

**Approach with strong turbulent lateral wind,
destabilization below 200 ft, late flare and hard landing**

⁽¹⁾Except where otherwise specified, times in this report are UTC.

Aircraft	Airbus A319-111 registered F-GRHS
Date and time	13 December 2011 at about 07 h 47 ⁽¹⁾
Operator	Air France
Place	Paris Charles-de-Gaulle Airport (95)
Type of flight	Scheduled public transport of passengers Flight from Hamburg airport to Paris Charles-de-Gaulle Airport
Persons on board	Captain (PF), copilot (PM), 3 cabin crew and 114 passengers
Consequences and damage	Main landing gear damaged

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.

1 – HISTORY OF FLIGHT

Note: the history of the flight was determined based on pilot testimony, FDR parameters and communications with the controllers. The CVR data could not be read out due to failure in the recorder that altered the intelligibility of the aural recordings.

The crew of the Airbus A319 took off from Hamburg Fuhlsbüttel (Germany) at 06 h 26 to undertake flight AF2511 to Paris Charles-de-Gaulle. The captain was pilot flying (PF).

Cruise took place at FL380 with autopilot 1 engaged.

At 7 h 09min the crew started the descent and prepared for an ILS approach to runway 27R. The approach was performed in the daytime under IMC conditions. The autopilot (AP), flight directors (FD) and autothrust (A/THR) were engaged. The speed was in selected mode. The crew chose configuration 3 for the landing due to the turbulent wind forecast (220°/29 kt, gusts to 37 kt).

At 7 h 37 min 43, established on the runway 27R localiser axis, the crew selected Conf 1, then 1 min 30 later, Conf 2. The indicated airspeed was 219 kt, dropping towards the selected target speed of 210 kt.

At 7 h 40 min 40 at a distance of about 14 NM from the threshold of 27 R, the aeroplane was established on the runway 27R glide slope.

A few minutes after descending through 3,500 ft QNH, turbulent wind conditions began and made the aircraft roll. The amplitude of this roll increased progressively, reaching 5° left and 4° right at 7 h 42 min 30. The angle of attack varied between about 0.5° and 2.5° pitch up. The aircraft automated systems moved the ailerons and the elevator alternately in order to counter these oscillations. The movement amplitude of the flight controls was relatively low.

At 7 h 42 min 43, the aeroplane was at 3,500 ft QNH, heading 255° (deviation of 11° right). The PF disengaged the A/THR then the AP and continued the approach manually. Five seconds later the crew announced they were at 9 NM on final for runway 27R. The controller cleared them to land and informed them of a wind from 220° at 25 kt with gusts to 38 kt. After AP disengagement, the recorded position of the PF's sidestick showed significant inputs by the PF in roll and pitch and inputs on the thrust until wheel touchdown (see graphs below).

The position of the PF's sidestick varied between the two maximum deflection positions to the left and to the right (-20° à +20°). The aeroplane remained on the localiser axis whilst the slope oscillated between 6° left and 6.5° right. Over the same period the position of the PF's sidestick varied between 14° pitch up and 8° pitch down (maximum deflection -16° to +16°). The aeroplane's angle of attack varied between 1° pitch down and 6.5° pitch up. The aeroplane oscillated around the glide path by 3° with a maximum deviation of about 80 ft below and about 110 ft above, respectively at 6.8 NM and 4.6 NM from the threshold of runway 27R. The drift angle of the aeroplane varied between 10° and 15° with the aeroplane's nose to the left of the localiser axis.

At 7 h 44 min 25, the crew extended the landing gear then selected Conf 3 before descending through 2,000 ft QNH. They then changed the speed to managed mode⁽²⁾.

At 7 h 45 min 41, when descending through 1,000 ft radio altimeter the aeroplane's flight path was stabilised. The indicated airspeed was 154 kt (Vapp target⁽³⁾=149 kt). The vertical speed was about -750 ft/min. The aircraft heading was 252° and the drift was 15° to the right. The wind was approximately from 210° for 45 kt⁽⁴⁾ (lateral component of 23 kt with gusts to 41 kt).

At 7 h 45 min 47, the indicated airspeed was 165 kt, 15 kt above the Vapp target (150 kt).

At 7 h 46 min 16, when descending through 500 ft radio altimeter the aeroplane was practically on the glide path (-0.2 point). Indicated airspeed was 148 kt (Vapp target=141 kt). The vertical speed was about -700 ft/min. The wind was approximately from 205° at 35 kt.

At 7 h 46 min 43, when descending through the minima at 200 ft radio altimeter, the aeroplane was slightly below the glide path (-0.3 point) with an indicated airspeed of 141 kt (Vapp target=138 kt). The vertical speed was about -600 ft/min. The aeroplane's heading was 253° and the drift was 11° to the right. The wind speed was about 34 kt and its direction from about 194°.

At 7 h 46 min 47, the aeroplane descended through 150 ft radio altimeter. It was below the glide path (-0.7 point) with a vertical speed of about -750 ft/min. The longitudinal angle of attack was +2.5°. The indicated airspeed was 151 kt (Vapp target= 138 kt, that is to say Vapp+13 kt). The PF made a pitch up input on the elevator (to ¾ stop). The aeroplane's angle of attack began to increase and the vertical speed in descent began to decrease.

At 7 h 46 min 51, the aeroplane was at 110 ft radio altimeter on the glide path, the vertical speed was about -375 ft/min the longitudinal angle of attack was +3.5°, the PF made a pitch down input and the vertical speed in descent started to increase.

⁽²⁾The speed change to managed mode allows the Vapp target value to appear (magenta triangle) on the PFD speed strip.

⁽³⁾The Vapp target displayed on the PFD is determined by the aeroplane's computers as a function of Vapp and the instant wind conditions (see Chapter 2.5.2).

⁽⁴⁾The maximum lateral wind component demonstrated for an Airbus A319 is 38 kt including gusts. This limit demonstrated by Airbus is expressed in terms of ground wind speed.

At 7 h 46 min 53, at a height of 90 ft radio altimeter, the aeroplane had an indicated airspeed of 159 kt (Vapp target=138 kt, that is to say Vapp + 21 kt). It was above the glide path (+ 0.4 point) with an angle of attack of +1.1°. The vertical speed was about -800 ft/min. The aeroplane's heading was 257° and the drift was 8° to the right. The wind was approximately from 190° at 26 kt.

At 7 h 46 min 57, at 25 ft radio altimeter, the aeroplane had an indicated airspeed of 152 kt (Vapp target=138 kt). The bank was 7° to the left and the angle of attack was +2.1°. The PF made two successive pitch down inputs (respectively ¼ then at 20 ft at 1/3 stop) that led to a decrease in the longitudinal angle of attack from 2.1° to 0.4° pitch up. The wind was approximately from 190° at 25 kt.

At about 20 ft, while the PF had not yet started the flare, the aeroplane moved from a 3° right bank to a 7° left bank. The PF made a roll input to the right stop. The thrust levers were moved back slightly without reaching the IDLE detent.

At 7 h 46 min 58, the flare was started at 15 ft radio altimeter at a speed of 155 kt, 17 kt above the Vapp (Vapp target =138 kt). The longitudinal angle of attack was +0.4° and the bank was 4° to the left. The PF started the flare and positioned the sidestick to the pitch up stop and the right stop with the rudder bar to the right in midway position. The PM also positioned his sidestick pitch up to a position a little more than halfway to the stop. The thrust levers were moved slightly forwards.

At 7 h 46 min 59, the main landing gear touched the runway with a vertical load factor of 2.66 g. The longitudinal angle of attack was +3.5° and the bank was 2.5° to the right and the vertical speed was about -800 ft/min. The PF then made a pitch down input to the stop on his sidestick while the PM stopped his pitch up input.

At 7 h 47 min 00, the thrust levers were selected on TOGA. One second later, the SRS mode engaged, then the thrust levers were positioned on IDLE. The spoilers extended then the thrust reversers were activated at 7 h 47 min 06.

At about 7 h 48 min, during taxiing towards the ramp, the crew informed the controller they had made a "very hard" touchdown.

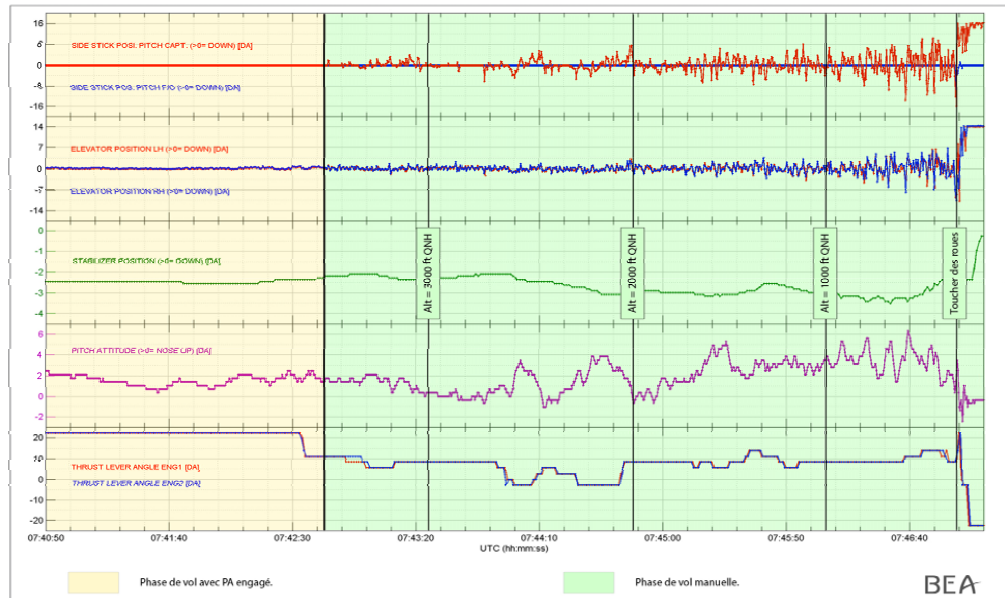
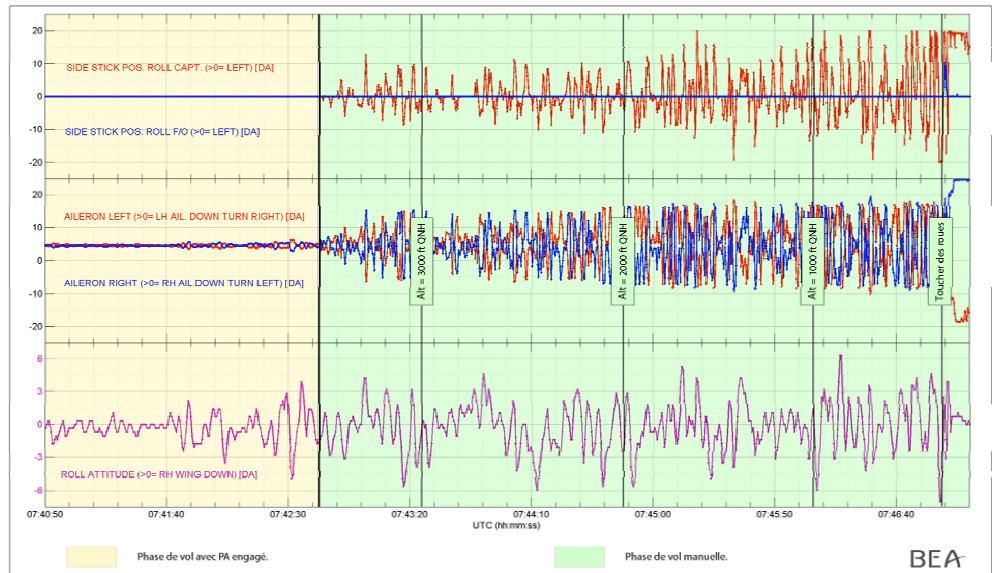


Figure 1: aircraft pitch attitude and PF roll, pitch and A/THR inputs between 4,000 ft and wheel touchdown

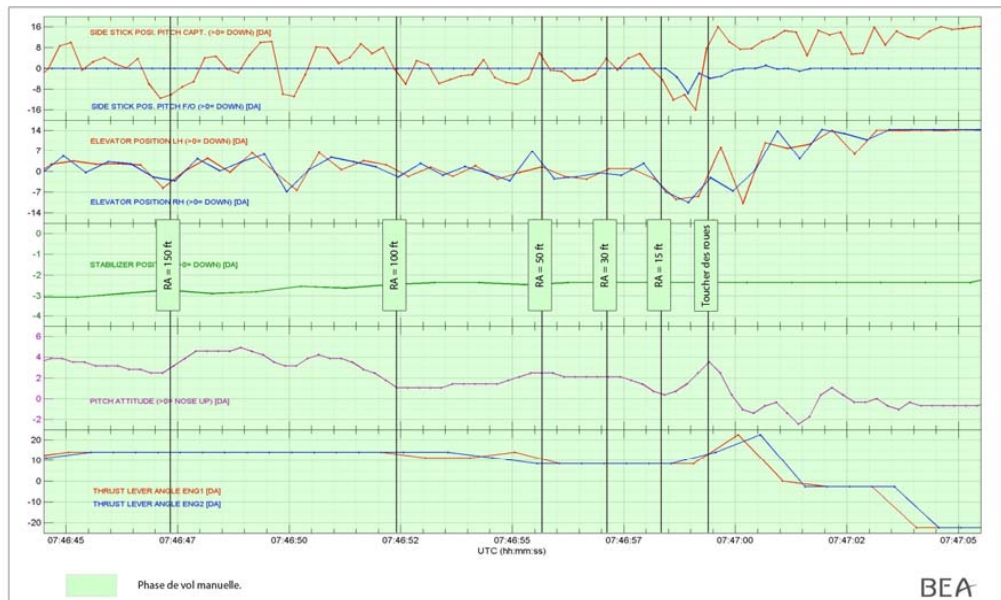
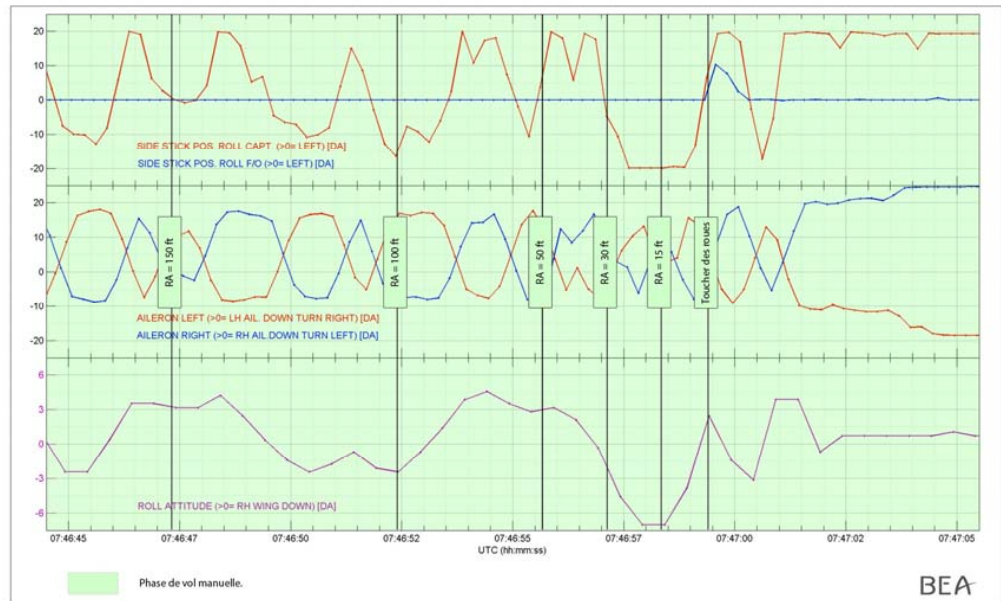


Figure 2: aeroplane attitude and PF roll, pitch and A/THR inputs between 200 ft and wheel touchdown

2 - ADDITIONAL INFORMATION

2.1 Damage to aircraft

The main left and right landing gear units were replaced.

2.2 Weight and balance

At the time of the event, the weight and balance were within the limits defined by the manufacturer. The weight recorded on the FDR on landing was about 60.4 t (MLW of 61 t).

2.3 Personnel Information

As of the date of the accident, the captain, aged 44, had a total of about 10,000 flying hours of which about 2,700 on type. He began his career with the airline in 1992 and had flown on Boeing 737 and 777. He obtained his Airbus A320 type rating in March 2007 and was appointed captain in June 2007.

The copilot, aged 25, had a total of about 2,100 flying hours of which about 1,660 on type. He began his career with the airline in 2008 and obtained his Airbus A320 type rating in August 2008.

2.4 Meteorological Information

The observation message at Charles de Gaulle airport at 7h30 was as follows:

METAR LFPG 130730Z **20026G38KT**⁽⁵⁾ 8000 BKN011 10/09 Q0997 TEMPO **21025G45KT**⁽⁶⁾

The ATIS R message at 7h34 indicated:

- ILS approach to runway 27R;
- Wet runway;
- wind 220 ° / 29 kt, gusts to 37 kt⁽⁷⁾;
- visibility 8 km, light rain, BKN at 1,000 ft;
- temperature 10 °C, dew point temperature 9°C;
- QNH 997 hPa.

Information on wind displayed

The wind information (speed and direction) recorded on the FDR was calculated in each of the 3 ADIRU. This wind information is exact to within 10 °/10 kt for wind speeds above 50 kt. For lower wind speeds, the wind direction is less reliable. The wind information provided below is for information.

Between 07 h 42 min (3,600 ft radio altimeter) and 7 h 46 min 50 s (150 ft radio altimeter) the recorded wind was variable in direction between 232° and 217° and variable in strength between 71 and 27 kt. During the approach, F-GRHS encountered, on average:

- 37 kt headwind;
- 32 kt left lateral wind.

Recalculation of the wind

In order to obtain more precise values, Airbus recalculated the wind components based on the difference between the ground speed vector (calculated by the inertial reference system) and the airspeed vector (calculated by the air data reference system indicator). Airbus has specific software that makes it possible to calculate the wind based on FDR data.

Between 850 ft radio altimeter and the ground, the calculations show:

- a decrease from 23 kt to 11 kt average head wind speed, accompanied by strong and rapid variations (two jumps of 12 kt in 2 seconds at respectively 650 ft and 300 ft radio altimeter). These variations comprise an increase then a significant decrease in the head wind in a few seconds, leading to variations in indicated airspeed;

⁽⁵⁾That is to say a lateral component of 24 kt with gusts to 35 kt.

⁽⁶⁾That is to say a lateral component of 23 kt with gusts to 37 kt.

⁽⁷⁾That is to say a lateral component of 21 kt with gusts to 27 kt.

- ❑ a decrease from 37 kt to 24 kt in the average speed of the lateral wind, accompanied by strong and rapid variations (jump of about 14 kt in 1 second at 450 ft);
- ❑ an average vertical wind speed of zero, accompanied by two maximum variations of 8 kt (about 810 ft/min) in 1 to 2 seconds, at a height of about 350 ft (updraft component) and 300 ft (downdraft component).

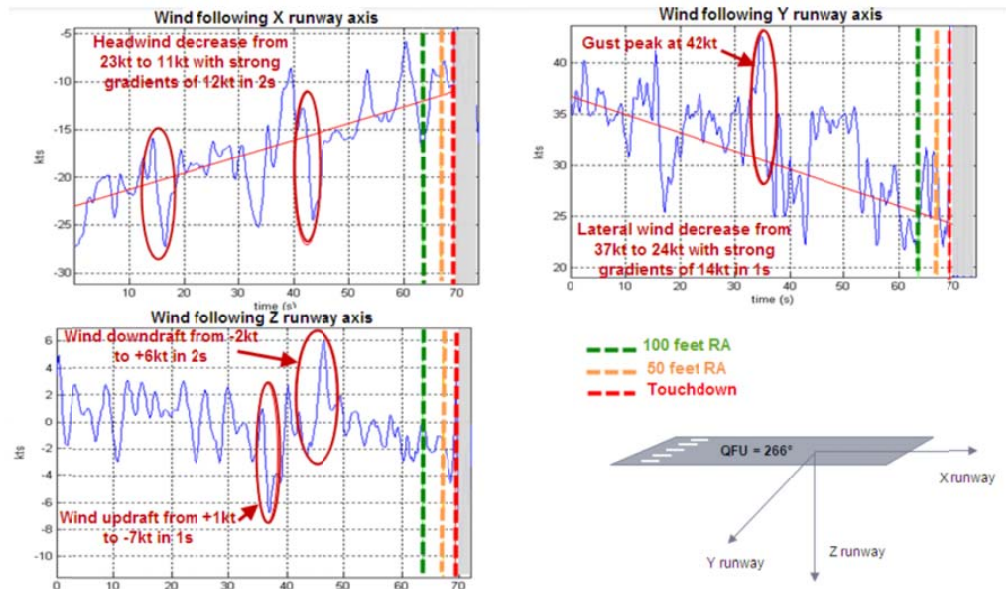
This reconstruction of wind components indicates:

- ❑ turbulent conditions with a strong lateral wind from the left and gusts that could exceed 40 kt just before the autopilot disconnection;
- ❑ an absence of any downwind on short final.

The recorded FDR data (reactive windshear)⁽⁸⁾ shows that the windshear detection warning was not triggered.

It could be supposed that the crew had been subjected to windshear, whose intensity nevertheless did not exceed the detection thresholds of the Reactive Windshear system. The significant wind variations occurred above 300 ft. Below 100 ft, the headwind varied from about 8 to 9 kt. Between 75 ft and the ground, the variation did not exceed 3 kt.

⁽⁸⁾Zone in which there are opposing winds and variable speeds over a short distance.



Source: Airbus

Figure 3: recalculation of wind

T=0 second corresponds to descending through 850 ft

2.5 Crew testimony

Captain (PF)

The captain stated that when consulting the meteorological information the day before the flight, he had identified the possibility of strong wind on arrival at Paris Charles de Gaulle. The meteorological situation being comparable at Lille (59) and Orly (94), he chose Lyon as the diversion airport and decided to load 11 tons of fuel.

He stated that during flight preparation, he had reviewed, with the copilot, the windshear and turbulence procedures. He added that during the pre-landing briefing the crew had decided to make the landing in Conf 3, AP and A/THR disengaged and AUTO BRAKE on medium.

He further stated that he was not used to using A/THR and that he preferred to make the approach with the A/THR disengaged. The stabilisation level was set at 1,000 ft AGL. He added that he had explained to the co-pilot that he might call for the approach to be aborted if he judged it necessary. The ATIS O received by ACARS at 06 h 47 mentioned a wind from 210 ° at 25 kt with gusts at 37 kt. He explained that he looked at the Vapp value displayed on the MCDU and that during the approach he used this value, adding 5 to 10 kt to it as the target speed for manual flying but without modifying the value displayed on the PERF APPROACH page on the MCDU. After descending through 200 ft, he saw the three red lights on the PAPI and the speed trend increase. He explained that he was surprised on short final by the rapid bank of the aircraft to the left and that he feared touching the runway with the left wing. He stated that he did not have the time to flare. He thought of making an aborted landing, but as he noticed that the aircraft did not skid, he preferred to reduce thrust and deploy the thrust reversers.

Copilot (PM)

The copilot stated that they had got the weather from ACARS, which made it possible for the crew to confirm the presence of gusts on arrival at CDG. He added that the procedure in turbulent flight had been reviewed and that, although this recommends the use of AP and A/THR, they agreed not to use them.

He explained that the flight became turbulent in the lower levels and stated that the situation was under control until 200 ft. He added that from 200 ft the situation became more difficult. He indicated to the captain that he was below the glide path on short final. He also called out "speed" and indicated that the speed then became nominal again. At a height that he estimated to be 30 or 40 ft, he felt a high aeroplane roll rate to the left and called out "bank".

2.6 Airbus and Air France operational documentation in force at the time of the accident

2.6.1 Stabilised approach

In the Airbus operational documentation in force at the time of the event, it is mentioned that the objective is to be stabilised on the final glide path at the approach speed (Vapp target) in the landing configuration from 1,000 ft AGL under IMC conditions, after a continuous deceleration on the glide path. To be stabilized, all of the following conditions must be met, at the latest at the stabilization altitude:

- speed between Vapp target-5 kt and Vapp target +10 kt;
- angle of attack between -2.5° and +7.5°;
- bank angle below 7°;
- vertical speed below 1,000 ft/min;
- LOC drift below 0.25 point;
- GS drift below 1 point.

If these criteria are not met, in particular due to external disturbances, the documentation recommends aborting the approach unless the crew consider that minimal corrections will make it possible to correct the deviations.

The Air France operational documentation states that below a height of 1,000 ft, the vertical speed must be limited to 1,000 ft/min. After call-out of “stabilised” by the PM, in case of obvious destabilisation or doubt on undertaking the landing, an aborted approach or landing must be performed.

2.6.2 Vapp, Ground speed mini, Vapp target

Vapp approach speed

The Vapp approach speed calculated by the FMGC is a function of the weight, the configuration, and the headwind.

$V_{app} = VLS^{(9)} + MAX(5kt, 1/3 \text{ of the value of the wind component on the axis of the runway given by the tower})$.

In case of risk of windshear linked to turbulent conditions the crew can increase at its discretion the value of the wind correction entered in the MCDU PERF page up to $V_{app} = VLS + 15$. This value will become the reference value for the calculation of Ground speed mini and the Vapp target.

Ground Speed mini

The objective of Ground Speed mini is to maintain a minimum energy level, whatever wind or gust variations there may be. It makes it possible to manage thrust effectively in case of gusts or longitudinal windshear. The Ground Speed mini is a calculated speed that is not directly presented to the pilot.

$GS \text{ Mini} = V_{app} - \text{the wind component on the runway axis given by the tower}$.

⁽⁹⁾VLS (Lowest selectable speed) describes the lowest speed that can be taken into account by the A/THR. Outside of the takeoff phase, it is 1.23 or 1.28 times the stall speed, at 1 g, in the configuration under consideration.

Vapp Target

The Vapp target is the target final approach speed calculated by the FMGC and displayed on the PFD speed strip (magenta triangle) in managed mode. It is the speed reference that the A/THR or the pilot (if the A/THR is disengaged) will look for when the final configuration has been selected and the speed is managed.

$V_{app} \text{ target} = \text{MAX} (V_{app}, GS \text{ mini} + \text{instant wind component on the aeroplane's longitudinal axis measured by the aeroplane}) = \text{MAX} (V_{app}, V_{app} + \text{the instant longitudinal gust (difference between the instant longitudinal wind measured by the aeroplane and that given by the tower)})$.

The Vapp target thus evolves as a function of the instant wind as measured by the aeroplane. When the longitudinal gust increases, Vapp target increases by as much. The pilot who observes the increase in the Vapp target is thus directly informed that the aircraft is being subjected to a positive longitudinal gust in relation to the tower wind entered into the MCDU.

2.6.3 Flight in turbulent conditions

Flight in turbulent conditions is the subject of specific recommendations in relation to the use of automated systems, the final configuration, the approach speed and flying technique.

Use of automated systems

The documentation (FCTM NO-100 « Approach general») recommends the use of all of the automated systems with A/THR in managed mode for the approach.

Managed speed should be used for final approach as it provides Ground Speed mini (GS mini) guidance, even when the VAPP has been manually inserted.

The purpose of the ground speed mini function is to keep the aircraft energy level above a minimum value, whatever the wind variations or gusts.

This allows an efficient management of the thrust in gusts or longitudinal shears. Thrust varies in the right sense, but in a smaller range ($\pm 15\%$ N1) in gusty situations, which explains why it is recommended in such situations.

It provides additional but rational safety margins in shears.

It allows pilots "to understand what is going on" in perturbed approaches by monitoring the target speed magenta bugs: when target goes up = head wind gust.

AP DISCONNECTION

During the final approach with the AP engaged, the aircraft will be stabilised. Therefore, when disconnecting the AP for a manual landing, the pilot should avoid the temptation to make large inputs on the sidestick.

Final configuration

Configuration 3 can be used as the final configuration, since it makes it possible to maintain a higher energy level and produces less drag than full configuration.

Flying

The FCTM "*Supplementary Information Adverse weather*" states:

If the aircraft is flown manually, the flight crew should be aware of the fact that flight control laws are designed to cope with turbulence. Therefore, they should avoid the temptation to fight turbulence, and should not over-control the sidestick.

The Air France operations manual in its GENOPS part specifies that increased use of flying aids must be preferred when it is necessary to make time available, in particular during an approach in marginal meteorological conditions.

Part TU A319 (Normal procedures - Phases of Flight - landing) adds that in case of an approach/landing with strong turbulence, the A/THR must be engaged and the speed managed. In case of a landing with a strong lateral wind, the careful use of the sidestick for lateral control must only be done with light inputs, in order to keep the wings horizontal. The sidestick must be in neutral when the main landing gear touches down.

2.6.4 Flare

Airbus indicates that in stabilised approach conditions, at a height of about 30 ft, the pilot begins the flare and positions the thrust levers on the IDLE detent. The pilot must not allow the aircraft to float, particularly with a lateral wind, nor try to prolong the flare by increasing the angle of attack to make a soft landing.

The manufacturer advises against pitch down inputs once the flare has begun. If it is not possible to reach a normal touchdown point, or if the aircraft is destabilized before the flare, the crew must abort the landing.

Airbus states the standard angle of attack during an approach at the Vapp on a trajectory of -3° for an Airbus A319 is 3.4° . The angle of attack during the touchdown is 7.7° .

If the flare is started too late, the time required to change the angle of attack will not be sufficient to allow an adequate change in the aeroplane's flight path. A late flare, with insufficient or reduced amplitude increases the risk of a hard landing.

2.7 Malfunction of CVR

The CVR had a malfunction which made the recorded data unusable.

This type of malfunction had been recorded on three occasions by the BEA on CVR recorders of this type (CVR TEAM AP71232101). EASA had been informed by letter on 17 February 2012.

Malfunctions on these recorders on each occasion led to a complete or partial loss of information useful to safety; in these four cases, two were part of investigations into a serious incident and an accident. These events led the BEA to warn EASA of the low level of reliability of this series of equipment.

The main operator of this series of CVRs is Air France, which owns a total of 67 CVRs of which 57 are used in operations on its A320 and A340 fleets. A consultation of the maintenance data from this operator made it possible to determine that over the period between January 2011 and September 2013, the airline removed 56 CVR TEAM recorders, 31 having been identified as non-functioning. Additional tests showed that of these 31 failed CVRs, only 23 were identified by the daily tests undertaken on board the aeroplane. Expert examination led by the equipment supplier (Cobham-TEAM) and the operator (Air France) brought to light some weaknesses in the bench test and tests performed on the aircraft during the pre-flight check and during maintenance. Inspection of the equipment using the tools supplied did not make it possible to complete a comprehensive check on correct CVR operation.

The BEA considers that in this situation it is impossible for operators to comment on the real operational condition of this series of on-board equipment. Consequently the risk of the loss of information necessary for safety investigations is high whenever a CVR from this series is used.

On 15 April 2014 EASA published Airworthiness Directive AD No : 2014-0088 which requires replacement of TEAM brand CVRs whose batch number is between AP71232101 and AP71231101. Operators had 18 months from 29 April 2014 to make the replacement. As of the date of publication of this report, Air France has replaced all of the CVRs in question.

3 - LESSONS LEARNED AND CONCLUSION

3.1 Flying in conditions with a strong lateral wind

This event illustrates the difficulties encountered by a crew when making an approach in very turbulent wind conditions that were close to the limit on the lateral wind component demonstrated the manufacturer.

During the final approach, the aircraft's stabilisation required numerous corrective inputs by the PF in roll and pitch, sometimes reaching the stop on the controls ("over-control" phenomenon). This intense activity in manual flying used a significant amount of the PF's resources over a long period due to disengagement of the AP at 3,500 ft QNH.

In this context, the decision to disengage A/THR may have made the work load excessive by obliging him to also concentrate on the speed and management of the thrust levers. The decision to mentally increase the value of the Vapp target by 5 to 10 kt rather than directly enter this increase on the MCDU PERF page also removed a reference for him (Vapp target) which would also have made it possible for the PM to monitor more easily any possible speed deviations. These various decisions may thus have added to the PF's considerable work load.

Between 1,000 ft and 200 ft, the latter managed to keep the aircraft stabilised on the flight path, which led the crew to continue the approach. They were then not aware that the intense manual flying with over-control sometimes to the stop would perhaps not allow them to deal with any deterioration in the meteorological conditions below 200 ft.

Below 200 ft the approach was destabilised on several occasions in relation to speed (variations of +2 kt to +20 kt above Vapp). Pitch and roll inputs on the PF's sidestick were very large and sometimes reached the stops. This situation represents an objective destabilisation criterion.

While it is expected that the crew begin the flare at about 30 ft (pitch up input and positioning the thrust levers on the IDLE détente), the PF successively made two pitch down inputs at 25 ft then at 20 ft leading to a decrease in the longitudinal angle of attack down to 0.4°, a value that is lower than the standard angle of attack value during a nominal approach (about 3.4°).

At about 20 ft the aeroplane rolled from 3° to the right to 7° to the left⁽¹⁰⁾. This roll obliged the PF to focus on controlling the aeroplane's bank to the detriment of controlling the angle of attack while he still had not started the flare. Fearing that the wing would touch the runway, he then made a roll input to the right stop. The A/THR levers were slightly pulled back without reaching the IDLE detent. The PF and the PM made pitch up inputs, respectively to the stop and to the half-stop while the aircraft was at 1,500 ft at a speed 17 kt above Vapp. When the main landing gear touched down, the aeroplane's angle of attack was 3.5° pitch up (the nominal angle of attack on touchdown is about 7.7°). This late flare made it impossible to reduce the aeroplane's vertical speed sufficiently to avoid a hard landing.

3.2 No decision to go around

The crew stated in its testimony that they were aware of the presence of very unfavourable wind conditions and that they had mentioned during preparation for the approach the possibility that they would have to abort it.

The PM indicated that he made the call-outs on bank, speed and flying below the glide path on short final, but he did not ask for the approach to be aborted. The PF, overwhelmed by the piloting, probably did not have the necessary resources to decide on his own to abort the approach before the wheels touched down.

In its publication "*Info Sécurité DGAC n°2013/06*"⁽¹¹⁾, the DGAC recalled the importance of the proactive role of the PM in operating aircraft with a two-person crew.

To quote part of the text, "*the PM's failure to react is often a determining factor in the causes of an accident; in addition it is often highlighted in safety investigation reports... Monitoring and check functions undertaken by the PM on the PF's actions form an essential element in optimal crew resource management*".

Further, the BEA issued a safety recommendation in 2013 relating to the effectiveness of CRM between two crew members in the context of a study of loss of control of the flight path during the approach phase during a go around⁽¹²⁾. Recommendation FRAN-2013-019 specifically covers the decrease in CRM performance in the context of unusual situations with a high work load.

Finally, the BEA report on the serious incident in August 2013 to an Airbus A320 on approach to Bordeaux Merignac airport⁽¹³⁾ revealed the difficulty for copilot, as PM, in calling for a go-around while the PF is fully occupied with managing a stressful situation.

⁽¹⁰⁾This value corresponds to the destabilization criteria. In his testimony the PM stated that he called out «bank».

⁽¹¹⁾http://www.developpement-durable.gouv.fr/sites/default/files/IS2016_03_signaux_manuels_urgence_feu_avion_au_sol_0.pdf

⁽¹²⁾<https://www.bea.aero/etudes/parg/parg.php>

⁽¹³⁾<https://www.bea.aero/fileadmin/documents/docspa/2013/fni130802/pdf/fni130802.pdf>

3.3 Use of aeroplane automated systems

The Airbus and Air France documentation mentions that, with strong lateral wind, the use of the sidestick for lateral control should only be made with small movements. The Airbus documentation in fact specifies that the aeroplane's flight control laws are designed to deal with turbulence, and that the crew must not try to fight it through excessive inputs on the sidestick.

It is not possible to establish retrospectively how the aeroplane would have behaved in the wind conditions encountered in the absence of any high amplitude inputs by the crew.

Nevertheless the amplitude of these movements could warn the crew of an undesirable situation, either of over-control by the crew or by exceeding the wind limits in which the aeroplane's flight control laws manage to stabilise its trajectory.

Thus since 2012, Air France has taken a number of preventive steps in the context of its management of "hard landing" risks. The following are of note:

- ❑ the change to the manufacturer's documentation which recommends specifically the use of A/THR;
- ❑ the modification in the crew training programmes on the use of A/THR and aborted approaches and landings, the implementation of recommendations in the operations manual part A:
 - "below the stabilisation level, a go-around must be performed:
 - as soon as a pilot calls out "Go Around";
 - in case of a E/GPWS (TAWS) warning, except in a specific aeroplane/ approach configuration mentioned during the briefing;
 - in case of successive deviation call-outs by one of the pilots or if the stabilisation conditions are not reached quickly enough."
- ❑ The development and follow-up of dedicated safety indicators that allow the airline's exposure to 'hard landing' risks to be monitored. The rate of hard landings (vertical load factor above 2g) has practically been stable since 2012, with an average of one hard landing per 10,000 flights.

Since clarification of the rules and limits set by the airline on the definition of destabilisation, the rate of aborted approaches in case of an unstabilised approach has almost doubled.

3.4 Causes

The hard landing resulted from excessive vertical speed during wheel touchdown due to:

- ❑ pitch down inputs close to the touchdown (25 ft and 20 ft radio altimeter);
- ❑ a flare that was started late at a radio altimeter height of about 15 ft;
- ❑ an excessive indicated airspeed ($V_{app} + 17$ kt during touchdown) and thus a high rate of descent.

The PF's high work load caused by manual flying in conditions with strong turbulent winds and in the absence of any call-out to abort the approach by the PM, despite the existence of objective destabilisation criteria after descending through 200 ft meant that the crew could not make the decision to abort the approach.