équipages afin de limiter l'apparition et l'amplitude de la fatigue tout en maintenant un niveau d'emploi compatibles avec des impératifs économiques. Ces normes, compromis entre les exigences de sécurité et de rentabilité, prennent en compte de nombreux paramètres tels que : le nombre d'heures de vol (par jour, semaine, trimestre et année), les temps de service, et le temps de repos avant le vol en tenant compte du type d'équipage (augmenté ou non augmenté), de l'horaire du vol (jour/nuit) et du nombre de fuseaux horaires franchis.

Malgré de nombreuses tentatives, il n'y a pas actuellement de consensus international (Caldwell *et al*. 2009) et des différences importantes demeurent selon les pays. Une récente volonté d'harmonisation des normes au niveau européen, votée au parlement européen le 9 octobre 2013 (EASA 2013), a provoqué un vif débat dans la population des pilotes, des experts et des scientifiques (ETSC 2013). D'autre part, aucune norme ne peut prendre en compte l'ensemble des facteurs contribuant à la fatigue au risque d'être trop complexe et inexploitable. En particulier, certains facteurs sont peu pris en compte tels le rythme circadien, le décalage horaire et d'autres ignorés tels la complexité des vols ou la variabilité individuelle. Une alternative a été proposée, consistant à utiliser des modèles mathématiques multiparamétriques d'estimation du niveau de fatigue (cf. paragraphe précédent) afin de fixer les périodes d'activité et de repos.

I.4. LES OBJECTIFS DE L'EXPERTISE

L'objectif de cette expertise était d'évaluer l'impact de l'activité aéronautique et des éventuelles altérations du cycle veille-sommeil sur le risque fatigue dans l'accident du 29 mars 2013, à partir des éléments apportés par les enquêteurs du BEA (par exemple les horaires de travail des pilotes le jour de l'accident et le mois précédent...). Cette expertise a été réalisée au regard de la littérature scientifique actuellement disponible et d'un modèle bio-mathématique validé de gestion du risque fatigue dans l'aviation civile (Modèle SAFTE) (Hursch et al. 2004). Nous avons laissé le soin aux experts de la sécurité aérienne d'interpréter nos résultats et conclusions dans le contexte global de l'enquête.

II. MATERIELS ET METHODE

II.1. DOCUMENTATION RELATIVE A L'ACCIDENT

L'expertise a été réalisée à partir des documents présentés par les enquêteurs du BEA (descriptif de l'accident, activités aéronautiques, horaires de travail, conditions de sommeil…), lors d'une réunion de travail le 28 juin 2013 à l'IRBA (locaux de l'unité Fatigue et Vigilance à l'Hôtel dieu).

Le planning d'activités aéronautiques du Commandant de bord (Cdb) et de l'Officier pilote de ligne (OPL) au cours des 2 mois précédents l'accident sont présenté en annexes 2 et 3.

Les auteurs de ce rapport n'ont jamais rencontré les personnels impliqués dans l'accident ni eu de contact avec eux. Ils n'ont pas utilisés d'informations relatives à l'accident autres que celles transmise par le BEA.

II.2. CALCUL DES PARAMETRES

D'après les définitions du règlement EU-OPS (sous partie Q),, nous avons calculé **:**

- **Temps de vol « cale à cale ».** Le temps écoulé entre le moment où l'avion se déplace de son lieu de stationnement en vue de décoller, jusqu'au moment où il s'immobilise sur la position de stationnement désignée et que tous les moteurs ou toutes les hélices sont arrêtés.
- **Temps de service de vol (TSV).** Toute période au cours de laquelle une personne exerce à bord d'un avion en tant que membre de son équipage. Ce temps est compté depuis le moment où le membre d'équipage doit se présenter, à la demande d'un exploitant, pour un vol ou une série de vols et se termine à la fin du dernier vol au cours duquel le membre d'équipage est en fonction.
- **Temps de service.** Temps écoulé entre le moment où un membre d'équipage doit commencer un service à la demande d'un exploitant jusqu'au moment où il est libéré de tout service.
- **Temps de repos.** Une période ininterrompue et définie pendant laquelle un membre d'équipage est libérée de tout service ainsi que de toute réserve à l'aéroport.

II.3. MODELISATION DE LA FATIGUE

Des nombreux modèles mathématiques ont été développés pour évaluer les modifications de la vigilance et de prédire l'apparition de la fatigue et son importance (Jewett *et al.* 1999, Hursh *et al.* 2004, Neri 2004). Ces modèles ont été créés à partir de résultats d'études en laboratoire et de terrain basées sur des questionnaires subjectifs et de test de performance mentale (temps de réaction principalement) (Van Dongen *et al.* 2007).

Seulement quelques modèles ont été validés sur le terrain en environnement opérationnel (Spencer et Robertson 2007, Hursh *et al.* 2006). Le modèle de prédiction de la fatigue **Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE™),** développé initialement par la défense américaine a été validé par rapport au risque d'accident et d'erreur dans l'aviation et le transport ferroviaire (Jewett *et al.* 1999, Hursh *et al.* 2004, CASA 2010). Ce modèle est aujourd'hui utilisé dans la programmation des vols dans l'armée américaine, de compagnies aériennes civiles, des compagnies ferroviaires ou de transport routier et nucléaire. Des logiciels (FAST, FlyAwake…) ont été conçus pour utiliser plus facilement ce modèle et estimer l'apparition et l'ampleur de la fatigue, ce qui permet d'optimiser la gestion des équipages et l'utilisation des contremesures (siestes, sommeil de récupération, caféine…).

Le modèle SAFTE prend en compte le réservoir de sommeil, le rythme circadien, l'inertie du sommeil, et le temps estimé de sommeil (lorsqu'il n'est pas connu) à partir de l'horaire en tenant compte de la physiologie du sommeil (CASA 2010). En sortie, le modèle SAFTE estime l'efficacité cognitive, qui dépend de la balance entre les processus de régulation du sommeil, les processus circadiens et l'inertie du sommeil (Figure 3). Le risque d'accidents liés aux facteurs humains est élevé lorsque le score d'efficacité est inférieur à 82.5% et augmente progressivement avec la baisse de l'efficacité. Lorsque le score d'efficacité est inférieur à 77.5 %, la chance de survenue d'un accident lié au facteur humain est de 65% plus important que la chance (Hursh *et al*. 2006).

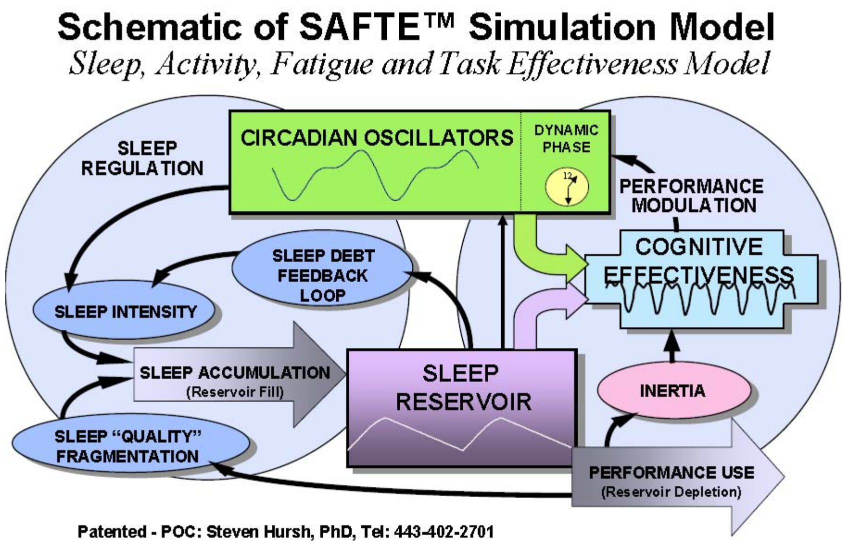


Figure 3. Modèle Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE™) (Hursh, 2003)

L'estimation du niveau de fatigue de l'OPL et du Cdb a été réalisée à l'aide du modèle SAFTE (Hursh 2005) en utilisant le logiciel FlyAwake$^{2.0®}$ (FlyAwake.org, MACROsystems, Inc). Ce logiciel, initialement créé pour le ministère de la défense américain (*US Department of Defense*, DoD), permet d'estimer l'efficacité cognitive, dont la dégradation est le reflet de la fatigue et de l'augmentation du risque d'accident.
Nous avons entré dans le logiciel, les données relatives au type d'équipage, les horaires et lieu de décollage et d'atterrissage, les périodes de sommeil (connues ou estimées), les temps de préparation de vol, la prise éventuelle d'une substance éveillante (café, thé…) et la réalisation de siestes.
En sortie, le logiciel donne un score d'efficacité cognitive en fonction du temps, et calcule pour chaque vol la valeur moyenne, minimale et maximale d'efficacité. Le calcul tient compte notamment de l'heure de la journée, du réservoir de sommeil, de la durée de l'éveil, des décalages horaires, de l'inertie au réveil…
Le graphique de résultat comprend une zone rouge dite d' « efficacité critique », qui indice un score inférieur au seuil de 77.5%. L'objectif est de maintenir la performance au-dessus du seuil de 82,5% (Beshany 2009) (Tabeau 1).

Catégories	**Score d'Efficacité (SE)**
Verte	SE ≥ 82.5 %
Jaune	80 % < SE ≤ 82,5 %
Orange	77.5 % < SE ≤ 80 %
Rouge (zone critique)	SE ≤ 77.5 %

Tableau 1. Analyse qualitative des scores d'efficacité prédits avec le logiciel FlyAwake

II.4. ANALYSE DE LA LITTERATURE SCIENTIFIQUE

Les activités aéronautiques et les résultats de l'analyse mathématique ont été interprétés au regard de la littérature scientifique accessible via la base de donnée PubMed de (US National Library of Medicine National Institutes of Health, http://www.ncbi.nlm.nih.gov/pubmed) et Google Scholar (http://scholar.google.fr/) en privilégiant les publications dans des revues scientifiques à comité de lectures ou les travaux de groupes d'experts reconnus. Les principaux mots clefs utilisés pour la recherche ont été : *aerospace medicine, aviation, circadian rhythm, duty, drowsiness fatigue, flight duty, flight, in-flight sleep, karolinska sleepiness scale, modeling, performance, pilot, psychomotor vigilance task, rest, risk management, safety, sleep, split duty…*

III. RESULTATS

III.1. HISTORIQUE DE L'ACCIDENT

- Le Commandant de bord (Cdb) et l'Officier pilote de ligne (OPL) ont été déclarés apte médicalement.
- La veille de l'accident, après un vol de mise en place (MEP), les pilotes sont arrivés à leur hôtel le 28/03/13 à 14:01 UTC. Le commandant de bord venait d'Athènes (UTC + 2) et l'OPL de Valence (UTC + 1). Le Cdb et l'OPL disent s'être couchés vers 22:00 locale (21:00 UTC). Ils ne relatent pas de difficultés particulières pour dormir.
- Le jour de l'accident (29/03/2013), avant le vol, l'équipage s'est présenté à l'aéroport vers 5:15 UTC soit 1 heure avant l'heure « block » prévue à 6:15 (UTC).
- L'équipage de l'Airbus A321 immatriculé SX-BHS, exploité par la compagnie Hermès Airlines, effectue un vol aller-retour entre les aéroports de Lyon Saint-Exupéry (France) et Dakar (Sénégal) dans le cadre d'un vol de transport public de passager non régulier pour le compte d'Air Méditerranée :
  - l'équipage décolle de Lyon à 06:44 et atterrit à Dakar à 12:03. A Dakar, des problèmes d'approvisionnement des repas les retardent d'environ 30 minutes ;
  - l'équipage décolle de l'aérodrome de Dakar à 13:44 et atterrit à Agadir à 16:13 pour une escale technique.
  - L'équipage décolle d'Agadir à 17:02 à destination de Lyon ;
  - à 19:46 min 03, l'équipage atterrit à Lyon. **L'avion touche la piste à environ 1600 m du seuil de piste, sort longitudinalement de la piste et s'immobilise à environ 300 m du seuil.**

Nous observons que le temps d'escale entre les vols est court : 1 h 40 environ entre de 1er et le 2ème vol et seulement 50 minutes entre le 2ème et e 3ème (Tableau 2).

Vols	Décollage	Atterrissage	Temps de vol	Problèmes
1	Lyon-Saint-Exupéry code AITA : LYS code OACI : LFLL **6h44**	Léopold-Sédar-Senghor Dakar code AITA : DKR code OACI : GOOY **12h03**	**5h19**	problèmes d'approvisionneme nt des repas retard ≈ 30 min.
2	Aéroport int. Dakar code AITA : DKR code OACI : GOOY **13h44**	Agadir - Al Massira, Agadir code AITA : AGA code OACI : GMAD **16h13**	**2h29**	
3	Agadir - Al Massira, code AITA : AGA code OACI : GMAD **17h02**	Lyon-Saint-Exupéry code AITA : LYS code OACI : LFLL **19h46**	**2h44**	**19h46 min 03**, Sortie de piste

Tableau 2. Récapitulatif des activités aériennes du 29/03/2013 (A321 SX- BHS)

III.3. ACTIVITES AERONAUTIQUES DES PERSONNELS NAVIGANTS

Les données relatives aux activités aéronautique de commandant de bord (Cdb) et de l'officier pilote de ligne (OPL) sont présentés dans les tableaux 3 et 4.

	Commandant de bord (Cdb)	Officier Pilote de Ligne (OPL)
	Non augmented crew	Non augmented crew
Temps de vol (29/03/2013)	10 h 32 min	10 h 32 min
Temps de service en vol (29/03/2013)	14 h 30 min	14 h 30 min
Temps de service (29/03/2013)	14 h 30 min	14 h 30 min
Temps de repos	15 h 00 min	15 h 00 min
Activité la veille du vol (28/03/2013) (UTC)	**-vol de Mise en place (MEP) :** 07:05-10:35 ATH CDG (A3610) 12:20-13:30 CDG LYS (AF7644) **-Hotel** du 28/03/13 14:01 au 29/03/13 4:59	**-vol de Mise en place (MEP) :** 06:05-08:15 VLC CDG (UX1005) 12:20-13:30 CDG LYS (AF7644) **-Hotel** du 28/03/13 14:01 au 29/03/13 5:14
Derniers vols (UTC)	**20/03/13 équipage non augmenté :** 10:30-11:29 ARN c/in 11:30-12:35 ARN GOT HRM 2009 14:00-18:25 GOT EBL HRM 2009 01:55-EBL CDG HRM 950F positioning crew	**24/03/13 équipage augmenté :** 0300-0359 CDG c/in 0400-0850 CDG VDA BIE 4266 1015-1550 VDA CDG BIE 4267 1551-1605 CDG c/out

Tableau 3. Activités du Cdb et de l'OPL au moment de l'accident (29/03/2013).

Heures de vol	Commandant de bord (Cdb)	Officier Pilote de Ligne (OPL)
Total chez Hermes Airline	CPT : 425 h 38m, F/O: 405 h 20m	F/O: 313 h 19m
180 jours	272 h 47m	153 h 13m
90 jours	138 h 55m	55 h 30m
30 jours	68 h 31m	45 h 45m
7 jours	14 h 30 min	27 h 35 m

Tableau 4. Temps de vols cumulés du Cdb et de l'OPL

III.4. CYCLES VEILLE/SOMMEIL

Les pilotes ont déclaré s'être couchés à 22:00 locale (21:00 UTC) et avoir bien dormis. Le 29/03/2013, ils ont quitté leur hôtel à 4:59 UTC pour le Cdb et 5:15 UTC pour l'OPL. L'opportunité maximale de sommeil est donc de 8 heures. Il est impossible de connaitre la durée réelle de leur sommeil, mais il peut être estimé entre 6h30 et 7h30 heures au maximum en tenant compte des périodes d'activité nécessaires à d'hygiène et à l'habillement… La durée moyenne de sommeil étant de 7 h 40 (Billiard et Dauvillier 2009) on peut estimer leur dette de sommeil inférieure à 2 heures. L'OPL Venant de Valence (UTC +1) et le Cdb d'Athènes (UTC + 2) ils n'ont pas subi de décalage horaire.

Au moment de l'accident (19:46 UTC), on peut estimer leur durée d'éveil entre 15h00 et 16h00. L'OPL et le Cdb ont déclaré ne pas avoir fait de sieste au cours de la journée.

Par contre, leur mise en place s'est faite après un vol matinal, notamment pour l'OPL avec un décollage de Valence à 6:05 UTC (soit 7:05 locale), ce qui a probablement généré une nuit courte. Le Cdb a décollé la veille d'Athènes à 7:05 (soit 09:05 locale).

III.5. MODELISATION DE LA FATIGUE

A. JOURNEE DU 29 MARS 2013

Au cours de la journée du 19 mars 2013, la modélisation de la fatigue à l'aide du logiciel FlyAwake a mis en évidence une efficacité estimée toujours supérieure aux valeurs critiques, considérées comme la zone d'apparition de la fatigue (figure 4 et 5). En effet, la valeur moyenne au cours des 3 vols (moyenne ± écart type) était de 90,1 ± 0,8 % pour l'OPL et de 93,6 ± 0.9 % pour le CDB. La valeur minimale, observée à la fin du 3ème vol était de 86 % pour l'OPL et 89,2 % pour le CDB.

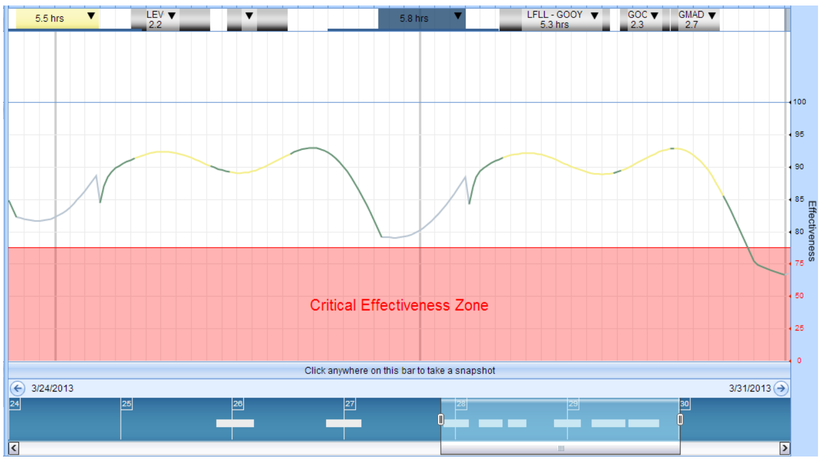


Figure 4. Modélisation de la fatigue (inverse de l'*effectiveness*) de L'OPL au cours du 28 et du 29/03/2013 (En jaune les périodes de vol et en bleu de sommeil).

Figure 5. Modélisation de la fatigue (inverse de l'*effectiveness*) du Cdb au cours du 28 et du 29/03/2013 (En jaune les périodes de vol et en bleu de sommeil).

B. 2 MOIS PRECEDENTS L'ACCIDENT

B1. Commandant de bord (Cdb)

Au cours des 2 mois précédents l'accident, la modélisation de la fatigue induite par l'activité aéronautique du Cdb n'a pas mis en évidence de valeur d'efficacité entrant dans la zone critique pendant un vol (figure 6). Au cours de la période étudiée, le 3/03/2013 a été la journée avec le plus d'heure de vol (11h) et de temps de service en vol (14h45). Le 29/03/13 arrive en seconde position.

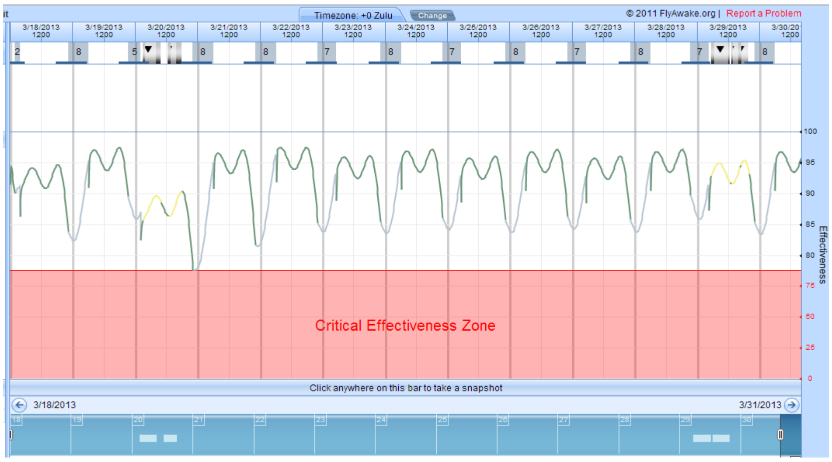


Figure 6. Modélisation de la fatigue (inverse de l'*effectiveness)* du Cdb au cours des 10 jours précédents l'accident

B2. Officier pilote de ligne (OPL)

L'analyse des activités aéronautiques au cours des 2 mois précédent a révélé une intrusion dans la zone critique 6 jours avant l'accident survenu le 24/03/2013 au soir (figure 7). Cette période a été suivi par un vol de retour sur Valence le 25/03/2015 et 2 jours de repos sans vol. Le 29/03/13, jour de l'accident a été la journée avec le plus d'heure de vol et de temps de service en vol au cours de la période étudiée.

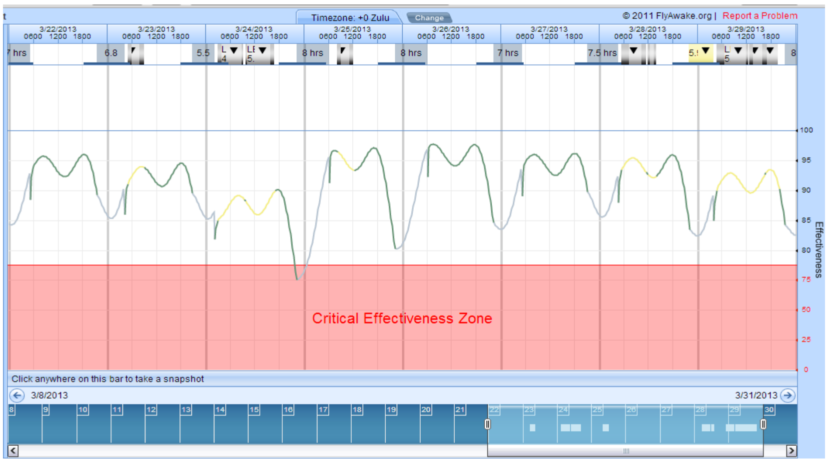


Figure 7. Modélisation de la fatigue (inverse de l'*effectiveness)* de l'OPL au cours des 10 jours précédents l'accident

IV. DISCUSSION

IV.1. FATIGUE DE L'EQUIPAGE

L'enquête réalisée par le BEA à partir des témoignages de l'équipage, l'écoute des enregistrements audio, les données de vols ainsi que sur l'ensemble de la documentation de la compagnie et du constructeur, a mis en évidence des altérations du niveau de performance de l'équipage, caractérisées par des erreurs techniques et non-techniques analysées selon les critères de L'annexe 1 *Core competencies and behavioural indicators* de la documentation Doc9995 AN/497 de l'OACI *Manual of Evidence-based Training*.

Pour la partie technique, l'équipage a été évalué sur : sa capacité à mettre en application des procédures (briefings, procédures et checklists, annonces), la qualité du pilotage en mode manuel et en mode automatique et les connaissances à la fois théoriques et procédurales.

Pour la partie non technique, l'équipage a été évalué sur : la conscience de la situation, la capacité de communication, le leadership et le travail en équipage, la capacité de résolution de problème et les processus de décision la gestion de la charge de travail.

Certains des éléments, objectivant la diminution des performances de l'équipage, peuvent être considérés comme des symptômes de fatigue et imputé à une diminution des performances cognitives:

- **difficultés du pilote à mémoriser et à restituer les donnée**s qui traduit une probable altération de la mémoire de travail ;
- **Application partielle des procédures, une dégradation du CRM et du partage des tâches prévu**
- **erreur de prise de décision,** caractérisée par l'absence de génération d'option et de toute considération d'une alternative à l'atterrissage (possible remise de gaz, attente, dégagement) ;
- **mauvaise conscience de la situation** et l'absence d'identification de menaces (vent arrière, piste mouillée, mauvaise visibilité, vitesse élevée, risques induits par la sortie de piste…) ;

En effet, de nombreuses études en laboratoire, simulateurs ou en vol réels ont apporté la preuve que la fatigue était induite par des altérations du système nerveux central (Caldwell *et al.* 2009). En particulier, la fatigue est associée à des dégradations des performances cognitives caractérisées par une diminution des capacités d'attention, une altération de la prise de décision et du raisonnement logique, une mauvaise conscience de la situation, une absence d'identification des risques (Hursh *et al.* 2004, Jackson *et al.* 2013). Ces dysfonctions sont compatibles avec les erreurs observées au cours du vol concerné par cette enquête qui sont la conséquence de la diminution de la performance et de l'efficacité des pilotes (Jewett *et al.* 1999, Hursh *et al.* 2004, Neri 2004, Van Dongen *et al.* 2007).

La fatigue des pilotes, en général, est principalement induite par les altérations du cycle veille/sommeil et/ou une charge de travail difficile et prolongée (Caldwel et al. 2009, Cabon et al. 2012). Néanmoins, l'expérience des pilotes (Cabon et al. 2012, Caldwell et al. 2009) et l'application de contremesures (courte sieste, adaptation des stratégies) sont efficaces pour maintenir un niveau de performance acceptable et diminuer le risque d'accident. Les informations transmises par le BEA ne font pas état de mise en place de contremesures spécifiques au cours du vol pour prévenir l'apparition de la fatigue.

IV.1. ALTERATIONS DU CYCLE VEILLE/SOMMEIL

Dans cette étude nous avons observé que le temps maximal de sommeil pouvait être estimé entre 6h30 et 7h30, sans décalage horaire, soit une dette de sommeil probablement inférieure à 2 heures. De nombreux auteurs recommandent que les pilotes aient une opportunité de sommeil d'au moins 8 à 8h30 heures par 24 heures afin de procurer au pilote au moins 7h à 7h30 de sommeil, si possible dans des horaires favorables au sommeil (22:00 – 8:00) (Goode 2003, Caldwell *et al.* 2009, Cabon *et al.* 2012).

Un sujet qui n'a pas de dette de sommeil, en bonne santé, peut très bien supporter 2 à 3 h de dette de sommeil (Belenky *et al.* 2003). Cela est vrai si l'on bénéficie d'un sommeil de bonne qualité et d'absence de restriction de sommeil au cours des jours précédents. En effet, un sujet qui n'a pas pu bénéficier d'un sommeil de bonne qualité et en quantité suffisante, peut souffrir de quelques heures de privation de sommeil (Belenky *et al.* 2003, Van Dongen *et al.* 2006).

Ayant peu volé au cours des jours précédents, ils ne présentaient donc pas de risque d'altération du cycle veille-sommeil liée à l'activité aéronautique ou aux déplacements professionnels. Seul l'OPL a enchainé 2 courtes nuits de suites (<7 h de sommeil), la première nuit courte ayant été induite par un vol matinal de mise en place. L'enchainement de courtes nuits, notamment avec réveils précoces est un facteur bien connu de fatigue et de dégradation des performances (Belenky *et al.* 2003, Bourgeois-Bougrine *et al.* 2003b). Néanmoins, les périodes de sommeil ont pu être réalisées au cours des heures favorables au sommeil et pas de décalage horaire de plus d'1 h puisque le Cdb et l'OPL étaient arrivés la veille. Le décalage horaire est un facteur majeur d'augmentation de la fatigue dans l'aviation civile, dès 2 heures de décalage (Bourgeois-Bougrine *et al.* 2003a, Powell et al. 2008).

L'OPL et le Cdb ont déclaré aux enquêteurs du BEA avoir passé une bonne nuit de sommeil. Néanmoins, cela n'exclut pas la présence chez ces personnels de troubles du sommeil pouvant être induits par le stress professionnel, des contraintes familiales, les enfants en bas âge (Coroenne et al. 2013a), une pathologie du sommeil, une mauvaise hygiène du sommeil (Philip et al 2005). Ces facteurs seraient à rechercher systématiquement dans le cadre d'une expertise en utilisant les questionnaires validés, et notamment l'Echelle de somnolence d'Epworth afin d'évaluer l'impact de la somnolence diurne excessive (Coroenne *et al.* 2013a).

La durée d'éveil continue (estimée entre 15 h à 16 h d'éveil) n'est pas suffisante pour entrainer une augmentation de la somnolence observée à partir de 17 h d'éveil chez des sujets soumis à une activité cognitive continue (Angus et Heslegrave 1985). Par contre, une diminution de la vigilance et de la performance mentale est observée chez ces sujets après 16 heures d'éveil (Angus et Heslegrave 1985). La simulation de la fatigue confirme cette analyse. Nous n'avons pas mis en évidence de score de performances inférieures au seuil critique au cours de la journée de l'accident, survenu à un horaire « favorable » à l'éveil physiologique

En conclusion, le planning aéronautique le jour de l'accident et au cours des 2 mois précédents ne semble pas, à lui seul, être susceptibles de favoriser l'apparition de la fatigue dans cette situation. Cette analyse est confortée par la modélisation de l'état de fatigue par le modèle SAFTE qui montre un score d'efficacité toujours supérieur à 86% au cours des vols et en particulier au moment de l'accident. Cependant, le score de performance le plus faible a été observé au moment de l'accident.

IV.3. AMPLITUDES D'ACTIVITES AERONAUTIQUE

L'équipage a cumulé un temps de service d'environ 14 h 30 au cours de cette journée. Plusieurs études ont mis en évidence une relation entre le temps de service en vol et la somnolence ressentie, la fatigue ressentie (Bourgeois-Bougrine *et al.* 2003b, Powell *et al.* 2007, Powell *et al.* 2008), la fréquence des rapports sécurité des vols (*Air safety reports*, ASR) dans des compagnies aérienne régionales (Cabon *et al*. 2012) et la fréquence des accidents (Good 2003). En particulier, dans une étude réalisée aux Etats Unis, sur plus de 1 million d'heure de vol, il a été mis en évidence que 20% des accidents liés aux facteurs humains, survenaient au-delà de 10 h de services en vol (Good 2003). Ramené à la quantité relative d'heure de vol, cette étude révèle une légère augmentation du risque d'accident entre 10 et 12 h de service en vol (risque relatif, RR= 1,65) qui devient très significative au-delà de 13 h d'activité (RR = 5,6) (figure 8).

Goode (2003) suggère de durcir la limitation du temps de service en vol par 24 h des pilotes pour limiter le risque d'accident dans les vols commerciaux. Ces résulats ont été confirmés par Powell et al, qui ont observé une augmentation proportionnelle de la fatigue resentie avec le temps de service en vol avec des variations importante en fonction de l'heure de la journée. Les valeurs sont maximales lorsque la période d'activité commence entre 18:00 et 03:00 ou se terminent entre 00:00 et 09:00 (Powell *et al.* 2008).

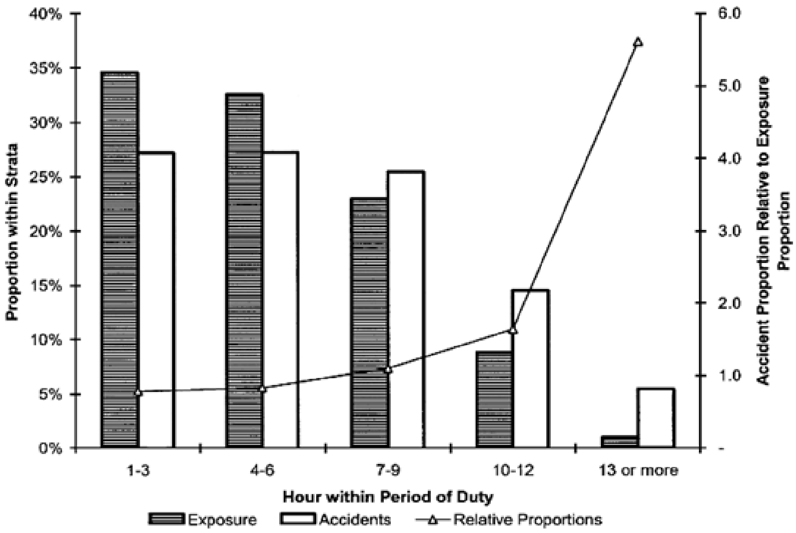


Figure 8 : proportion relative d'exposition aux accidents en fonction du temps d'activité (Goode 2003)

Le conseil européen de sécurité dans les transports (ETSC 2013), a récemment publié des recommandations concernant la durée maximale de temps de service en vol au cours d'une journée. Ils recommandent en se basant sur des données de la littérature scientifique, de modifier la durée des périodes d'activité en fonction de l'heure de la journée. Ils recommandent par exemple, pour une prise de service entre 06:00 et 07:00 un temps de service en vol maximal de 12 h. Le temps de service en vol maximal de 14 h pouvant être seulement pris avec une prise de service entre 08:00 et 11:00.

L'activité aérienne au cours de l'accident est également caractérisée par plusieurs vols et des escales de courte durée (1 h 45 entre de 1er et le 2ème vol et d' 50 minutes entre le 2ème et le 3ème vol). Peu de données existent sur les effets du nombre de vol au cours de la journée sur la fatigue et le risque d'accident et plusieurs auteurs reconnaissent la connaissance insuffisante des effets des atterrissages multiples (ETSC 2013). Des études complémentaires sont nécessaires (Moebus 2008). Néanmoins, plusieurs auteurs ont observé une relation entre le nombre de vols successifs et la fatigue ressentie (Bourgeois-Bougrine *et al.* 2003, Powell *et al.* 2007, Cabon *et al.* 2012). Un consensus d'expert a recommandé (Moebus 2008) que le temps de service en vols au cours de journée avec plusieurs vols, ne dépasse pas 14 h et ne commence jamais avant 0:00 et ne se termine après 22:00.

Après un vol de 3 h 30 en monomoteur, Sauvet et al. (2009) ont observé un score d'hypovigilance altéré immédiatement et 2 h 30 après la fin du vol (figue 9). Dans son analyse, validée par un groupe d'expert, Moebus (2008) recommande que la période de repos entre deux vols soit égale à au moins un tiers de la durée du dernier vol et que des conditions adéquates au sommeil puissent être proposées aux pilotes qui souhaitent faire une sieste.

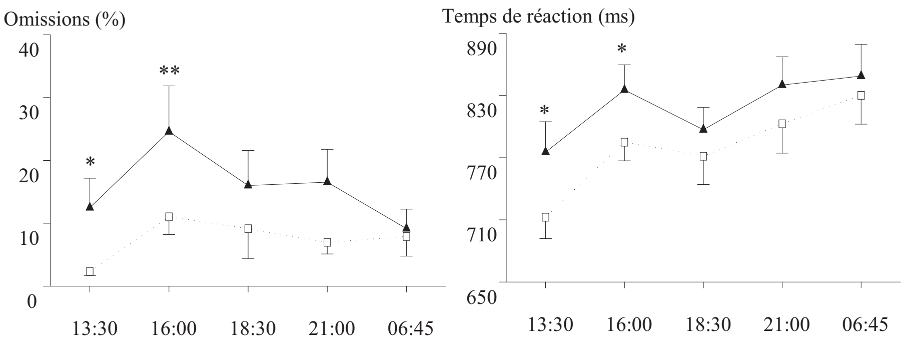


Figure 9 : Evolution de performance à un test de vigilance avant (☐) et après (▲) un vol de 3 h 30 (10h00 a.m. à 1 h 30 p.m.) * différence entre les valeurs observées à la même heure *p<0,05, **p<0,01 (Sauvet *et al*. 2009).

En conclusion. Les périodes de service en vol de plus de 14 h dépassent les limites physiologiques et sont compatible avec l'apparition de la fatigue, le nombre d'ASR et le risque d'accident. La fatigue induite par le temps de service en vol, peut être majorée par des facteurs ajoutés (vol de nuit, charge de travail mental important, multiplication des vols…).

IV.4. MODELISATION DE LA FATIGUE

Dans notre analyse, la modélisation de la fatigue induite par les activités aéronautiques n'a pas mis en évidence de score critique au cours de la journée de l'accident. Il convient cependant de tirer quelques leçons sur la méthode bio-mathématique utilisée. Tout d'abord, la question de ce qui est du niveau maximum acceptable de risque de fatigue reste encore controversée à la fois en aéronautique mais aussi dans le dans le monde des transports. Actuellement, il n'y a pas de méthode validée de détection de l'apparition de la fatigue et de son amplitude (Caldwell *et al.* 2009).

L'utilisation des modèles bio-mathématiques a montré son efficacité sur la fatigue ressentie (Beshany 2009) par rapport à l'application des règles aéronautiques. En effet, ces modèles offrent une bonne prise en compte du rythme circadien et de la physiologie du sommeil (durée d'éveil, heure de lever, sieste…). Cependant, ils ne prennent pas en compte le nombre de vol et le temps de service en vol (Rangan et Van Dongen 2013) qui sont des facteurs important de fatigue, notamment lors des vols moyen-courriers répétés (Bourgeois-Bougrine *et al.* 2003, Powell *et al.* 2007, Cabon *et al.* 2012). Des travaux récents, Rangan et Van Dongen (2013), proposent de nouvelles approches qu'il faudra évaluer, tels l'approximation de premier ordre du risque de fatigue, proportionnelle à la fois au temps de service passé, à l'horaire mais aussi à l'aire sous la courbe d'efficacité (intégrale du score d'efficacité en fonction du temps) qui prend mieux en compte le temps de service aérien.

En conclusion, la gestion de la fatigue en vol et la prédiction de sa survenue et de son ampleur sont des problèmes complexes. Les modèles bio-mathématiques, bien adaptés à la modélisation des effets de la privation de sommeil et des altérations du rythme circadien doivent être améliorés pour prendre en compte le temps de service en vol et les vols multiples. Cette expertise illustre la nécessité de confronter ces modèles de prédiction du risque fatigue à l'analyse d'éléments objectifs de fatigue des pilotes (ASR, accidents, analyse systématique des vols…).

V. CONCLUSION

Les horaires de travail le jour de l'accident et au cours des 2 mois précédents ne semblent pas, à elle seule, avoir entrainé des altérations du cycle veille/sommeil susceptibles d'avoir induit un état de fatigue important. Cette analyse est confortée par la modélisation de l'état de fatigue par le modèle SAFTE qui montre un score d'efficacité toujours supérieur à 86 % au cours des vols. Cependant, le temps de service en vol important (14 h 30), est associé dans la littérature scientifique avec une augmentation du risque de sensation de fatigue, d'ASR et d'accident. Cet état de diminution des performances est renforcé par la multiplication des vols et leur complexité. La gestion de la fatigue en vol est un problème complexe. Les modèles bio-mathématiques, bien adaptés à la modélisation des effets de la privation de sommeil et des altérations du rythme circadien doivent être améliorés pour prendre en compte le temps de service en vol et les vols multiples.

VI. REFERENCES

- Akerstedt T (2003). "Shift work and disturbed sleep/wakefulness". Occup Med. 53:89-94.
- Akerstedt T, Folkand S (1986). "Prediction duration of sleep from the three model of regulation of aterness". Occup Envirom Med. 53:136-41.
- Angus R, Heslegrave R (1985). "Effects of sleep loss on sustained cognitive performance during a command and control simulation". Behav Res Methods Instrum Comput. 17:55–67.
- Barth J, Holding DH (1976). "Risk versus effort in the assessment of motor fatigue". Journal of motor Behavior. 8:189-94.
- Belenky G, Wesensten NJ et al. (2003)."Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: a sleep dose-response study". J Sleep Res. 12:1-12.
- Beshany RP (2009). "Analysis of navy flight scheduling methods using flyawake". Thèse, Naval postgraduate school, Monterey, California, USA, 61 pages.
- Billiard M, Dauvilliers Y (2009). "Les troubles du sommeil". Masson. p.18-34.
- Bourgeois-Bougrine S, Cabon P, Mollard R, Coblentz A, Speyer JJ (2003b). "Fatigue in aircrew from short-haul flights in civil aviation: the effects of work schedules", Hum Fact Aerosp Safety. 3(2): 177-87.
- Bourgeois-Bougrine S, Carbon P et al. (2003a). "Perceived fatigue for short- and long-haul flights: a survey of 739 airline pilots." Aviat Space Environ Med 74(10):1072-7.
- Cabon P, Bourgeois-Bougrine S, Mollard R, Coblentz A, Speyer JJ (2003) "Electronic pilot-activity monitor: a countermeasure against fatigue on long-haul flights". Aviat Space Environ Med. 74(6):679-82.
- Cabon P, Deharvengt S, Grau JY, Maille N, Berechet I, Mollard R (2012). "Research and guidelines for implementing Fatigue Risk Management Systems for the French regional airlines". Accid Anal Prev. S45:41-4.
- Caldwell JA, Gilreath SR (2002). "A survey of aircrew fatigue in a sample of U.S. Army aviation personnel." Aviat Space Environ Med 73(5): 472-80.
- Caldwell JA, Mallis MM et al. (2009). "Fatigue countermeasures in aviation". Aviat Space Environ Med 80(1): 29-59.

- CASA 2010. "Biomathematical fatigue modelling in civil aviation fatigue risk management. Application guidance". Civil Aviation Safety Autority (CASA), Australia, 15 mars 2010. http://www.casa.gov.au/wcmswr/_assets/main/aoc/fatigue/fatigue_modelling.pdf. (dernier accès le 25/10/2013).
- Chennaoui M, Lagarde D (2013). « Le sommeil et la fatigue en condition extrême chez le militaire », in « Sport et Sommeil », Leger D etDuforez F. Collection Sport et Santé, ed. Chiron, Paris.
- Chennaoui M, Sauvet F et al. (2011). "Effect of one night of sleep loss on changes in tumor necrosis factor alpha (TNF-α) levels in healthy men". Cytokine. 56(2):318-24.
- Colquhoun L. (1976). "Psychological and psychophysiological aspects of work and fatigue". Activitas nervosa Superio, 18: 257-63.
- Coroenne M, Lely L et al. (2013a). « Hypovigilance chez les personnels de la patrouille maritime, enregistrements électrophysiologiques au cours de vols réels ». Médecine aéronautique et spatiale. 54:125-33.
- Coroenne M, Sauvet F et al. (2013b). « Etude des facteurs de risque individuels d'hypovigilance chez les personnels de la patrouille maritime ». Médecine aéronautique et spatiale. 53:129-37.
- Dinges DF (2004). "Critical research issues in development of biomathematical models of fatigue and performance". Aviat Space Environ Med. 75(S3):A181-91.
- Dussault C, Lely L, Langrume C, Sauvet F, Jouanin JC (2009.) "Heart Rate and sympathovagal balance after military flight in war zones". Aviat Space Env Med. 80:796-802.
- EASA 2013. "EASA welcome new flight time limitations rules". European Aeronautical Safety Agency (EASA). 09/10/2013. Communiqué de presse, (dernier accès le 22/10/2013). http://easa.europa.eu/communications/press-releases/EASA-press-release.php?id=124
- ETSC 2013. "ETSC Position on Flight Time Limitations". European Transport Safety Council (ETSC), mai 2013. http://www.etsc.eu/documents/ETSC_position_FTL.pdf, (dernier accès le 22/10/2013).
- Gillberg M (1995). "Sleepiness and its relation to the length, content, and continuity of sleep". J Sleep Res. 4(S2): 37-40.
- Goode JH (2003). "Are pilots at risk of accidents due to fatigue?" J Safety Research. 34:309-313.
- Hursh SR, Raslear TG, Kaye AS, Fanzone JF (2006). "Validation and Calibration of a Fatigue Assessment Tool for Railroad Work Schedules". Technical report DOT/FRA/ORD-06/21, U.S. Department of Transportation, Federal Railroad Administration.
- Hursh SR, Redmond DP et al. (2004). "Fatigue models for applied research in warfighting". Aviat Space Environ Med. 75(S3):A44–53.
- Jackson ML, Gunzelmann G et al. (2013). "Deconstructing and reconstructing cognitive performance in sleep deprivation". Sleep Med Rev. 17(3):215-25.
- Jewett ME, Bordely AA, Czeisler CA (1999). "Proceedings of the workshop models of circadian rhythmicity, sleep regulation, and neurobehavioral function in humans". Journal of biological rhythms. 14(6):429-624.
- Lagarde D, Batejat D (1994). "Evaluation of drowsiness during prolonged sleep deprivation". Neurophysiol Clin. 24(1):35-44.
- Lille F, Cheliout F, Burnod Y, Hazemann P (1979). "Effects of aging and occupational activity on active wakefulness". Gerontology, 25(6): 337-44.
- Neri D (2004). "Preface: fatigue and performance modeling workshop, June 13-14, 2002". Aviation, space and environmental medicine. 75(3):A1-3.
- Philip P, Sagaspe P et al. (2005). "Fatigue, sleep restriction and driving performance". Accid Anal Prev. 37(3):473-8.

- Powell D, Spencer M, Holland D & Petrie K (2008), "Fatigue in two-pilot operations: implications for flight and duty time limitations". Aviat, Space Environ Med. 79(11):1047-50.
- Powell DM, Spencer MB, Holland D, Broadbent E, Petrie KJ (2007). "Pilot fatigue in short-haul operations: effects of number of sectors, duty length, and time of day". Aviat Space Environ Med.78:698-701.
- Powell DMC, Spencer MB, Petrie KJ (2010). "Fatigue in airline pilots after an additional day's layover period". Aviat Space Environ Med. 81:1-5.
- Rangan S, Van Dongen HP (2013). "Quantify fatigue risk in model based fatigue risk management".Aviat Space Environ Med. 84(2):155-7.
- Sauvet F, Jouanin JC et al. (2009) "Heart rate variability in novice pilots during and after a multi-leg cross-country flight." Aviat Space Env Med. 80:862-9.
- Smart TL, Singh B (2006). Excessive daytime sleepiness in a trained military pilot. Aviat Space Environ Med. 77:753-7
- Spencer MB, Robertson KA (2007) "The application of an alertness model to ultra-longue range civil air operations". Somnologie. 11(3):159-66.
- Van Dongen HPA, Maislin G, Mullington JM, Dinges DF (2003). "The cumulative cost of additional wakefulness: Dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation". Sleep. 26:117-26.
- Van Dongen HPA, Mott CG et al. (2007) "Optimization of biomethematical model prediction for cognitive performance impairment in individuals: accounting for unknown traits and uncertain states in homeostatic and circadian process". Sleep. 30(9):1125-39.
- Wegmann, HM, Gundel A et al. (1986) "Sleep, sleepiness, and circadian rhythmicity in aircrews operating on transatlantic routes." Aviat Space Environ Med. 57: B53-64.
- Wright N, McGown A (2001) "Vigilance on the civil flight deck: incidence of sleepiness and sleep during long-haul flights and associated changes in physiological parameters." Ergonomics. 44(1):82-106.
- Wright N, Powell D et al. (2005) "Avoiding involuntary sleep during civil air operations: validation of a wrist-worn alertness device." Aviat Space Environ Med. 76(9): 847-56.
- Yen JR, Hsu CC et al. (2009) "Investigation of fatigue issues on different flight operations" J transport Manag. 5(5): 236-40.

VII. ANNEXE 1 : DEMANDE DU BEA (4/07/2013)

RÉPUBLIQUE FRANÇAISE
Ministère de l'Ecologie
du Développement durable
et de l'Energie

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

COURRIER ARRIVÉ LE
05 AOUT 2013
ACTION :

Le Bourget, le 4 juillet 2013

de la part de
BEA

à l'attention de

Monsieur le Médecin Général Inspecteur
Directeur de l'Institut de Recherche
Biomédicale des Armées (IRBA)
BP 73,
91223 Brétigny sur Orge

Objet : Demande de devis sur une étude fatigue

Monsieur le Directeur,

Dans le cadre de l'enquête de sécurité ouverte par le BEA à la suite de la sortie de piste de l'airbus A321 immatriculé SX-BHS survenue le 29 mars 2013 sur l'aéroport de Lyon, nous souhaiterions solliciter vos compétences afin de nous fournir une évaluation du niveau de fatigue de l'équipage.

Nous avons déjà pris contact avec Messieurs Chennnaoui et Sauvet de l'Unité de Vigilance. Ils nous ont présenté les travaux qu'ils seraient en mesure de nous fournir :

- évaluation du niveau de fatigue généré par une longue journée de travail,
- évaluation d'une éventuelle dette de sommeil (fatigue chronique) préexistante avant cette journée.

Ces travaux nous paraissent très intéressants et adaptés à ce que nous recherchons. Par conséquent, nous vous sollicitions afin d'obtenir un devis et des informations sur les délais nécessaires à la réalisation d'un travail formalisé et la rédaction d'un rapport que nous pourrions intégrer dans le rapport du BEA.

Veuillez, Monsieur le Directeur, agréer l'expression de mes sentiments distingués.

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

VIII. ANNEXE 2 : PROGRAMME D'ACTIVITE INDIVIDUELLE (OPL)

«HERMES AIRLINES » - PROGRAMME D'ACTIVITE INDIVIDUELLE
Officier pilote de ligne OPL (First Officer)

Edité le 13.05.13 _ 10:54:10 Date du/au.. 29.01.13 / 29.03.13 GMT

Temps total du 29.01.13 au 29.03.13 Vols en fonction : 45h45 , Vols en MEP : 23h45

```
! Date HrD_b HrFin ApD ApA Cie/N°Vol Avion Typ Aff Dur_e Fonct Activit_ / Commentaires ! GMT

! MAR 29JAN ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! MER 30JAN ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! JEU 31JAN ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! VEN 01FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! SAM 02FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! DIM 03FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! LUN 04FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! MAR 05FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! MER 06FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! JEU 07FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! VEN 08FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! SAM 09FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! DIM 10FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! LUN 11FEV ! REPOS!
+------------------------------------------------------------------------------------------------------------+
! MAR 12FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
! MER 13FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
! JEU 14FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
! VEN 15FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
! SAM 16FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
! DIM 17FEV REPOS!
+-----------------------------------------------------------------------------------------------------------+
! LUN 18FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
! MAR 19FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
! MER 20FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
! JEU 21FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
! VEN 22FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
! SAM 23FEV ! REPOS!
+-----------------------------------------------------------------------------------------------------------+
DIM 24FEV ! REPOS!
+----------------------------------------------------------------------------------------------------------+
! LUN 25FEV! 6:20 8:30 VLC FCO IB 5716 2:10!
! LUN 25FEV! 10:00 12:00 FCO ATH A3 651 2:00!
! LUN 25FEV! 12:01 23:59 ATH ATH HOT!
+-----------------------------------------------------------------------------------------------------------+
! MAR 26FEV! 0:00 6:59 ATH ATH HOT 6:59!
! MAR 26FEV! 7:00 15:00 ATH ATH BUR 8:00 BUREAU!
! MAR 26FEV! 16:01 23:59 ATH ATH HOT 7:58!
+-----------------------------------------------------------------------------------------------------------+
! MER 27FEV! 0:00 6:59 ATH ATH HOT 6:59!
```

! MER 27FEV! 7:00 13:00 ATH ATH BUR 6:00 BUREAU!
! MER 27FEV! 14:15 17:45 ATH CDG A3 618 3:30!
! MER 27FEV! 17:46 23:59 CDG CDG HOT 6:13!
! MER 27FEV! 19:00 23:59 CDG CDG REPOS!
+---+
! JEU 28FEV! 0:00 23:59 CDG CDG REPOS!
+---+
! VEN 01MAR! 0:00 7:00 CDG CDG REPOS!
+---+
! SAM 02MAR! 12:05 13:04 CDG CDG CNV 0:59 DEBUT DE CONVOCATION!
! SAM 02MAR! 13:40 16:35 CDG OUD BIE 9300 2:55 !
! SAM 02MAR! 17:40 20:25 OUD CDG BIE 9301 2:45 !
! SAM 02MAR! 20:26 20:40 CDG CDG DBF 0:14 DEBRIEF !
+---+
! DIM 03MAR! 0:00 23:59 CDG CDG HOT 23:59!
+---+
! LUN 04MAR! 0:00 21:09 CDG CDG HOT 21:09!
! LUN 04MAR! 21:10 23:10 CDG VLC AF 2330 2:00!
+---+
! MAR 05MAR! REPOS!
+---+
! MER 06MAR! REPOS!
+---+
! JEU 07MAR! REPOS!
+---+
! VEN 08MAR! REPOS!
+---+
! SAM 09MAR! REPOS!
+---+
! DIM 10MAR! REPOS!
+---+
! LUN 11MAR! REPOS!
+---+
! MAR 12MAR! REPOS!
+---+
! MER 13MAR! REPOS!
+---+
! JEU 14MAR! 12:00 14:10 VLC CDG AF 2531 2:10!
! JEU 14MAR! 14:11 23:59 CDG CDG HOT 9:48!
+---+
! VEN 15MAR! 9:00 9:59 CDG CDG CNV 0:59 DEBUT DE CONVOCATION!
! VEN 15MAR! 10:00 13:10 CDG OUD BIE 4258 3:10!
! VEN 15MAR! 14:30 17:35 OUD CDG BIE 4259 3:05!
! VEN 15MAR! 17:36 17:50 CDG CDG DBF 0:14 DEBRIEF!
! VEN 15MAR! 17:51 23:59 CDG CDG HOT 6:08!
+---+
! SAM 16MAR! 0:00 4:59 CDG CDG HOT 4:59!
! SAM 16MAR! 5:00 5:59 CDG CDG CNV0:59 DEBUT DE CONVOCATION!
! SAM 16MAR! 6:00 8:30 CDG ALG BIE 4322 2:30!
+---+
! SAM 16MAR! 9:35 12:15 ALG CDG BIE 4323 2:40!
! SAM 16MAR! 12:16 12:30 CDG CDG DBF 0:14 DEBRIEF!
! SAM 16MAR! 15:00 16:20 CDG TLS AF 7786 1:20!
! SAM 16MAR! 16:21 23:59 TLS TLS HOT 7:38!
+---+
! DIM 17MAR! 0:00 13:04 TLS TLS HOT 13:04!
! DIM 17MAR! 13:05 14:04 TLS TLS CNV 0:59 DEBUT DE CONVOCATION!
! DIM 17MAR! 14:05 15:10 TLS BOD BIE 4560 1:05!
! DIM 17MAR! 15:55 18:50 BOD RAK BIE 4560 2:55!
! DIM 17MAR! 18:51 19:05 RAK RAK DBF 0:14 DEBRIEF!
! DIM 17MAR! 19:06 23:59 RAK RAK HOT 4:53!
+---+
! LUN 18MAR! 0:00 16:09 RAK RAK HOT 16:09!
! LUN 18MAR! 16:10 17:09 RAK RAK CNV 0:59 DEBUT DE CONVOCATION!
! LUN 18MAR! 18:25 21:05 RAK LYS BIE 933T 2:40!
! LUN 18MAR! 21:06 21:20 LYS LYS DBF 0:14 DEBRIEF!
! LUN 18MAR! 21:21 23:59 LYS LYS HOT 2:38!
+---+
!MAR19MAR! 0:00 6:04 LYS LYS HOT 6:04!
! MAR 19MAR! 11:00 13:00 ZRH VLC LX 2142 2:00!
! MAR 19MAR! 20:00 23:59 VLC VLC 3:59! REPOS!
+---+
! MER 20MAR! REPOS!
+---+
! JEU 21MAR! REPOS!
+---+
! VEN 22MAR! REPOS !
+---+

! SAM 23MAR! 6:05 8:15 VLC CDG UX 1005 2:10!
! SAM 23MAR! 8:16 23:59 CDG CDG HOT 15:43!
! DIM 24MAR! 0:00 2:59 CDG CDG HOT 2:59!
! DIM 24MAR! 3:00 3:59 CDG CDG CNV 0:59 DEBUT DE CONVOCATION!
! DIM 24MAR! 4:00 8:50 CDG VDA BIE 4266 4:50!
! DIM 24MAR! 10:15 15:50 VDA CDG BIE 4267 5:35!
! DIM 24MAR! 15:51 16:05 CDG CDG DBF 0:14 DEBRIEF!
! DIM 24MAR! 16:06 23:59 CDG CDG HOT 7:53!
+--+
! LUN 25MAR! 0:00 9:09 CDG CDG HOT 9:09!
! LUN 25MAR! 9:10 11:10 CDG VLC UX 1006 2:00!
+--+
! MAR 26MAR! REPOS!
+--+
! MER 27MAR! REPOS!
+--+
! JEU 28MAR! 0:00 6:00 VLC VLC 6:00 REPOS!
! JEU 28MAR! 6:05 8:15 VLC CDG UX 1005 2:10!
! JEU 28MAR! 12:20 13:30 CDG LYS AF 7644 1:10!
! JEU 28MAR! 13:31 23:59 LYS LYS HOT 10:28!
+--+
! VEN 29MAR! 0:00 5:29 LYS LYS HOT 5:29!
! VEN 29MAR! 5:30 6:29 LYS LYS CNV 0:59 DEBUT DE CONVOCATION!
! VEN 29MAR! 6:30 12:10 LYS DKR BIE 7816 5:40!
! VEN 29MAR! 13:30 16:20 DKR AGA BIE 7817 2:50!
! VEN 29MAR! 16:45 19:50 AGA LYS BIE 7817 3:05!
! VEN 29MAR! 19:51 20:05 LYS LYS DBF 0:14 DEBRIEF!
! VEN 29MAR! 20:06 23:59 LYS LYS HOT 3:53! **Programmée**
+--+
! SAM 30MAR! 0:00 23:59 LYS LYS HOT 23:59!
+--+
! DIM 31MAR! 0:00 8:49 LYS LYS HOT 8:49!
! DIM 31MAR! 8:50 10:00 LYS CDG AF 07641 1:10!
+--+
! DIM 31MAR! 11:25 14:40 CDG ATH AF 01832 3:15!
! DIM 31MAR! 14:41 23:59 ATH ATH HOT 9:18!
+--+
! LUN 01AVR! 0:00 23:59 ATH ATH HOT 23:59!
+--+
! MAR 02AVR! 0:00 3:29 ATH ATH HOT 3:29!
! MAR 02AVR! 3:30 6:20 ATH ZRH LX 1843 2:50!
! MAR 02AVR! 10:00 12:00 ZRH VLC LX 2142 2:00!

IX. ANNEXE 3 : PROGRAMME D'ACTIVITE INDIVIDUELLE (CDB)

« HERMES AIRLINES » - PROGRAMME D'ACTIVITE INDIVIDUELLE
Commandant de bord (captain)

Edit_ le 13.05.13 _ 12:24:07 Date du/au. 29.01.13 / 29.03.13 GMT

Temps total du 29.01.13 au 29.03.13, Vols en fonction : 100h25, Vols en MEP :75h35

```
+------------------------------------------------------------------------------------------------------------------+
! Date HrD_b HrFin ApD ApA Cie/N°Vol Avion Typ Aff Dur_e Fonct Activit/Commentaires!
+---------------------GMT------------------------------------------------------------------------------------------+
! MAR 29JAN! REPOS!
+------------------------------------------------------------------------------------------------------------------+
! MER 30JAN! REPOS!
+-----------------------------------------------------------------------------------------------------------------+
! JEU 31JAN! REPOS!
+------------------------------------------------------------------------------------------------------------------+
! VEN 01FEV! 7:05 10:35 ATH CDG A3 610. 3:30!
! VEN 01FEV! 15:00 16:10 CDG LYS AF 7646 1:10!
! VEN 01FEV! 16:11 23:59 LYS LYS HOT 7:48!
+------------------------------------------------------------------------------------------------------------------+
! SAM 02FEV! 0:00 6:59 LYS LYS HOT 6:59!
! SAM 02FEV! 7:00 7:59 LYS LYS CNV 0:59! DEBUT DE CONVOCATION!
! SAM 02FEV! 8:15 10:05 LYS FCO BIE 9860 1:50!
! SAM 02FEV! 11:10 13:10 FCO TLS BIE 997F 2:00!
! SAM 02FEV! 13:55 15:40 TLS FCO BIE 9972 1:45!
! SAM 02FEV! 16:40 18:50 FCO CDG BIE 986F 2:10!
! SAM 02FEV! 18:51 19:05 CDG CDG DBF 0:14! DEBRIEF!
! SAM 02FEV! 19:06 23:59 CDG CDG HOT 4:53!
+-----------------------------------------------------------------------------------------------------------------+
! DIM 03FEV! 0:00 14:49 CDG CDG HOT 14:49!
! DIM 03FEV! 14:50 15:49 CDG CDG CNV 0:59! DEBUT DE CONVOCATION !
! DIM 03FEV! 15:50 18:40 CDG DJE BIE 4312 2:50!
! DIM 03FEV! 19:50 23:05 DJE CDG BIE 4313 3:15!
! DIM 03FEV! 23:06 23:20 CDG CDG DBF 0:14! DEBRIEF!
! DIM 03FEV! 23:21 23:59 CDG CDG HOT 0:38!
+----------------------------------------------------------------------------------------------------------------+
! LUN 04FEV! REPOS!
+----------------------------------------------------------------------------------------------------------------+
! MAR 05FEV! 0:00 11:44 CDG CDG HOT 11:44!
! MAR 05FEV! 11:45 15:05 CDG ATH A3 611 3:20!
+----------------------------------------------------------------------------------------------------------------+
! MER 06FEV! REPOS!
+----------------------------------------------------------------------------------------------------------------+
! JEU 07FEV! 6:05 7:30 ATH SOF A3 7307 1:25!
! JEU 07FEV! 7:31 23:59 SOF SOF HOT 16:28!
+-----------------------------------------------------------------------------------------------------------------+
! VEN 08FEV! 0:00 8:29 SOF SOF HOT 8:29!
! VEN 08FEV! 8:30 9:40 SOF ATH KM 781 1:10!
+-----------------------------------------------------------------------------------------------------------------+
! SAM 09FEV! 9:00 12:00 ATH ATH BUR 3:00! BUREAU! +-----------------------------------------------------------------------------------------
---------------------------------+
! DIM 10FEV! 9:00 12:00 ATH ATH BUR 3:00! BUREAU !
+-----------------------------------------------------------------------------------------------------------------+
! LUN 11FEV! 9:00 12:00 ATH ATH BUR 3:00! BUREAU!
! LUN 11FEV! 20:00 23:59 ATH ATH REPOS!
+-------------------------------------------------------------------------------------------------------------+
! MAR 12FEV! REPOS!
+-------------------------------------------------------------------------------------------------------------+
! MER 13FEV! REPOS!
! MER 13FEV! 9:00 12:00 ATH ATH BUR 3:00! BUREAU!
+-------------------------------------------------------------------------------------------------------------+
! JEU 14FEV! 7:05 10:35 ATH CDG A3 610. 3:30!
! JEU 14FEV! 10:36 23:59 CDG CDG HOT 13:23!
+-------------------------------------------------------------------------------------------------------------+
! VEN 15FEV! 0:00 8:39 CDG CDG HOT 8:39!
! VEN 15FEV! 8:40 11:20 CDG OUD BIE 4258 2:40!
! VEN 15FEV! 12:45 15:45 OUD CDG BIE 4259 3:00!
! VEN 15FEV! 18:35 21:50 CDG ATH A3 619 3:15!
+-------------------------------------------------------------------------------------------------------------+
! SAM 16FEV! REPOS!
```

```
+----------------------------------------------------------------------------------------------------------------+
! DIM 17FEV! 14:40 18:10 ATH BRU SN 6524 3:30!
! DIM 17FEV! 19:25 21:05 BRU GOT SN 2319 1:40!
+----------------------------------------------------------------------------------------------------------------+
DIM 17FEV! 21:06 23:59 GOT GOT HOT 2:53!
+----------------------------------------------------------------------------------------------------------------+
! LUN 18FEV! 0:00 11:39 GOT GOT HOT 11:39!
! LUN 18FEV! 11:40 12:25 GOT CPH AF 437 0:45!
! LUN 18FEV! 15:30 17:30 CPH MAN HRM 2014 2:00!
! LUN 18FEV! 17:31 17:45 MAN MAN DBF 0:14! DEBRIEF!
! LUN 18FEV! 17:56 23:59 MAN MAN HOT 6:03!
+----------------------------------------------------------------------------------------------------------------+
! MAR 19FEV! 0:00 23:59 MAN MAN HOT 23:59!
+----------------------------------------------------------------------------------------------------------------+
! MER 20FEV! 0:00 14:29 MAN MAN HOT 14:29!
! MER 20FEV! 14:30 15:29 MAN MAN CNV 0:59! DEBUT DE CONVOCATION!
! MER 20FEV! 16:25 19:10 MAN ARN HRM 2015 2:45!
! MER 20FEV! 19:11 19:25 ARN ARN DBF 0:14! DEBRIEF!
! MER 20FEV! 19:26 23:59 ARN ARN HOT 4:33!
+----------------------------------------------------------------------------------------------------------------+
! JEU 21FEV! 0:00 7:29 ARN ARN HOT 7:29!
! JEU 21FEV! 7:30 8:29 ARN ARN CNV 0:59! DEBUT DE CONVOCATION!
! JEU 21FEV! 8:40 11:05 ARN MAN HRM 2016 2:25!
! JEU 21FEV! 11:06 16:19 MAN MAN HOT 5:13!
! JEU 21FEV! 16:20 18:30 MAN GOT HRM 2013 2:10!
! JEU 21FEV! 18:31 18:45 GOT GOT DBF 0:14 DEBRIEF !
! JEU 21FEV! 18:46 23:59 GOT GOT HOT 5:13!
+----------------------------------------------------------------------------------------------------------------+
! VEN 22FEV! 14:50 17:00 GOT CDG AF 3223 2:10!
! VEN 22FEV! 19:50 20:55 CDG NTE AF 7728 1:05!
! VEN 22FEV! 20:56 23:59 NTE NTE HOT 3:03!
+----------------------------------------------------------------------------------------------------------------+
! SAM 23FEV! 0:00 15:29 NTE NTE HOT 15:29!
! SAM 23FEV! 15:30 16:19 NTE NTE CNV 0:49! DEBUT DE CONVOCATION !
! SAM 23FEV! 16:25 17:20 NTE BES BIE 5116 0:55!
! SAM 23FEV! 17:55 21:30 BES TFS BIE 5116 3:35!
! SAM 23FEV! 23:20 3:30 TFS LYS BIE 1985 4:10!
+----------------------------------------------------------------------------------------------------------------+
! DIM 24FEV! 3:31 3:45 LYS LYS DBF 0:14! DEBRIEF!
! DIM 24FEV! 3:46 15:04 LYS LYS HOT 11:18!
! DIM 24FEV! 15:05 16:15 LYS CDG AF 7645 1:10!
! DIM 24FEV! 18:35 21:50 CDG ATH A3 619 3:15!
+----------------------------------------------------------------------------------------------------------------+
! LUN 25FEV! REPOS!
+----------------------------------------------------------------------------------------------------------------+
! MAR 26FEV! 9:00 12:00 ATH ATH BUR 3:00! BUREAU!
+----------------------------------------------------------------------------------------------------------------+
! MER 27FEV! REPOS!
+----------------------------------------------------------------------------------------------------------------+
! JEU 28FEV! REPOS!
+----------------------------------------------------------------------------------------------------------------+
! VEN 01MAR! 0:00 7:00 ATH ATH REPOS!
! VEN 01MAR! 7:05 10:35 ATH CDG A3 0610 3:30!
+----------------------------------------------------------------------------------------------------------------+
+VEN 01MAR! 12:20 13:30 CDG LYS AF 7644 1:10!
! VEN 01MAR! 13:31 23:59 LYS LYS HOT 10:28!
+----------------------------------------------------------------------------------------------------------------+
! SAM 02MAR! 0:00 5:54 LYS LYS HOT 5:54!
! SAM 02MAR! 5:55 6:54 LYS LYS CNV 0:59! DEBUT DE CONVOCATION !
! SAM 02MAR! 7:25 11:35 LYS TFS BIE 1984 4:10!
! SAM 02MAR! 12:25 15:50 TFS NTE BIE 5117 3:25!
! SAM 02MAR! 15:51 16:05 NTE NTE DBF 0:14! DEBRIEF !
! SAM 02MAR! 17:55 19:00 NTE CDG AF 7731 1:05!
! SAM 02MAR! 19:01 23:59 CDG CDG HOT 4:58!
+----------------------------------------------------------------------------------------------------------------+
! DIM 03MAR! 0:00 7:59 CDG CDG HOT 7:59!
! DIM 03MAR! 8:00 8:59 CDG CDG CNV 0:59! DEBUT DE CONVOCATION !
! DIM 03MAR! 9:25 14:10 CDG VDA BIE 4266 4:45!
! DIM 03MAR! 15:30 16:30 VDA TLV BIE 4266 1:00!
! DIM 03MAR! 17:30 22:45 TLV CDG BIE 4266 5:15!
! DIM 03MAR! 22:46 23:00 CDG CDG DBF 0:14! DEBRIEF !
! DIM 03MAR! 23:01 23:59 CDG CDG HOT 0:58!
+----------------------------------------------------------------------------------------------------------------+
! LUN 04MAR! 0:00 11:44 CDG CDG HOT 11:44!
! LUN 04MAR! 11:45 15:05 CDG ATH A3 0611. 3:20!
! LUN 04MAR! 20:00 23:59 ATH ATH 3:59 REPOS!
+----------------------------------------------------------------------------------------------------------------+
! MAR 05MAR! REPOS!
```

```
+------------------------------------------------------------------------------------------------------------------+
! MER 06MAR! REPOS!
+------------------------------------------------------------------------------------------------------------------+
! JEU 07MAR ! REPOS!
+------------------------------------------------------------------------------------------------------------------+
!VEN 08MAR! 0:00 7:04 ATH ATH 7:04 REPOS!
! VEN 08MAR! 7:05 10:35 ATH CDG A3 610 3:30!
! VEN 08MAR! 12:20 13:30 CDG LYS AF 7644 1:10!
! VEN 08MAR! 13:31 23:59 LYS LYS HOT 10:28!
+------------------------------------------------------------------------------------------------------------------+
! SAM 09MAR! 0:00 5:54 LYS LYS HOT 5:54!
! SAM 09MAR! 5:55 6:54 LYS LYS CNV 0:59 ! DEBUT DE CONVOCATION !
! SAM 09MAR! 7:20 12:05 LYS TFS BIE 1984 4:45!
! SAM 09MAR! 13:10 16:30 TFS NTE BIE 5117 3:20!
! SAM 09MAR! 16:31 16:45 NTE NTE DBF 0:14! DEBRIEF !
! SAM 09MAR! 16:46 23:59 NTE NTE HOT 7:13!
+------------------------------------------------------------------------------------------------------------------+
! DIM 10MAR! 0:00 10:24 NTE NTE HOT 10:24!
! DIM 10MAR! 10:25 11:30 NTE CDG AF 7725 1:05!
! DIM 10MAR! 11:31 15:34 CDG CDG HOT 4:03!
! DIM 10MAR! 15:35 16:34 CDG CDG CNV 0:59! DEBUT DE CONVOCATION !
! DIM 10MAR! 17:50 20:55 CDG DJE BIE 2932 3:05!
! DIM 10MAR! 21:40 0:40 DJE CDG BIE 2933 3:00!
+------------------------------------------------------------------------------------------------------------------+
! LUN 11MAR! 0:41 0:55 CDG CDG DBF 0:14! DEBRIEF !
! LUN 11MAR! 0:56 11:44 CDG CDG HOT 10:48!
! LUN 11MAR! 11:45 15:05 CDG ATH A3 611 3:20!
! LUN 11MAR! 20:00 23:59 ATH ATH 3:59! REPOS!
+------------------------------------------------------------------------------------------------------------------+
! MAR 12MAR! REPOS!
+------------------------------------------------------------------------------------------------------------------+
! MER 13MAR! REPOS!
+------------------------------------------------------------------------------------------------------------------+
! JEU 14MAR! REPOS!

-!VEN 15MAR! 7:05 10:35 ATH CDG A3 610 3:30!
! VEN 15MAR! 10:36 23:59 CDG CDG HOT 13:23!
+------------------------------------------------------------------------------------------------------------------+
! SAM 16MAR! 0:00 17:54 CDG CDG HOT 17:54!
! SAM 16MAR! 17:55 18:54 CDG CDG CNV 0:59! DEBUT DE CONVOCATION !
! SAM 16MAR! 18:55 23:50 CDG TFS BIE 4644 4:55!
+------------------------------------------------------------------------------------------------------------------+
! DIM 17MAR! 0:45 4:50 TFS CDG BIE 4645 4:05!
! DIM 17MAR! 4:51 5:05 CDG CDG DBF 0:14! DEBRIEF !
! DIM 17MAR! 5:06 16:54 CDG CDG HOT 11:48!
! DIM 17MAR! 16:55 19:00 CDG FRA LH *1043 2:05!
! DIM 17MAR! 19:40 21:35 FRA ARN LH *808 1:55!
! DIM 17MAR! 21:36 23:59 ARN ARN HOT 2:23!
+------------------------------------------------------------------------------------------------------------------+
! LUN 18MAR! 0:00 18:49 ARN ARN HOT 18:49!
! LUN 18MAR! 18:50 19:49 ARN ARN CNV 0:59! DEBUT DE CONVOCATION!
! LUN 18MAR! 19:50 0:10 ARN ISU HRM 2017 4:20!
+------------------------------------------------------------------------------------------------------------------+
! MAR 19MAR! 1:30 6:55 ISU ARN HRM 2018 5:25!
! MAR 19MAR! 6:56 7:10 ARN ARN DBF 0:14! DEBRIEF!
! MAR 19MAR! 7:11 23:59 ARN ARN HOT 16:48!
+------------------------------------------------------------------------------------------------------------------+
! MER 20MAR! 0:00 10:29 ARN ARN HOT 10:29!
! MER 20MAR! 10:30 11:29 ARN ARN CNV 0:59! DEBUT DE CONVOCATION!
! MER 20MAR! 11:30 12:35 ARN GOT HRM 2009 1:05!
+------------------------------------------------------------------------------------------------------------------+
! MER 20MAR! 14:00 18:25 GOT EBL HRM 2009 4:25!
! MER 20MAR! 20:15 1:55 EBL CDG HRM 950F 5:40!
+------------------------------------------------------------------------------------------------------------------+
! JEU 21MAR! 1:56 11:59 CDG CDG HOT 10:03!
! JEU 21MAR! 12:00 15:00 CDG ATH A3 611 3:00!
! JEU 21MAR! 18:00 23:59 ATH ATH 5:59! REPOS!
+------------------------------------------------------------------------------------------------------------------+
! VEN 22MAR! REPOS!
+------------------------------------------------------------------------------------------------------------------+
! SAM 23MAR! REPOS!
+------------------------------------------------------------------------------------------------------------------+
! DIM 24MAR! REPOS!
+------------------------------------------------------------------------------------------------------------------+
! LUN 25MAR! REPOS !
+------------------------------------------------------------------------------------------------------------------+
! MAR 26MAR! REPOS!
```

```
+-----------------------------------------------------------------------------------------------------------------------+
! MER 27MAR ! REPOS!
+-----------------------------------------------------------------------------------------------------------------------+
! JEU 28MAR! 0:00 6:00 ATH ATH 6:00! REPOS!
! JEU 28MAR! 7:05 10:35 ATH CDG A3 610 3:30!
! JEU 28MAR! 12:20 13:30 CDG LYS AF 7644 1:10!
! JEU 28MAR! 13:31 23:59 LYS LYS HOT 10:28!
+-----------------------------------------------------------------------------------------------------------------------+
! VEN 29MAR! 0:00 5:29 LYS LYS HOT 5:29!
! VEN 29MAR! 5:30 6:29 LYS LYS CNV 0:59! DEBUT DE CONVOCATION !
! VEN 29MAR! 6:30 12:10 LYS DKR BIE 7816 5:40!
! VEN 29MAR! 13:30 16:20 DKR AGA BIE 7817 2:50!
! VEN 29MAR! 16:45 19:50 AGA LYS BIE 7817 3:05!
! VEN 29MAR! 19:51 20:05 LYS LYS DBF 0:14 DEBRIEF!
! VEN 29MAR! 20:06 23:59 LYS LYS HOT 3:53!
+-----------------------------------------------------------------------------------------------------------------------+
! SAM 30MAR! LYS LYS HOT 23:59!
+-----------------------------------------------------------------------------------------------------------------------+
! DIM 31MAR! 0:00 8:49 LYS LYS HOT 8:49!
! DIM 31MAR! 8:50 10:00 LYS CDG AF 7641 1:10!
! DIM 31MAR! 11:25 14:40 CDG ATH AF 1832 3:15!
+-----------------------------------------------------------------------------------------------------------------------+
```

Appendix 7

Hermes Airlines Operations Manual Extracts

1 - Operations Manual (revision 0 and revision 1) in force on the date of the accident

1.1 Extracts from Parts A and D on pre-requisites for Flight Crew

HERMES AIRLINES	Operations Manual Part A QUALIFICATION REQUIREMENTS	Page: 11 Chapter: 5 Re-Issue: 02 Revision. 0 Date: 23/08/2012

5.2.1 General

The minimum requirements for employment and promotion are specified by the company in accordance with HCAA, EU-OPS and ICAO regulations. All training and checking programs are specified in the OM Part A and/or O.M. Part D and are approved by the Authority.
To operate company airplanes flight crew must possess the following:
- Valid JAR-FCL pilot license (ATPL or CPL with Frozen ATPL credit theory).
- To be type rated. Previous military experience in transport aircraft meets this requirement.
- Valid Class I medical certificate.
- Multi engine rating.
- Instrument rating.
- Emergency and safety equipment training.
- Crew Resource Management training.
- Security training.
- Dangerous Goods training.
- Route and aerodrome competence according to chapter 5.
- Recency of experience according to chapter 5.
- Valid recurrent OPC / LPC and Line checks.
- The requirements of sections 5.2.1 and 5.2.2.2

Page: 12 Chapter: 5 Re-Issue: 02 Revision. 0 Date: 23/08/2012	Operations Manual Part A QUALIFICATION REQUIREMENTS	HERMES AIRLINES

5.2.2 Commander

5.2.2.1 Nomination as Commander

OPS 1.950

A flight crew member before can be appointed as Commander he/she must meet the requirements under 5.1.1.

5.2.2.2 Minimum Qualification Requirements

OPS 1.1240

The minimum qualification requirements for a flight crew member to act as commander of a commercial air transport flight are:
- The requirements of section 5.1.1.
- Minimum: 3.500 hours in public transport flight operations (certified).
- Successful completion of the command course as specified in the OM Part D
- Line Training in command under supervision (for minimum requirements refer to OM- D).
- Nomination as Commander.

NOTE
The above minimum experience requirements may differ, according to company needs.

HERMES AIRLINES	Operations Manual Part A QUALIFICATION REQUIREMENTS	Page: 13 Chapter: 5 Re-Issue: 02 Revision. 0 Date: 23/08/2012

5.2.4 Co-pilot

A co-pilot is a flight crew member acting in accordance with Chapter 1.
The co-pilot occupies the right-hand pilot seat.
Minimum requirements for the position of a new entry co-pilot are:
- JAR - FCL CPL (A) / IR / ME with JAR - FCL ATPL (A) Theory Credit.
- Valid Class I Medical.

Minimum flight experience and or additional requirements are defined by Flight Operations.

1.2.4 Minimum Qualification / Experience Levels (flight and cabin crew members)

1.2.4.1 Commander – type rated and non-type rated- Direct Entry

	With Type Rating	Without Type Rating
Commander	Minimum 1500 hrs total flying time of which 500 hrs PIC on Type • JAR-FCL A.T.P.L **and** • First class medical certificate Or equivalent acceptable to the HCAA	Minimum 2500 hrs total flying time, of which 500 hrs PIC on similar types in commercial air transport • JAR-FCL A.T.P.L • First class medical certificate Or equivalent acceptable to the HCAA

Note: *Type rated commanders with less than 500 hours on the type will be considered after careful review of their previous experience*

1.2.4.2 Co-pilot — type rated and non-type rated- Direct Entry

	With Type Rating	Without Type Rating
Co-pilot	Minimum 1500 hrs total flying time of which 500 hrs on Type • JAR-FCL C.P.L(A) with A.T.P.L credit theory/ A.T.P.L(A) • Frozen ATPL • First class medical certificate Or Equivalent acceptable to the HCAA	Minimum 200 hrs total flying time of which 30 hrs on multi-engine aircraft. • JAR-FCL C.P.L / A.T.P.L • Frozen ATPL • First class medical certificate Or Equivalent acceptable to the HCAA

Note: *Type rated Co-pilot with less than 500 hours on the type will be considered after careful review of their previous experience*

2.1.3 Command Training

When a command vacancy exists consideration will always be given to the promotion of a company Co-pilot to fill the position. The role of Commander is a complex one involving a great deal more than the ability to fly the aeroplane on normal Line operations. The selection of candidates for Command Training will remain the responsibility of the flight operation manager; Training Manager and chief pilot the final decision on promotion rests with the flight operation manager. The following guidelines may assist the Chief Pilot selection process.

2.1.3.1 Qualification

For upgrading to Commander a minimum of 3000 hours(Jet) total flying time including 500 hours on type is required. A Co-pilot with less experience than this who is considered to be of "above-average" ability may be selected for Command Training at the discretion of the flight operation manager training manager and Chief Pilot.
For commanders with no pervious expense on the type minimum requirement is 5000 hours total flying time including 500 hours command time on aeroplanes of MTOM more than 40 tons.

1.2 Extracts from Parts A and D on normal procedures during a precision approach

For the approach and landing, Chapter 2 – Operations Manual Part B A320-F- Normal Procedures calls for reference to FCOM Vol 3.03.16 and to the AFM Ch. Normal Procedures.

1.2.1 FCOM Hermes Airlines – Standard Operating Procedures – Precision Approach (applicable to MSN 642)

HERMES AIRLINES **A318/A319/A320/A321** FLIGHT CREW OPERATING MANUAL	**PROCEDURES** **NORMAL PROCEDURES** STANDARD OPERATING PROCEDURES - PRECISION APPROACH

INTERMEDIATE/FINAL APPROACH

Applicable to: ALL

The objective is to be stabilized on the final descent path at VAPP in the landing configuration, at 1 000 ft above airfield elevation (in instrument conditions, or at 500 ft above airfield elevation in visual conditions, after continuous deceleration on the glide slope).

To be stabilized, all of the following conditions must be achieved prior to, or upon reaching this stabilization height:
- The aircraft is on the correct lateral and vertical flight path
- The aircraft is in the desired landing configuration
- The thrust is stabilized, usually above idle, to maintain the target approach speed along the desired glide path
- No excessive flight parameter deviation.

If the aircraft is not stabilized on the approach path in landing configuration, at 1 000 ft above airfield elevation in instrument conditions, or at 500 ft above airfield elevation in visual conditions, or as restricted by Operator policy/regulations, the flight crew must initiate a go-around, unless they think that only small corrections are necessary to rectify minor deviations from stabilized conditions due, amongst others, to external perturbations.

Applicable to: ALL

APPR pb on FCU..PRESS

- *Press the APPR pb, only when ATC cleares the aircraft for the approach. This arms the LOC and G/S modes*
- *LOC and/or G/S capture modes will engage no sooner than 3 s after being armed.*

BOTH APs..ENGAGE

When APPR mode is selected, AP1 pb and AP2 pb should be engaged.

-

Applicable to: MSN 0517-0642

AT GREEN DOT SPEED

FLAPS 1 ....ORDER

FLAPS 1 ....SELECT

- *At high weights, if the green dot speed is close to VFE NEXT, the crew may select a lower speed*
- *FLAPS 1 should be selected more than 3 nm before the FAF (Final Approach Fix).*

Note: *The ECAM automatically displays the STATUS page, if it is applicable, and if the flight crew has not already selected a system page manually.*

- Check deceleration toward "S" speed
- The aircraft must reach, or be established on, the glideslope with FLAPS 1 and S speed at, or above, 2 000 ft AGL.
- If the aircraft speed is significantly higher than S on the glideslope, or if the aircraft does not decelerate on the glideslope, extend the landing gear to slow it down. It is also possible to use speed brakes. However, the flight crew should be aware that the use of speed brakes causes an increase in VLS.

TCAS Mode selector ....TA or TA/RA

L2 *The flight crew should use the TA/RA mode as the default mode of the TCAS.*
The flight crew may use the TA ONLY mode in specific airports, and for specific procedures (identified by Operators) that may provide resolution advisories that are neither wanted nor appropriate (e.g. closely-spaced parallel or converging runways).

L1 FMA ....CHECK and ANNOUNCE

LOC CAPTURE ....MONITOR

The flight crew must always monitor the capture of LOC beam. During the capture phase, the associated deviation indications on the PFD and ND must indicate movement towards the center of the scale.

G/S CAPTURE ....MONITOR

● **If above the glideslope:**

FCU ALTITUDE ....SET ABOVE A/C ALTITUDE

V/S mode ....SELECT

Note: *1. When reaching VFE, the AP maintains VFE and reduces the V/S without MODE REVERSION.*

2. If the aircraft intercepts the ILS above the radio altimeter validity range (no radio altitude indication available on the PFD), CAT 1 is displayed on the FMA. Check that the FMA displays the correct capability for the intended approach, when the aircraft is below 5 000 ft.

GO-AROUND ALT ....SET

Set the go around altitude on the FCU.

AT 2 000 FT AGL (MINIMUM)

FLAPS 2 .... ORDER
FLAPS 2 .... SELECT

- *Check deceleration towards F speed*
- *If the aircraft intercepts the ILS glideslope below 2 000 ft AGL, select FLAPS 2 at one dot below the glideslope*
- *If the aircraft speed is significantly higher than S on the glide slope, extend the landing gear in order to slow down the aircraft. The use of speed brakes is not recommended*
- *When the speed brakes are deployed, extending the flaps beyond FLAPS 1 may induce a slight roll movement, and in calm conditions a small lateral control asymmetry may remain until disturbed by a control input or by an atmospheric disturbance.*

Applicable to: ALL

WHEN FLAPS ARE AT 2

LDG GEAR DOWN .... ORDER
L/G lever .... SELECT DOWN
AUTO BRK .... CONFIRM
If the runway conditions have changed from the approach briefing, consider another braking mode.
GROUND SPOILERS .... ARM
EXTERIOR LIGHTS .... SET

Set:
- The NOSE selector to TAXI
- The RWY TURN OFF sw to ON

WHEN LANDING GEAR IS DOWN

FLAPS 3 .... ORDER
FLAPS 3 .... SELECT

- *Select FLAPS 3 below VFE. next.*
- *Retract the speed brakes before selecting FLAPS 3 to avoid an unexpected pitch down, when the speed brakes retract automatically.*

WHEEL SD page .... CHECK

- *WHEEL SD page appears below 800 ft, or at landing gear extension.*
- *Check for three green indications on the landing gear indicator panel. At least one green triangle on each landing gear strut on the WHEEL SD page is sufficient to indicate that the landing gear is downlocked. Rely also on the "LDG GEAR DN" green LDG MEMO message to confirm that the landing gear is downlocked.*

● **If residual pressure is indicated on the triple indicator:**
RESIDUAL BRAKING PROC .... APPLY

FLAPS FULL .... ORDER
FLAPS FULL .... SELECT
Select FLAPS FULL below VFE next. Check deceleration towards VAPP.

A/THR..CHECK IN SPEED MODE OR OFF
WING ANTI-ICE..OFF

Only switch the WING ANTI ICE to ON, in severe icing conditions.

SLIDING TABLE ⚙ ....STOW
LDG MEMO..CHECK NO BLUE LINE
CABIN REPORT..OBTAIN
CABIN CREW..ADVISE
LANDING CHECK LIST..COMPLETE
FLIGHT PARAMETERS..CHECK

The PF announces any FMA modification.

The PNF calls out, if:

- The speed becomes less than the speed target -5 kt , or greater than the speed target +10 kt
- The pitch attitude becomes less than -2.5 °, or greater than plus 7.5 ° nose up
- The bank angle becomes greater than 7 °
- The descent rate becomes greater than 1 000 ft/min
- Excessive LOC or GLIDE deviation occurs.
  1/4 dot LOC; 1 dot GS

Following PNF flight parameter exceedance callout, the suitable PF response will be:

- Acknowledge the PNF callout, for proper crew coordination purposes
- Take immediate corrective action to control the exceeded parameter back into the defined stabilized conditions
- Assess whether stabilized conditions will be recovered early enough prior to landing, otherwise initiate a go-around.

Applicable to: ALL

AT MINIMUM + 100 FT :

ONE HUNDRED ABOVE..MONITOR OR ANNOUNCE

Applicable to: ALL

AT MINIMUM :

MINIMUM..MONITOR OR ANNOUNCE
CONTINUE OR GO AROUND..ANNOUNCE

Do not duck under the glideslope. Maintain a stabilized flight path down to the flare. At 50 ft, one dot below the glideslope is 7 ft below the glideslope.

HERMES AIRLINES	Operations Manual Part B A-320F Company Policy	Page: 39 Chapter: 13 Issue: 01 Revision. 0 Date: 14/10/2011

13.2.25 Approach

13.2.25.1 General

Aircraft approach category is C. However, if it is necessary to maneuver at speeds in excess of category C speed range, the minimums for category D should be used.

- Use stabilized approach technique for non precision approaches as described below.
- The aircraft intercepts the final descent path in landing configuration, and at VAPP. For this purpose, the flight crew should insert VAPP as a speed constraint at the FAF.
- Decelerated approach is preferred when executing ILS approach (Wx and ATC permitting). It allows a smooth approach and potential fuel savings compared to the stabilized approach.
- FLAPS 2 at one dot below the glideslope.
- The PF maintains a selected speed of 160KT, at latest 5 nm from touchdown.
- At 5 nm, push managed speed, and Gear Down, set NOSE switch to TAXI and set RWY TURN OFF switch to ON.
- When the gear is down and below VFE Next - select Flap 3.
- When Flaps are at 3 and below VFE Next - select Flap Full.

Progressively and the latest at 1.000ft above runway elevation, in IMC conditions, the aircraft should be stabilized on the final descent path in the landing configuration with thrust above idle or at 500ft in VMC.

According to calculations by Airbus, the increase in fuel consumption when a stabilized approach is performed, in comparison to a decelerated approach for the A320 is +45Kgrs/min. It is obvious that the stabilized approach needs more fuel as flaps and landing gear are extended earlier and thus increase drag.

2. Operations Manual (revision 2) in force after the accident

2.1 Extracts from Parts A and D on pre-requisites required for Flight Crew

Page: 8 Chapter: 5 Re-Issue: 02 Revision. 0 1 Date: 09/08/2013	Operations Manual Part A QUALIFICATION REQUIREMENTS	HERMES AIRLINES

5.1.2 Flight Crew

5.1.2.1 Requirements for employment

The minimum requirements for Flight Crewmember employment are:

- a valid Commercial Pilot Licence (CPL);
- Instrument Rating (IR) privileges;
- theoretical Airline Transport Pilot Licence (ATPL);
- Multi Crew Cooperation (MCC) course;
- English language ICAO Proficiency Level 4 (Operational);
- High School diploma (or equivalent);
- a valid and current Class1 medical certificate;

5.1.2.2 Co-pilot

Before acting as a member of the required Flight Crew on any flight operated by the Company, a Flight Crewmember must:

- meet employment requirement criteria as per 5.1.2.1;

- have successfully completed, within the prescribed period of validity and in accordance with OM Part D:

  - initial Crew Resources Management (CRM) training;
  - the HERMES AIRLINES Conversion Course ;
  - Recurrent Training and Checking ;

- meet the Recency requirements as outlined in 5.2.6.

- receive relevant Route/Aerodrome familiarization as per 5.4.1.4.

A Co-Pilot may act as "Pilot-in-Command Under Supervision of the Commander" (PICUS) for the purpose of upgrading the CPL to the ATPL (the total flight time shall be credited). Co-pilots also act as PICUS during Command Training.

5.1.2.2.1 Commander

Before being designated and undertake the duties of Commander on a Company flight, a Flight Crewmember must:

- meet the requirements of 5.1.2.2;
- hold a valid ATPL with the appropriate type rating;
- have minimum 5000h in public transport flight operations (certified), or 3000h flown for the company with the same type in which he will be qualified as a commander.
- have successfully completed the Command Course as per OM Part D;
- hold relevant Route/Airport competence qualifications and any additional qualification for the required operations.

Flight CMs with more than 5 years' experience operating as Commander are nominated Senior Captains; such nomination must be certified by an official letter received from the Company.

Note: The maximum age limit to act as a crewmember is 65. In cases where the PIC is over 60 years of age, the other crewmember's age limit is 60 years old.

Page: 10 Chapter: 1 Re-Issue Date:10/12/2012	**Operations Manual Part D** **General**	HERMES AIRLINES

1.4.1 Minimum Qualification / Experience Levels of Flight Crew

1.4.1.1 Commander – type rated and non-type rated- Direct Entry

Refer to OM Part A 5.1.2.2.1

1.4.1.2 Co-pilot -– type rated and non-type rated- Direct Entry

Minimum 200 hrs. total flying time of which 30 hrs. on multi-engine aircraft.

- JAR-FCL C.P.L / A.T.P.L
- Frozen ATPL
- First class medical certificate or Equivalent acceptable to HCAA

1.4.1.3 Upgrade to Commander EU OPS 1.955

Refer to OM Part A 5.2.1

2.1.4 Command Training

When a command vacancy exists consideration will always be given to the promotion of a company Co-pilot to fill the position. The role of Commander is a complex one involving a great deal more than the ability to fly the aeroplane on normal Line operations. The selection of candidates for Command Training will remain the responsibility of the Flight Operation Manager; Training Manager and Chief Pilot. The final decision on promotion rests with the Flight Operation Manager. The following guidelines may assist the Chief Pilot selection process.

2.1.4.1 Qualification

Refer to OM Part A 5.2.1

2.2 Extract from Part B on normal procedures during a precision approach

Only *"Part B - Chapter 13 - Company Policy"* of the Manual has been modified

13.2.25 Approach

13.2.25.1 General

Aircraft approach category is C. However, if it is necessary to maneuver at speeds in excess of category C speed range, the minimums for category D should be used.

- Use stabilized approach technique for non-precision approaches as described below.
- The aircraft intercepts the final descent path in landing configuration, and at VAPP. For this purpose, the flight crew should insert VAPP as a speed constraint at the FAF.
- Decelerated approach is preferred when executing ILS approach (Wx and ATC permitting). It allows a smooth approach and potential fuel savings compared to the stabilized approach.
- At GREEN DOT select FLAPS 1. Flaps 1 must be selected more than 3 miles before the FAF.
- FLAPS 2 at 2000ft AGL. Check deceleration towards F speed.
- When Flaps are 2 select Gear Down, set NOSE switch to TAXI and set RWY TURN OFF switch to ON.
- When the gear is down and below VFE Next - select Flap 3.
- When Flaps are at 3 and below VFE Next - select Flap Full.

Progressively and the latest at 1.000ft above runway elevation, in IMC and VMC conditions, the aircraft should be stabilized on the final descent path in the landing configuration with thrust above idle .

According to calculations by Airbus, the increase in fuel consumption when a stabilized approach is performed, in comparison to a decelerated approach for the A320 is +45Kgrs/min. It is obvious that the stabilized approach needs more fuel as flaps and landing gear are extended earlier and thus increase drag.

NOTE

- *It is required that all approaches are stabilized approaches in terms of a/c configuration, flight path, speed and thrust not beyond 1000ft AGL in IMC and in VMC. If a proper stabilization is not reached a GO AROUND must be performed.*

Appendix 8

Hermes Airlines Flight Analysis

2012 Statistics

2012	January	February	March	April	May	June
Flights	**98**	**167**	**275**	**476**	**640**	**782**
Dual input	11,2%	17,96%	9,09%	1,47%	12,5%	23,78%
Unstabilized approach	13/3/2 18,37%	29/8/2 23,35%	40/12/8 21,81%	135/23/10 35,29%	163/26/12 31,40%	210/29/25 33,76%
Late A/THR reduction	23/46/9 79,6%	59/69/6 78,44%	82/130/14 82,18%	121/167/27 66,17%	201/175/43 65,47%	272/253/33 71,35%
Long flare	5/0/2 7,14%	32/9/3 26,35%	42/11/2 20%	48/13/4 13,66%	77/12/7 15%	118/30/9 20%
Long landing	1/4/2 7,14%	16/9/2 16,17%	30/20/10 21,81%	77/26/8 23,32%	103/51/19 27,03%	136/88/32 32,74%

2012	July	August	September	October	November	December
Flights	**789**	**665**	**603**	**399**	**245**	**156**
Dual input	34,34%	30,97%	27,03%	29,57%	30,61%	30,12%
Unstabilized approach	230/42/18 36,75%	213/40/17 40,60%	168/29/10 34,33%	117/9/6 33,08%	72/10/6 35,92%	40/6/3 31,41%
Late A/THR reduction	260/242/42 68,95%	214/221/40 71,43%	196/177/43 68,99%	127/128/30 71,43%	63/108/24 79,59%	58/63/11 84,61%
Long flare	121/34/12 21,7%	90/25/3 17,74%	84/20/1 17,41%	48/11/7 16,54%	48/11/7 16,54%	14/3/0 10,9%
Long landing	148/113/49 39,30%	123/95/52 40,60%	133/73/40 41,46%	99/57/21 44,36%	42/22/11 30,61%	31/12/4 30,13%

2012 Annual Report

In the annual report for 2012, the following points are mentioned:

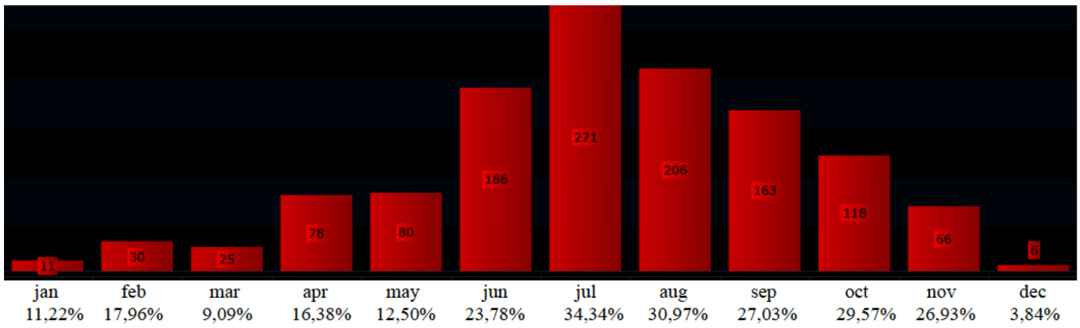
- **Number of flights**

2012	January	February	March	April	May	June	July	August	September	October	November	December
Flights	98	167	275	476	640	782	789	665	603	399	245	156

■ Dual input

Dual input is characterized when the deflection between the two sidesticks is greater than 0.5°.

DUAL INPUT



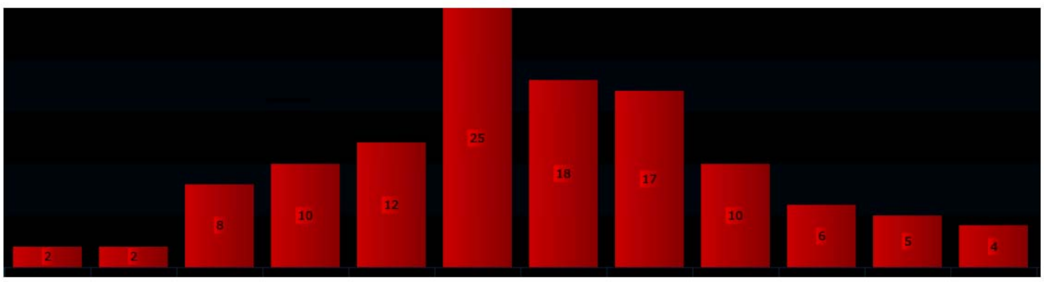
The report indicates the following suggestions: *"The bad and possible hazardous habit of the dual input must be addressed to the crews. The numbers appear to be great but the fact that the parameter is set at only ½ degree displacement increases the numbers due to inadvertent movement of the side stick during normal operations (mike button etc.). A reevaluation of setting the parameters to a more realistic figure for every day operations may be considered".*

■ Unstabilized approach

The severity of unstabilized approaches depends on the 3 AGL altitudes below which the approach is considered to be unstable (at least one of stabilization criteria is not met).

- ❒ X = 1000 ft (light)
- ❒ X = 500 ft (medium)
- ❒ X = 300 ft (high)

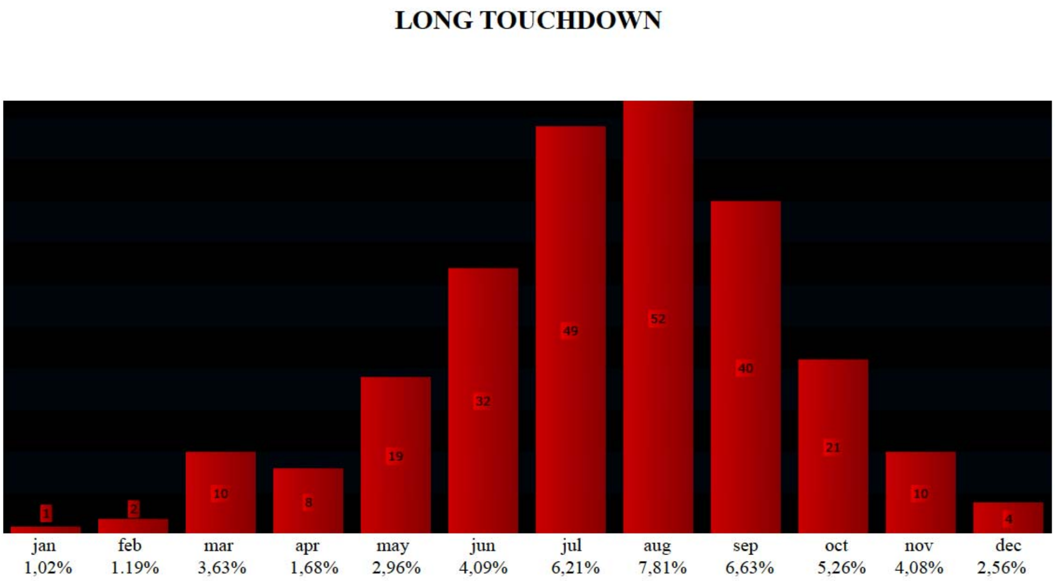
Unstabilized Approches



January	February	March	April	May	June	July	August	September	October	November	December
2,04%	1,19%	2,90%	2,10%	1,87%	3,19%	2,28%	2,55%	1,65%	1,50	2,04%	2,56%

The report indicates the following suggestions: *"An increase of the stabilization height to 1000' regardless of meteorological conditions will reduce the rates as previous experience has shown. Crews must be made aware that a "rushed" high energy approach has more dangers than benefits from gaining 1 or 2 minutes less flying time. Crews that show a repetitive tendency must be called and made aware of this fact".*

■ Long touchdown



The report indicates the following suggestions: *"Crews should be made aware that « eating » the runway in order to achieve a smooth landing is not a safe practice. Further analysis to follow so as to see if these events are from specific crews"*.

The late A/THR reductions during landing and long flares are not mentioned in the report.

However, Hermes Airlines did provide the BEA with these statistics:

■ late A/THR reductions during landing

Thrust reduction is considered late when it occurs below the following altitudes:

- ❒ X = 10 ft (light)
- ❒ X = 5 ft (medium)
- ❒ X = 0 ft (high)
- ❒ Long flare-out

■ Long flare

The flare is considered long when the duration between passing the radio altitude of 30 ft and the touchdown is greater than:

- ❒ Time = 9 seconds (light)
- ❒ Time = 11 seconds (medium)
- ❒ Time = 13 seconds (high)

Late Thrust Reduction	23/46/9 79,60%	56/69/6 78,44%	82/130/14 82,18%	121/167/27 66,17%	201/175/43 65,47%	272/253/33 71,35%	260/242/42 68,95%	214/221/40 71,43%	196/177/43 68,99%	127/128/30 71,43%	63/108/24 79,59%	58/63/11 84,61%
Long Flare	5/0/2 7,14%	32/9/3 26,35%	42/11/2 20,00%	48/13/4 13,66%	77/12/7 15,00%	118/30/9 20,07%	121/34/12 21,17%	90/25/3 17,74%	84/20/1 17,41%	48/11/7 16,54%	26/7/6 15,92%	14/3/0 10,90%

2013 Statistics

Analysis of 2013 flights

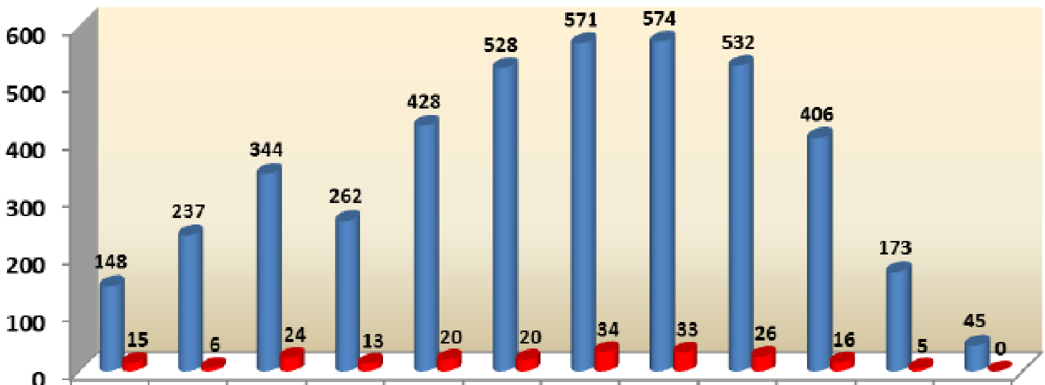
The figures below are those provided by Hermes.

- **Number of flights**

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Flights	148	237	344	262	428	528	571	574	532	406	173	45

- **Dual input**

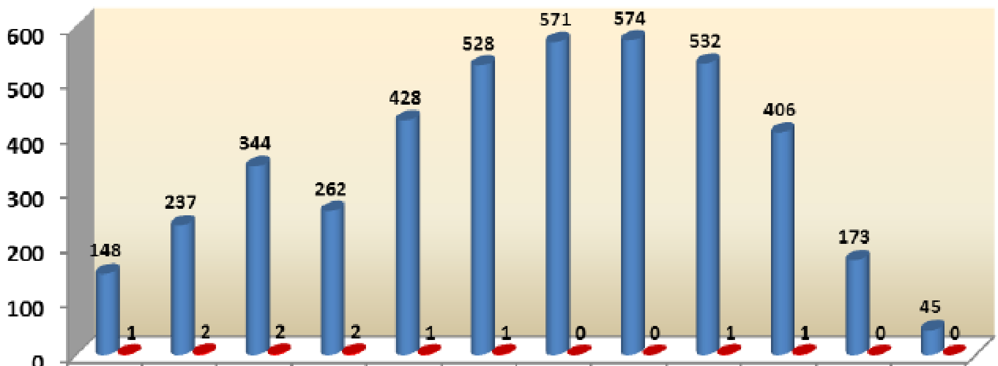
Dual Stick Input



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Flights	148	237	344	262	428	528	571	574	532	406	173	45
Events	15	6	24	13	20	20	34	33	26	16	5	0

- **Unstabilized approach**

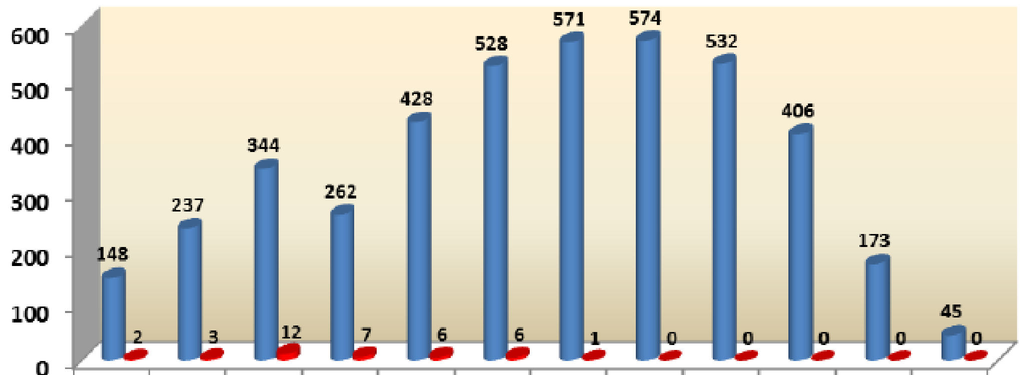
Unstabilized Approach



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Flights	148	237	344	262	428	528	571	574	532	406	173	45
Events	1	2	2	2	1	1	0	0	1	1	0	0

■ Long touchdown

Long Touchdown



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Flights	148	237	344	262	428	528	571	574	532	406	173	45
Events	2	3	12	7	6	6	1	0	0	0	0	0

Appendix 9

Previous Events

1 - A/THR anomaly

- **Serious incident on 11 July 2011 in Bamako (Mali) to the Airbus A320-214 registered 6V-AII operated by Air Senegal.**

At the time of writing this report, the final report on this serious incident has not yet been published by the Malian authorities.

On Monday 11 July 2011, the Airbus A320-214 registered 6V-IIA, operated by Senegal Airlines was making the regular public transport passenger flight from Dakar (Senegal) to Bamako (Mali). The weather conditions were VMC.

The crew conducted an ILS approach to runway 06 (2700 m). The approach speed calculated by the FMCG (PN B546CAM0102 or PN B546CAM0104) was 139 kt in the «FULL» configuration.

When passing 500 ft AGL, the significant parameters were as follows:

- ❒ the aeroplane had captured the Localizer
- ❒ the aeroplane had not yet captured the Glide Slope (captured at 400 ft AGL)
- ❒ the CAS was 172 kt (Vapp + 34 kt) and decreasing.
- ❒ the tailwind component recorded in the FDR was 9 kt.

At a radio altitude of about 150 ft, the N1 were 28% and began to rise.

At radio altitude of 50 ft the aeroplane passed over threshold 06. The CAS was 146 kt and the attitude of the aeroplane stabilized at a nose-up of approximately 5°. A few seconds later, the N1 speed reached 66%.

On passing a radio altitude of approximately 30 ft, the thrust levers were placed in the "IDLE" position and the A/THR disengaged. The N1 decreased speed and reached about 29% in 6 seconds.

The aeroplane touched the runway about 1,500 meters from runway threshold 06. The CAS was 129 kt.

The aeroplane overran the runway at approximately 48 kt and came to rest a hundred metres after the threshold. The passengers and crew members were unharmed and the aeroplane was not damaged.

2 - Unstable approach and runway excursion

■ **Serious incident on 7 September 2010 in Lyon (69) to the Boeing 737-400 registered TC-TLE operated by Tailwind Airlines.**[1]

[1 http://www.bea.aero/docspa/2010/tc-e100907/pdf/tc-e100907.en.pdf]

On arrival at Lyon Saint-Exupéry, the crew made a non-precision localizer/DME approach to runway 36R. The cloud ceiling was close to the MDA. The final descent began before the final approach point published for the altitude of the aircraft and remained below the theoretical profile for the approach. An MSAW warning was generated in the control tower. The controller ordered a go-around. The crew made a go-around. The minimum height provided by the radio altimeter was 250 ft at 1.4 NM from the runway threshold.

The investigation showed that the incident was due to:

❒ misidentification of the stepdown fix by the crew;

❒ inadequate control of the final glide path by the crew.

The publication of two FAPs, one of which is to be used on instruction from the controller, including the fact that its use was extended to the non-precision approach, and the absence of information to the crew concerning the exact identification of the final approach procedure to use, constituted contributory factors.

The BEA sent the DGAC four safety recommendations with regard to:

❒ Communication to crews of the complete identification of the final approach procedure;
❒ Identification and removal of any publications of non-precision approaches with several FAFs
❒ Clarification of reference materials used by procedure designers;
❒ Radar vectoring practices

"The investigation showed that the premature descent initiated by the crew was due to:

❒ *the publication of two final approach points (FAP) in the approach chart used by the crew:*

  ■ *one at 4,000 ft, represented in the on-board navigation databases;*
  ■ *the other, at 3,000 ft, usable on instruction from the controller and absent from the databases;*

❒ *the systematic use of radar vectoring for precision and non-precision approaches, for aircraft from GOMET and for others, to the intermediate stepdown fix at 3,000 ft.*

In addition, the SNA procedures did not specify that crews should be informed, prior to the approach, of the exact identification of the final approach procedure currently in effect.

Consequently, the BEA recommended that:

❒ *DGAC ensure that crews are informed with sufficient notice of the full identification of the final approach procedure to be followed; [FRAN-2013-001]. .*

❒ *DGAC identify any non-precision approach charts with several final approach fixes (FAF) and removes this type of publication; [FRAN-2013-002] ;*

❒ *DGAC ensure that radar vectoring practices include the need to guide crews to a published altitude for the start of the final approach. [FRAN-2013-004]."*

Recommendation FRAN-2013-001:

DGAC reply dated 4 July 2013:

"The DSNA will remind SNA operations department heads so that controllers communicate as soon as possible to crews on arrival the complete identification of the arrival procedure in use for landing."

BEA's Opinion on 9 October 2013:

"The BEA considers the response of the DGAC to be partially adequate.

In fact the recommendation relates to the complete identification of the final approach, and not that of the arrival procedure. The latter term refers to the path required to reach the initial approach point from the en-route phase."

Additional reply from the DGAC on 12 January 2015:

The use of the phrase "arrival procedure" could possibly lead to confusion, and it is indeed the complete identification of the procedure that was intended in the DGAC's response. The initial consultations undertaken following this response already revealed, for some approaches, ways of improving identification of the approach procedure. The initial reply is thus modified as follows:

"The DSNA asked SNA operations department heads to check the procedures used to inform crews, within an adequate time frame, of the complete identification of the final approach procedure in use; particular attention is to be paid to phases of changes in the runway in use. Action will be taken to raise controllers' awareness and, where required, to revise working methods."

Recommendation FRAN-2013-002:

Response from the DGAC dated 4 July 2013:

DGAC reply dated 4 July 2013:

"Initially the SNA identify any non-precision approach procedures that include several FAF and will then proceed to reissue these publications."

Recommendation FRAN-2013-004:

DGAC reply dated 4 July 2013:

«Implementation of the actions announced in the previous recommendations will lead controllers to use an unambiguous interception altitude of the final approach: each non-precision approach procedure with several FAF will be replaced by several procedures with a single FAF, indexing each one of them (Z, Y, W, etc.). Each identified procedure will therefore no longer include any more than a single stepdown before initiating the final descent. This altitude used by controllers when radar vectoring will be the same as that in the procedure followed by the crews and integrated into the FMS if any."

BEA's Opinion on 9 October 2013:

"The BEA considers the DGAC's reply to be inadequate.

While the need expressed by this recommendation is theoretically covered by the responses to previous recommendations for non-precision approaches, the ability to use several FAP for precision approaches remains. This was also the case for the incident in question: the Lyon controllers guided the aircraft to an FAF not published in a non-precision approach (ILS without glide path) in the same way that they guided the aeroplanes to one of the two FAP published for the precision approach (full ILS). This extension of the guide practices for precision approaches to non-precision approaches may exist in other SNAs. The need to adapt radar guidance to the correctly identified final approach, taking into account the altitude of the FAF or FAP published, must therefore include adequate information for the air traffic controllers."

Additional reply from the DGAC on 12 January 2015:

As the mixed ILS and LOC procedure pages (glide out of service) appear on the same chart, the DSNA will examine the ILS/LOC procedure pages in order to maintain a single FAF useable at the nominal altitude of the published procedure, with the exception of Strasbourg where a second FAF that is only useable in the context of the API will continue to be published with a « restricted use » note. Actions to raise controllers' awareness and, where required, to revise working methods will complete the disposition. The initial reply is thus modified as follows:

"Implementation of the actions announced in the previous recommendations will lead controllers to use an unambiguous interception altitude of the final approach: each non-precision approach procedure with several FAF will be replaced by several procedures with a single FAF, indexing each one of them (Z, Y, W, etc.). Each identified procedure will therefore no longer include any more than a single stepdown before initiating the final descent. This altitude used by controllers when radar vectoring will be identical to that in the procedure followed by the crews and integrated into the FMS if any.

For ILS approaches, operational needs require maintaining several FAPs at some aerodromes. Glide failure situations being rare, the existence of a single FAF, as proposed in the recommendation, is considered as operationally acceptable. France having chosen to jointly publish ILS and LOC procedures on the same page, the DSNA will start to re-examine ILS/LOC pages so that, even when several FAPs exist, only one single FAF useable at the nominal altitude in the procedure is published. An exception is made for Strasbourg where a second FAF only useable in the context of the API will continue to be published with a corresponding "restricted use "note.

Actions to raise controllers' awareness and, where required, to revise working methods will complete the disposition. SNA operations department heads will ensure that controllers radar vectoring aeroplanes towards a non-precision approach, notwithstanding the different altitudes that can be used for radar vectoring for precision approaches, will only use the single interception altitude published in the procedure page. "

"Accident on 16 October 2012 at Lorient Lann Bihoué aerodrome (France) to the Bombardier CRJ-700 registered F-GRZE operated by Brit Air[2]

The crew was cleared for an ILS RWY 25 approach. During the descent, the controller informed them of a wind from 160° of 17 kt with gusts of 26 kt and a lasting, severe squall. Visibility was reduced to between 2000 and 3000 meters and the runway was wet with puddles of water. He signalled that the previous aircraft had encountered difficulties during landing due to the phenomenon of "aquaplaning".

The crew made the approach in the flaps 30° configuration. The ILS 25 approach was stable at 1000 ft. The autopilot was disengaged at around 500 feet. The main landing gear of the aeroplane touched the runway about 1100 m from its end.

The aeroplane overran the runway, its left wing striking the antennas of the LOC, before coming to rest in a grass field about 200 m from threshold 07.

The investigation showed that the accident was caused by the crew's decision to continue the landing when they did not know the degree to which the runway conditions were contaminated and were unaware of the remaining length of runway available.

Continuing the landing can be explained by:

Insufficient situational awareness due to:

- ❐ The level of crew performance, additionally degraded by fatigue and routine;
- ❐ Unfamiliarity with safety margins and inadequate TEM training;
- ❐ An approach to safety by the operator that did not encourage crews to question their plan of action.

The following factors contributed to the event:

- ❐ The crew's underestimation of the meteorological conditions;
- ❐ Operational instructions that were sometimes unclear, thereby undermining teamwork;
- ❐ The characteristics of runway 25, which were not documented in the Brit Air Operations Manual;
- ❐ The organisation of aerodrome operations preventing deviations identified concerning runway 25 from being corrected in a timely manner,
- ❐ Lack of a common phraseology that prevented both crews and the controllers from having a shared understanding of the real condition of the runway;
- ❐ The organisation of training and checks that prevented the operator from knowing and improving its safety performance;
- ❐ Inadequate management by the airline of fatigue risk.

[2] http://www.bea.aero/docspa/2012/f-ze121016.en/pdf/f-ze121016.en.pdf

The BEA sent five safety recommendations, some of which related to the following points:

- Threat and error management.
- Fatigue risk management.
- DGAC check that operators of aerodromes and of aircraft holding an AOC evaluate the recommendations of the European Action Plan (EAPPRE) through their own SMS.

Preliminary DGAC reply on 3 April 2014:

"The European action plan for the prevention of runway excursions, established under the aegis of Eurocontrol, compiles recommendations to prevent and reduce this risk, by addressing all the operators concerned as well as the regulators and monitoring authorities. The DSAC and the DSNA were involved in its drafting.

The DGAC supports this type of initiative, which identifies good practices in the most comprehensive way possible and allows each stakeholder the flexibility required to assess and implement those that are most relevant to their own risks.

The DGAC has prioritized the recommendations that concerned the Authorities in the safety review of the State Safety Programme and forwarded the EAPPRE plan to the operators it monitors, focusing on specific recommendations for each area.

The change in DSAC monitoring procedures mentioned in response to previous recommendations will consider the recommendations of the EAPPRE plan as identified good practices to be evaluated by operators in their SMS."

3 - Dual input

The list below details some similar dual input events that have occurred.

- **Serious incident on 28 May 2006 in Zaragoza (Spain), Airbus A320[3]**

Summary

"The aircraft, an Airbus A320, en route from Barcelona to Santiago de Compostela, passed through an area of strong turbulence while at FL325 that caused the aircraft to descend sharply while banking significantly to either side. As a consequence of the aircraft's sudden motion, four passengers and three flight attendants were slightly injured. The crew managed to stabilize the aircraft at FL310 and continue on to its destination.

The investigation revealed that this incident resulted from the wake turbulence of a preceding Airbus A340-300 that was on the same airway, 10.13 NM ahead of the Vueling Airbus A320-200 and on the same heading. It was also flying to point "Kuman" at FL330.

The crew's actions were not in compliance with the procedures for flying the aircraft and served to exacerbate the effects of the external disturbance".

[3] http://www.fomento.gob.es/NR/rdonrdonlyres/21313F00.98A2_4F14_A582_4D0A8FA188/2006.029.IN.ENG.pdf

Excerpts from the report:

"Both pilots providing simultaneous inputs to their sidesticks starting practically at the same time and continuing for 21 seconds, from 12:38:37 to 12:38:58. During the 21 seconds of dual inputs to the sidesticks, aural "dual inputs" messages sounded in the cockpit. The captain states that he did not hear the messages. The co-pilot did hear them, although he immediately released control to the captain when he did so. The co-pilot did not notice the luminous signs that should have turned on the instant when the captain pressed his override button and that indicate which sidestick has priority''.

"The maximum sidestick inputs to either side induced the aircraft to suffer banking movements. As for the pitch commands, the fact that the crew's inputs were largely in opposing directions meant that the resulting movement was smooth, and thus had little effect on the pitch of the aircraft''.

Safety Recommendations

"When an abnormal or emergency situation occurs during a flight, the crew must take immediate actions to neutralize it by following the proper procedures. In order to execute these actions quickly and accurately, the crew must carry them out "automatically". This is achieved through instruction and training.

The investigation into this incident revealed that the crew did not properly adhere to the procedures required by the situation. As a result, and in an effort to improve the safety of operations, the following safety recommendation is issued.

REC 03/11 It is recommended that the aircraft operator, Vueling, review and enhance its Airbus A-320 crew training programs so as to improve the crews' knowledge and application of aircraft procedures, in particular as these apply to dual sidestick inputs, flying in severe turbulence and rudder use."

The CIAIAC has provided the BEA with the responses to the recommendations it made:

"1. Since 2011, all new pilots in the company are trained and verified in Flight in Turbulence & Jet Upset Recovery in their Operator Conversion Training.

2. All active pilots in the company as part of its Recurrent training have completed:

Ground training:

- ❒ *2011 - June-July: e-learning in Flight Turbulence & Jet Upset Recovery (training and testing);*
- ❒ *2012 - May-June: e-learning Flight in Turbulence & Jet Upset Recovery (training and testing);*
- ❒ *2015 - January: Next e -learning in Flight Turbulence & Jet Upset Recovery planned (training and testing).*

Simulator training:

- *Every 6 months as part of the simulator training: Briefing reinforcing and emphasizing to Task shearing and Workload management. Since 2006, training and simulator checks have been standardized through a variety of methods/actions.*

Every 6 months new syllabus for training and testing simulator sessions are developed and these are followed strictly applying the following policy:

- *PF and PNF and other divisions of tasks the flight crew;*
- *Positive Transfer of aircraft control;*
- *Philosophy consistent checklist;*
- *Emphasis on prioritizing tasks (''fly, navigate, communicate'');*
- *Proper use of all levels of automation flight.*

In addition to the frequency of 1 time every 3 years, in manoeuvres practiced in the simulator, train and verify the procedures Jet Upset Recovery (high altitude stall, unreliable speed,). The last time was from the first half of November 2012 to June 2013.

3. The Vueling SMS nor FDM has detected any similar event from the 2006 incident."

■ Accident on 14 February 2012 at London Luton, Airbus A319[4]

Summary

"The flight crew carried out a manually flown ILS approach to Runway 26 at London Luton Airport. Shortly before touchdown, both pilots sensed the aircraft was sinking and a go-around was initiated. The aircraft made firm contact with the runway before starting to climb. The normal acceleration recorded at touchdown was 2.99g, which is classified as a Severe Hard Landing. The subsequent landing was uneventful. All three landing gear legs exceeded their maximum certified loads and were replaced; there was no other damage to the aircraft".

Conclusion

"Both pilots responded to an increased rate of descent approaching touchdown and each initiated a TOGA 10 go-around. Their initial sidestick inputs were in opposition and, without the use of the takeover sidestick pushbutton, the net effect was a pitch-down control input. If the commander had operated the sidestick takeover pushbutton, his nose-up pitch input would not have been counteracted by the nose-down input of the Captain under training. In the event, his control input reduced the effect of the nose-down input made by the Captain under training".

■ Dual input phenomenon mentioned in the ASR database of the DGAC

The DGAC database indicates that 145 mandatory incident reports (ASR) by the crews of French operators involving the triggering of *''DUAL INPUT''* alarms have been recorded.

[4] http://www.aaib.gov.uk/publications/bulletins/january_2013/airbus_a319_111__g_ezfv.cfm

Cases of dual input mainly follow the scenarios listed below according to their frequency of occurrence:

- during the final approach phase or the flare when the co-pilot is PF. In many cases the co-pilot is on line-oriented flight training;
- during a missed approach;
- during turbulence;
- due to involuntary input of one of the crew members on his sidestick.

4 - Wind information supplied to crews

In 2013 the BEA published a study[5] on the loss of control during the approach phase of a missed approach. One aspect mentioned in this study deals with the wind information provided to crews. Several relevant extracts follow:

[5] http://www.bea.aero/etudes/parg/parg.php

"Airbus A 320

The wind is calculated by each of the 3 ADIRU based on the difference between the ground speed vector (calculated by the inertial unit) and the airspeed vector (calculated by the air data computer, assuming zero side-slip).

The wind speed and direction is indicated on both pilots' navigation displays (ND), in the top left corner, by an arrow accompanied by numerical values in the form DDD/SS (where DDD is the wind direction in degrees magnetic and SS the speed in knots).[...]

[...] When operating normally, the wind indicated by the left ND is the wind calculated by ADIRU 1 and the wind indicated in the right ND is calculated by ADIRU 2.

Inaccuracies in calculating the ground speed have a significant impact on the accuracy of the calculated wind: assuming zero error in the measurement of the airspeed, the accuracy is ± 8 to 9 kt in terms of speed and ± 10° in direction, so long as the actual speed is at least 50 kt. However, there is no indication of the degree accuracy in the flight ops manual or FCOM. On the A 380 the wind speed and direction can be determined more accurately when GPS information is available: approximately a few degrees in direction and less than 5 kt in terms of speed.[...]

Operational utilisation of the displayed wind

- *According to manufacturers*

The Airbus and Boeing operating procedures do not envisage that pilots will consider the displayed wind values when making decisions, particularly for landing. The wind values, including gusts) which must be used by the pilots to take the decision as to whether or not to land is the wind information provided by the control tower, which is averaged over a period of two minutes. Ultimately, it is the Captain who makes the decision.

However, Boeing does state that the wind information determined by the FMC is accurate.

- *According to certain airlines*

All the airlines which participated in the study indicated that their pilots use the wind information presented in the cockpit when making a decision regarding a go around. Their training teaches them to consider this information qualitatively. The pilots indicated that they usually find this information to be reliable. In contrast, they report that the accuracy of the wind information provided by ATC can vary significantly from one continent to another.[…]

Wind displayed to crews

Wind information is vital for crews for the conduct of the flight, especially for the decision to perform a go-around, particularly where there is a tailwind.

Two sources of information are used by crews:

- *ATC wind provided by the ATC service;*
- *The aeroplane wind calculated by the ADIRU alone or combined with GPS information.*

Statutorily, only ATC wind is valid. However, four issues were highlighted in the study:

- *ATC wind is not instantaneous wind but averaged wind;*
- *The degree of confidence of the crew in ATC wind differs from one continent to another;*
- *In case of tailwind, the ground wind is usually significantly lower than the wind at altitude encountered during the approach. This can create a conflict for any go-around decision;*
- *The wind presented to crews and displayed on the ND or the associated FMS page is often used by the crew to make the decision.*

However, crews know neither the accuracy of the wind presented, nor its source. For example, on A330, aeroplane wind is calculated only from ADIRU, and is not guaranteed below 50 kt. Conversely, aeroplane wind including GPS information is very accurate (on A380 or B 777 for example).

Whatever the source, crews tend to trust aeroplane wind to the detriment of ATC wind. Unfortunately, many public transport aircraft do not use the GPS source to provide accurate wind to crews. This information is not documented in FCOM's.

The problem of aeroplane wind is outside the scope of this study. Wind is a key parameter taken into account in piloting and the strategies adopted. Without compromising the regulatory aspect of ATC wind, the BEA believes that information on aeroplane wind must be as accurate as possible and that the crew must also know the precision of the information presented."

5 – Previous event involving Hermes Airlines: Serious incident on 11 April 2012, at Lyon St Exupéry, Airbus A 320[6]

History of the Flight

The crew took off from Ajaccio (2A) bound for Lyons Saint-Exupéry. The flight was chartered by Air Méditerranée and performed by Hermes Airlines. The Captain was the instructor (PNF) and was sitting in the right-hand-side seat. The student /pilot in command was PF in the left seat.

When the aeroplane was cleared for an arrival at PINED 1, the approach controller announced low wind and suggested radar vectoring for an ILS approach to runway 36L, which was accepted by the crew. It was dark and instrument meteorological conditions (IMC) applied. During this arrival, the crew noted inconsistencies in the DME distances displayed on the ND: the PNF called out 99 NM and the PF 40 NM[7].

About one minute after the beginning of radar vectoring, the controller, who realized that the aeroplane was high on the glide, asked *''...forty nautical [...] is that OK for you, four zero?''*. The crew, while programming the FMGS for an ILS approach to runway 36L, answered *''Actually we... we'll need to make a thirty six''*. The controller, who interpreted the response of the crew as a confirmation of a landing on runway 36, did not understand that the crew wanted to make a late turn onto heading 360. He provided a heading of 315° to the localiser axis for runway 36L. As the Ajaccio AC ILS had not been deselected, the FMGS did not automatically select the ILS for runway 36L at Lyons.

The controller specified a heading of 320° so that the aeroplane would intercept the localiser axis for runway 36L. As the frequency of the ILS for runway 36L was not active, the aeroplane crossed the axis without intercepting it. The crew then displayed the ILS for runway 36L. While the Capture mode engaged for a selected altitude of 3,000 ft at a speed of 240 kt, the crew decided to select an altitude of 400 ft on the control panel (FCU)[8], which caused a mode reversion of the autopilot from ALT* to VS 1200 ft/min, the current vertical speed of the aeroplane at that time. They set the approach mode and engaged the AP 2 autopilot. The crew turned left to intercept the localiser axis, and then the aeroplane descended below the radar minimum safe altitude of 3,000 ft.

The controller asked the crew whether they had the correct ILS frequency, which they confirmed.

While the aeroplane was in clean configuration at a speed of 230 kt and an altitude of 2,460 ft (height of 950 ft), the GPWS *''TERRAIN TERRAIN PULL UP PULL UP''* alarm sounded. The instructor took over sole control of the inputs, pushed the thrust levers to the TOGA detent and selected a maximum pitch attitude of 9.5°, without calling out that he was taking over control. Autopilots AP 1 and 2 disengaged. The airplane being in clean configuration, the SRS mode did not engage and did not give the crew the expected nose-up instructions corresponding to the avoidance manoeuvre in progress. The vertical and horizontal guidance modes VS -1200 and HDG were still activated[9]. When the pitch attitude of the aeroplane reached 9°, the instructor applied nose-down inputs.

[6] http://www.bea.aero/docspa/2012/sx-v120411.en/pdf/sx-v120411.en.pdf

[7] When preparing the radio navigation equipment for takeoff, the PNF manually entered the frequency of the Ajaccio AC ILS in the NAV RADIO page of the multi-function control and display unit (MCDU) to prepare for a possible quick return flight (QRF). This frequency remained selected throughout the flight to the approach. The DME received at the time was that of Marseille (ML), with the same frequency, at about one hundred nautical miles.

[8] Altitude lower than the runway threshold elevation.

[9] The common guidance mode GA can be activated only if the flap control lever is placed at least in detent 1.

In response to an MSAW warning that triggered a few seconds later, the controller called out: *"you maintain 2,500 ft, you are too low, you are below the glide"* and requested to be called back once the aeroplane was established on the glide path. The aeroplane was at 2,420 ft in a climb. The instructor continued applying nose-down inputs while converging on the localiser axis and simultaneously acknowledged the message. He probably tried to stabilize the aeroplane at an altitude of 2,500 ft. The nose-down inputs were maintained for about twenty seconds. The thrust lever was positioned in the CLIMB detent. At this moment the crew was waiting for the controller's instruction to climb. The calibrated airspeed increased sharply and the aeroplane started to descend again to an altitude of 2,150 ft. At 320 kt and a height of 900 ft, the thrust levers were positioned in the IDLE detent. At this time, a second MSAW alert was triggered. The controller intervened again: *"...check your altitude immediately, you are too low"*.

A few seconds later the student in the left seat applied nose-up inputs on the sidestick for about ten seconds while the instructor was applying nose-down inputs. The aural and visual DUAL INPUT warning triggered for a minute. During this dual input phase, the PNF continued to communicate with ATC and requested radar vectoring to abort the approach. Communications, probably referring to taking over control, were confused PF: *"[leave it, leave it]"*, PNF *"[you take it]"*, PF *"[I have the controls, 5,000 ft, leave it, 5,000...;]"*. The controller asked the crew to climb to 5,000 ft. As the instructor applied nose-up inputs the student applied nose-down inputs. During this period the aeroplane climbed. The crew placed the thrust levers in the CLIMB detent.

The DUAL INPUT warning stopped. The instructor in the right seat then took over the controls. The AP2 autopilot was connected.

The aeroplane parameters stabilized. A second approach was performed and the crew landed on runway 36L.

The investigation highlighted the following points:

Flight Management

The failure to carry out checks of the RADIO NAV page on the FMGS, which are normally carried out when passing FL100 in a climb and during approach preparation, did not allow the crew to detect that the FMGS had not automatically selected the ILS for runway 36L at Lyons Saint-Exupéry and that the Ajaccio AC ILS was still active on arrival.

When trying to capture the localiser axis, the crew used a great deal of their resources managing the display of the ILS frequency to the detriment of their monitoring of the aeroplane's vertical flight path and its configuration. The selection on the FCU of a target altitude of 400 ft, while the altitude of Lyons airport is 880 ft, indicates a loss of situational awareness and introduced a risk of dangerous ground proximity.

During the GPWS PULL UP emergency procedure, the failure to maintain the control column to the rear stop meant that the aeroplane could not reach the best climb angle in a night-time environment with poor weather conditions in which the crew had few or no external visual references. The 9.5° attitude displayed did not correspond to the missed approach attitude (15°) or to that of the GPWS procedure (control column to the rear stop).

At the time of the first MSAW warning, the controller was not aware that the crew was reacting to the GPWS warnings. The GPWS PULL UP emergency procedure does not provide for an information message for the controller. The changes in the flight path performed by the crew without informing the controller did not help him understand the intentions of the crew.

The dual input phase occurred after the crew's decision to abort the approach, after the second MSAW warning. A period of confusion was observed during a flight phase that was inherently dynamic and required precise flight control, especially at high speed.

The occurrence of dual inputs, which is a reflex action, may have been encouraged by a combination of several factors:

- the instructor did not formalize his taking over the controls (no *"I have control"* callout); even though the dual input phase did not immediately follow the control take-over the lack of callout did disrupt the role sharing;
- the crew had extensive experience of aeroplanes with dual flight controls and although the instructor was dual-qualified to fly Boeing 737 and Airbus A320, whose interface with the flight controls is very different.

Requirements to serve as a Captain

The student pilot-in-command had recently been hired by the airline to serve as a Captain on Airbus A320. He was undertaking line-oriented flight training and had a total of 25 flying hours on Airbus A320. He had almost no experience as a Captain.

Both crew members had extensive flying experience on Boeing 737, whose operating logic and presentation of information are different from those of the Airbus A320.

Causes

The incident was due to:

- initially, continuing the descent during the ILS approach to runway 36L while the airplane was not configured or stabilized on the localiser axis, resulting in dangerous ground proximity;
- after the first GPWS warning the inadequate application of the GPWS emergency procedure, in particular in terms of setting the attitude.

- The following factors contributed to the incident:

- inadequate application of normal procedures, task-sharing and emergency procedures, resulting in highly degraded crew situational awareness (position in space, configuration);
- the limited experience on type of both crew members;
- the operator's desire to quickly train a pilot with low experience on type as a Captain;
- variable criteria to serve as a Captain;
- the use of inappropriate MSAW phraseology by the controller.

Note: The Greek Air Accident Investigation & Aviation Safety Board (AAISB), made the following comment: "in the contributing factors mentioned in para. 3 .3 "Causes", the BEA could add "the crew's lack of CRM".

The BEA shares this aspect of the analysis but considers that the lack of CRM resulted from inadequate application of the standard, task-sharing and emergency procedures. These elements are already mentioned in the contributing factors. No activation of the sidestick priority button was recorded during the flight. During the dual input phase, the inputs made by the two pilots were often in opposite directions. The altitude of the aeroplane evolved from 2,200 ft to 4,460 ft and then 4,130 ft, and the aeroplane attitude varied between -1° and 15°.

Appendix 10

Airbus information letter and EASA SIB

To: A320 Operators Fleet Managers, Flight Safety Officers, Flight Operations Managers

FMGC – Upgrading your fleet from FMS 1 (B398/B546 standards) to FMS 2

Dear Customers,

The intent of this letter is to inform you about an Airbus initiative aiming at facilitating your FMS1 to FMS 2 upgrade at discounted price in order to take benefit of all the related safety and economics enhancements.

As per our Airbus records, your A320 fleet, or part of your A320 fleet, is still fitted with the first generation of Flight Management and Guidance System commonly known as FMS Legacy standard B398/B546.

This Legacy standard has been superseded by FMS2 standard several years ago. This evolution provides a wide range of improvements, especially in operational domains, including some which may have direct safety enhancement benefits as follows:

- ***Take-Off Securing function*** to alert flight crew of incorrect take off parameters, thus avoiding take-off with wrong take off parameters (e.g wrong speed) in case of erroneous pilot data entry.
- ***Automatic engagement of NAV mode*** (or NAV mode engagement maintained) ***during Go Around*** to reduce crew workload and limit the potential deviation from the required flight path when performing Go Around.
- ***Triple click aural alert activation and Flight Mode Annunciator (FMA) enhancement*** displayed on PFD to increase crew awareness about any AP/FD/ATHR modes change not resulting from a crew action, approach capability degradation or vertical speed (V/S) or a flight path (FPA) target

not held by the AFS. Thus, potential lack of crew awareness of AFS modes is avoided in case of inappropriate FMA check.

- ***Automatic FD bars engagement at Go Around* initiation** to reduce crew workload and limit potential large speed excursion.
- ***Cancellation of thrust increase commanded by ATHR***, occurring ***below 150ft*** when aircraft is in excess of speed (beyond VAPP+10kt), thus avoiding a potential long flare resulting in an increased landing distance, in case of inappropriate speed monitoring by the pilot during the landing phase.

In addition, FMS2 standard provides further operational enhancements, e.g. it is a prerequisite for the future functions (SESAR, NEXTGEN, ROPS, ADS-B), it is equipped with an increased Nav Data Base capacity and has improved maintenance cost.

For all the above reasons, Airbus recommends that you upgrade your FMS1 standard to the second generation FMS2 standard.

To support you in this project, Airbus has built optional packages enabling AP/FD TCAS deployment across the A320 Family Fleet in cooperation with main FMGS equipment suppliers, Thales and Honeywell.

FMS1 standard upgrade to FMS2 being part of these AP/FD TCAS packages can take benefit of significantly discounted prices (order of magnitude is beyond **30% discount** from the catalogue price).

This package is proposed through RFC/RMO process, managed by Airbus Upgrade Services. This specific retrofit offer will be valid up to end 2014.

We therefore recommend that you contact your Key Account Manager or your Customer Support Director who will be ready to support you to launch a fleet study and evaluate the opportunity for your fleet upgrade.

Best regards,

EASA Safety Information Bulletin

SIB No.: **2013-19**
Issued: **14 November 2013**

Subject:	**Non-stabilized Approach followed by Runway Overrun at Lyon "Saint Exupéry" Airport**
Ref. Publications:	Airbus Service Information Letter (SIL) 22-039 Revision 04, dated 04 October 2011. Airbus Service Bulletin (SB) A320-22-1089 Revision 10, dated 05 November 2004. Airbus SB A320-22-1090 Revision 11, dated 20 July 2004. Airbus SB A320-22-1103 Revision 04, dated 13 March 2004. Airbus SB A320-22-1116 Revision 04, dated 29 March 2004. Airbus Letter to Fleet Managers, Flight Safety Officers and Flight Operations Managers, Ref. ME 1333744, dated 31 July 2013.
Applicability:	Airbus A319 aeroplanes with CFM56 or IAE V2500 engines, A320 aeroplanes with CFM56 engines, and A321 aeroplanes with CFM56 or IAE V2500 engines.
Description:	Following an instrument landing system (ILS) approach, during night, in rainy condition, an A321 aeroplane experienced a runway overrun. Investigation revealed that the approach was not stabilized with an overspeed of 19 knots (kts) over the runway threshold, followed by a long flare (18 seconds) with touchdown far beyond the touchdown zone. The aeroplane exited the runway at 75 kts and came to rest around 300 meters beyond the end of the runway. During the final approach, at 150 feet Radio Altimeter (RA) altitude, the corrected airspeed of the aeroplane was 165 kts (24 kts overspeed). Auto thrust (ATHR) in Speed/Mach mode commanded an undue N1 increase up to 70%. At this stage of the investigations, it is identified that the main contributor to this runway overrun was a non-stabilized approach not followed by a go-around. Auto Thrust misbehaviour in case of large overspeed led to an unexpected thrust increase, which is considered as a contributor to the long flare.

This is information only. Recommendations are not mandatory.

This Auto Thrust characteristic, reported as "Spurious thrust increase during approach", was initially found in 1996 and a recommended fix was developed and introduced in Flight Guidance (FG) Second Generation (2G) standard (std) "C8/I8" in 2001.

The number of affected aeroplanes is estimated at 385 when Legacy Flight Management Guidance Computer (FMGC) P/N B398xxxxxx or P/N B546xxxxxx are fitted. Some operators have chosen not to implement the optional upgrade that improves the Auto Thrust behaviour. The FG 2G std "C8/I8" is available through Airbus (optional) SB A320-22-1089, SB A320-22-1090, SB A320-22-1103 and SB A320-22-1116.

Airbus has recently put in place an incentive programme (see Airbus Letter Ref. ME 1333744 dated 31 July 2013) to replace the FMGC Legacy by the FMGC equipped with FMS2 and FG, providing ROW/ROPS (Runway Overrun Warning/ Runway Overrun Protection System) and AP/TCAS (Autopilot/Traffic Collision Avoidance System) capabilities. Information is also available through Airbus SIL 22-039.

It has been determined that the ROPS function, which is also part of the optional modification specified above, would have triggered a «RUNWAY TOO SHORT» aural alert before touchdown.

At this time, the safety concern described in this SIB is not considered to be an unsafe condition that would warrant Airworthiness Directive (AD) action under EU 748/2012, Part 21.A.3B.

Recommendation(s): Flight crews should follow the Aircraft Flight Manual procedures during normal and abnormal operation which take into account conditions which could impact landings.

Flight crews are reminded that a go-around decision is the safer solution to a non-stabilized approach, and that landing could be more difficult with overspeed, contaminated runway, and under tail wind conditions.

Operators are recommended to upgrade the Legacy FMGC FG 2G B398/B546, known as FMS1 standard, to the standard FMGC FG 2G C8/I8, or a later improved FMGC standard, known as FMS2 standard that avoids the identified Auto Thrust misbehaviour.

Contact(s): For further information contact the Safety Information Section, Executive Directorate, EASA. E-mail: ADs@easa.europa.eu.

For further technical information or advice, or to obtain copies of the referenced service publications, contact:
Airbus – Airworthiness Office – EIAS,
Fax +33 5 61 93 44 51,
E-mail: account.airworth-eas@airbus.com.

This is information only. Recommendations are not mandatory.

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