



## Serious incident to the BOEING 777 - 228ER registered F-GSPG operated by Air France on 2 May 2015 near Mount Cameroon (Cameroon)

<b>Time</b>	20:14 <sup>(1)</sup>
<b>Operator</b>	Air France
<b>Type of flight</b>	Commercial air transport - passenger
<b>Persons on board</b>	Captain (PM); co-pilot <sup>(2)</sup> (PF); relief pilot; 11 cabin crew; 23 passengers
<b>Consequences and damage</b>	None

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation published in August 2021. As accurate as the translation may be, the original text in French is the work of reference.

### Activation of EGPWS warning while flying around cloud masses, execution of an emergency manoeuvre, at night, en-route at FL90

The serious incident occurred in the Cameroon airspace. The BEA was informed of the event by the Air France Operations Control Centre and notified the Cameroonian civil aviation authorities. These authorities then delegated the investigation to the BEA.

#### 1 - HISTORY OF THE FLIGHT

*Note: The history of the flight is principally based on the crew statements and the data from the flight data recorder (FDR). The CVR data was not preserved.*

The crew composed of a captain and two co-pilots<sup>(3)</sup> were performing a flight departing from Malabo (Equatorial Guinea) bound for Paris, via Douala (Cameroon). The leg between Malabo and Douala, which takes about 40 minutes, was carried out at FL 90. The captain was the PM and the co-pilot, the PF.

<sup>(1)</sup>Except where otherwise indicated, the times in this report are in Coordinated Universal Time (UTC). One hour should be added to obtain the legal time applicable in Cameroon on the day of the event.

<sup>(2)</sup>Within Air France, a co-pilot is designated by the term First Officer (FO).

<sup>(3)</sup>The assigned aeroplane had had to be replaced due to a technical tolerance. The holdup that this caused increased the crew's flight duty time and as a consequence, required an augmented crew with an additional co-pilot (relief pilot)

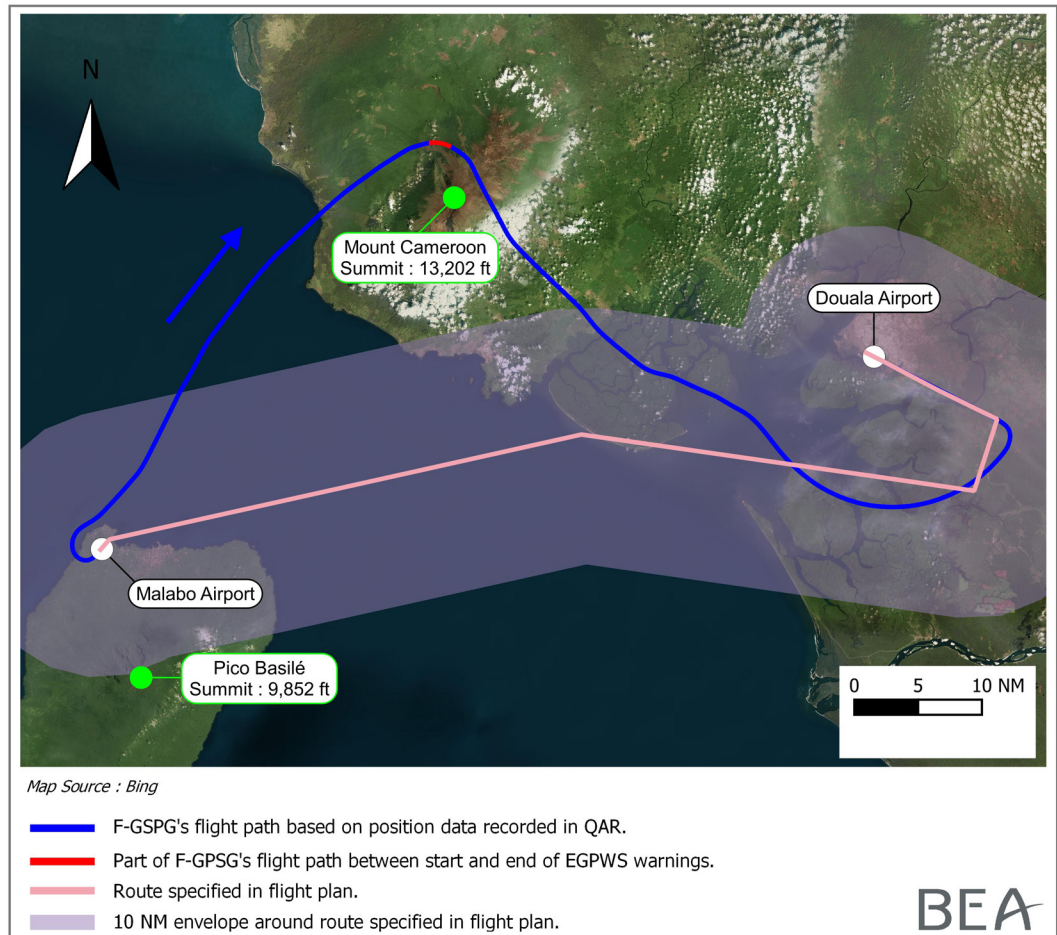


Figure 1: Flight path of F-GSPG and filed flight plan

Due to the stopover infrastructures and the short flight time of the leg, a “departure and arrival” briefing was carried out in the cockpit before take-off.

The flight file forecast cumulonimbus and visibility greater than 10 km at Malabo. At Douala, the 17:00 METAR indicated the presence of a storm, cumulonimbus and a ceiling of 1,600 ft. The TAF forecast rain showers and visibility reduced to 3,000 m as well as a ceiling at 1,300 ft between 2 May 20:00 and 3 May 06:00. The Operations Control Centre informed the crew that the storm over Douala was in the process of moving west and that two aeroplanes had just landed there.

In contrast, the precise meteorological conditions along the route were not known.

During the briefing, the crew covered the following specific points:

- The terrain on the left side of the take-off path required a right turn to be made which is the opposite to the path specified by the FMS<sup>(4)</sup>.
- The meteorological conditions at Douala were considered acceptable. The crew had been informed by the company's flight operations department that the zone of convective activity which was present over Douala was moving from east to west.
- The workload linked to the numerous exchanges with the ATC without a radar between Malabo and Douala was high for the PM.

<sup>(4)</sup> This point is mentioned on the aerodrome sheet in the company's flight file.

The aeroplane left the gate on time at 19:53. A member of the cabin crew was authorised to fly in the cockpit and was seated on the observer seat, on the right of the relief pilot's seat.

At 20:03, the crew took off from runway 22, initially turned right onto heading 030° to join the flight plan route and then engaged the autopilot (AP).

At the end of the turn after the take-off, the crew indicated that they observed numerous storm cells on the radar on the flight plan route and to the south. It was night, the cells were not touching, the crew could make out their shape and see lightning. The aeroplane continued its path north-east, deviating northwards from the flight plan route. The PF's and PM's navigation displays (ND) were in the *Weather* (WXR) mode<sup>(5)</sup>. The scale on the PM's ND was 20 then 40 and finally 80 NM during the climb, on the PF's ND, it was 80 and then 40 NM at the end of the climb. The crew used the Douala arrival chart STAR RWY 30 (6-40) to navigate.

<sup>(5)</sup> See [paragraph 2.3](#).

The PF saw a large red return on his ND ahead of the aeroplane and another oblong red return on their right which seemed to be "moving forward" with the aeroplane. As the PF did not understand what was causing this second return, he was not sure about its nature and decided to set his radar to *Terrain* mode to clarify the situation, which simultaneously increased the scale to 80 NM. He returned to *Weather* mode six seconds later. Following this check, he thought that the return ahead of the aeroplane was a ground return from Mount Cameroon and that the oblong red return on the right of the route was a "false return".

Around ten minutes after take-off, the aeroplane was 6 NM north-west of Mount Cameroon. The crew indicated in their statements that the exchanges with the ATC had become dense.

The PM suggested to the PF that he take a right heading to join the start of the DME arc to runway 30 at Douala. When the aeroplane was on a heading of 61°, the PF controlled a right continuous-turn to the selected heading of 120°.

At 20:14:02, around 30 s after the start of the turn, the aeroplane was at an approximate height of 5,000 ft when the EGPWS "TERRAIN AHEAD" caution was activated for four seconds. The two ND automatically changed to *Terrain* mode. Three seconds after the activation of the warning, the PF increased the selected heading to 134°. The aeroplane continued to turn right with a bank angle of around 25°.

A few seconds later, at 20:14:12, the radio altimeter height had decreased to 4,150 ft and the "TERRAIN AHEAD PULL UP" warning sounded for eight seconds. The crew indicated that the NDs turned red. In their statements, the cabin crew member in the cockpit and the PF indicated that they made out trees on the right of the aeroplane.

The PF disengaged the AP and made a nose-up input. He advanced the thrust levers full forward to obtain maximum thrust one second later. The autothrottle (A/T) was disengaged five seconds after the start of the manoeuvre.

During the eight seconds of the warning, the pitch attitude and vertical speed increased. The maximum pitch attitude was 15°. The aeroplane remained in its turn and the relief pilot asked the PF to level the wings.

The EGPWS warning ceased at 20:14:20. The bank was briefly cancelled before the turn resumed with a bank angle of around 25°. FL120 and a heading of 150° were selected.

On approaching FL110, the PM told the PF to stop climbing. The pitch attitude was held and the PM again told the PF to stop climbing on flying through FL120. The radio altimeter height reached its minimum value of 2,100 ft corresponding to an altitude of 11,500 ft. The summit of Mount Cameroon is at an altitude of 13,202 ft.

At 20:15:30, the aeroplane reached FL130. The crew resumed navigation to the ILS DME arc of runway 30 at Douala and landed without further incident.

At the conclusion of the flight crew debriefing and after coordination with the Air France Operations Control Centre, it was decided to continue the rotation to Paris with the same crew.

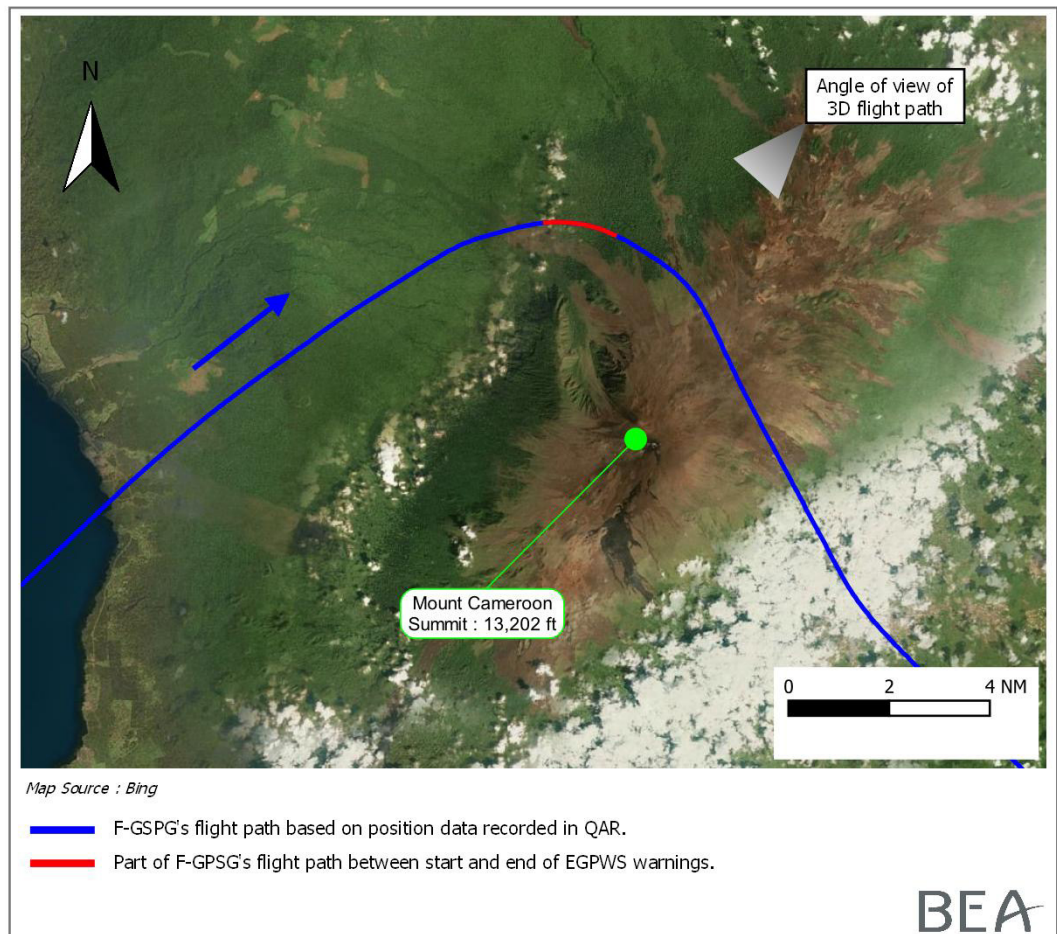
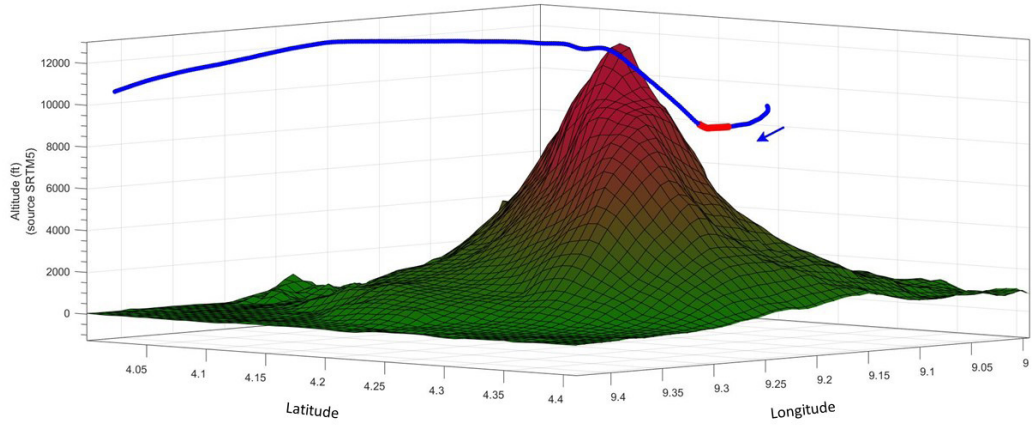
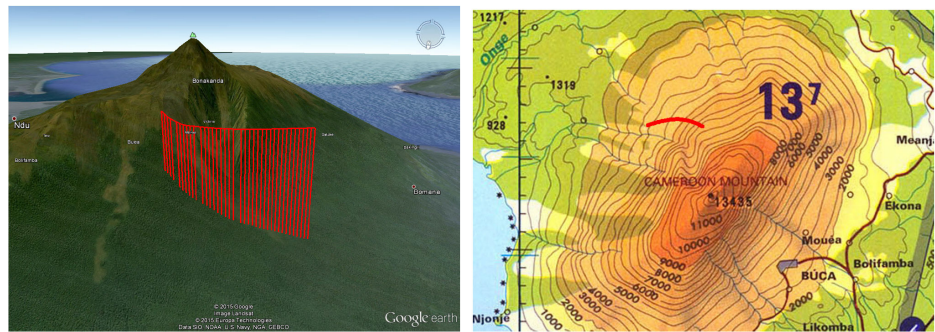


Figure 2: Flight path of F-GSPG while avoiding Mount Cameroon



- F-GSPG's flight path based on position data recorded in QAR.
- Part of F-GSPG's flight path between start and end of EGPWS warnings.

Figure 3: 3D flight path of F-GSPG while avoiding Mount Cameroon



Source: Honeywell

Figure 4: Flight path of aeroplane during activation of EGPWS alerts

## 2 - ADDITIONAL INFORMATION

### 2.1 Crew information

	Licence	Total exp. (in h)	On type (in h)	As captain (in h)
Captain (PM)	ATPL(A)	18,035	5,998	12,600
Co-pilot (PF)	ATPL(A)	5,076	3,353	-
Relief pilot	ATPL(A)	15,116	447	-

## 2.2 Statements

### 2.2.1 Captain (PM)

The captain indicated that during the flight preparation, he had had difficulties in obtaining precise information about the meteorological conditions at Douala. The crew had had to make several calls to Douala and Paris in order to be orally informed of the numerous storms present at Douala. They thus learnt that two aeroplanes had been able to land. In the absence of a weather chart, they decided to wait an extra 15 to 20 minutes before leaving. The captain perceived the flight, at this time, as being badly prepared. He considered the meteorological conditions as being the main threat for this flight.

He indicated that during the briefing, the co-pilot (PF) had insisted on the need to use the heading function to manage the aeroplane's path on take-off to avoid terrain on the island and join the flight plan route.

They chose to divide the ND information as follows: *Terrain* mode for him and *Weather* mode for the PF. He specified that he asked the relief pilot to particularly monitor the flight path. Little mention was made of Mount Cameroon, probably, according to him, because its presence was obvious for everyone. Furthermore, the presentation of this terrain on the chart used during the flight<sup>(6)</sup> suggests that it is not a threat in flight.

The captain indicated that he set the ND to *Weather* mode during the climb.

During the flight, the ND was red, with cumulonimbus everywhere. He thought they were south of Mount Cameroon which incited him to suggest to the PF that he make a right turn in order to join the DME arc for the approach to Douala. He added that both co-pilots had had doubts before the turn was started.

When the "PULL UP" warning sounded, he was surprised and immediately called out pull up, pull, pull to the PF. He looked outside because he was afraid that there might be other traffic. This led him to ask the PF to stop climbing. This fear was linked to a simulator training session in which there had been an in-flight collision with another aeroplane.

He did not envisage becoming PF for the approach and landing due to the PF's composure.

He considered that a three-person crew contributed to creating a dilution in responsibilities despite the instruction given to the second co-pilot to monitor the path.

### 2.2.2 Co-pilot (PF)

The co-pilot had carried out the Douala - Malabo flight as PF the day before the incident. The flight itself had taken 17 minutes and the weather had been good. He had carried out this flight three or four times in the past.

During the pre-flight briefing, they had mentioned the terrain at take-off from Malabo. He remembered that the captain asked the second co-pilot to be vigilant in general and with respect to the safety altitudes in particular.

<sup>(6)</sup> Douala STAR RWY 30 (6-40) LIDO arrival chart. See [paragraph 2.5.2](#).

Obtaining weather information from Paris and Douala had been perceived as complicated, so that once in flight, the management of the meteorological environment had taken up all their attention. Furthermore, the exchanges with the ATC were difficult and the air traffic control considered aggressive. Doubts about two red forms on the ND in *Weather* mode, one form ahead of them and one on their right which seemed to be moving with the aeroplane made him change to *Terrain* mode. He then thought that the form ahead of them was Mount Cameroon.

He indicated that he initially refused to turn right on the captain's request because of the presence of the red return on their right. The turn was then executed in order to avoid getting close to the red form ahead, identified as being Mount Cameroon. The turn was started with caution due to doubts as to the exact nature of the return on their right.

Shortly after, he perceived the warning and saw trees on the mountain while they were in a turn. He explained that he focused on the pitch attitude, which he estimated at 20°, and the thrust during the emergency manoeuvre. The manoeuvre was started in a turn. He heard the second co-pilot call for the wings to be levelled. He thought that the ND displayed red blocks up to around 13,000 ft and heard the PM's calls to stop climbing at 11,000 ft and then 12,000 ft. They stabilized at 13,000 ft.

He stayed PF for the approach to Douala. The captain asked him if he was feeling well and his calm voice helped him feel better. The approach took place without incident. He explained that he concentrated on holding the centreline, slope and speed. Once the "Shutdown" checklist had been completed, he felt his body trembling. He looked in the operations manual for the procedure to be followed in the event of a serious incident, thinking that the rotation would be stopped.

He added that the training in managing EGPWS alerts was useful and that he had done it numerous times when flying in a straight line and when approaching terrain. He specified, however, that he thought it would be useful to train in the manoeuvre when in a turn.

Concerning the analysis of the incident, he considered that the crew had poorly identified the threat posed by Mount Cameroon in the event of leaving the flight plan route, the priorities having been identified in the following order during the briefing: weather, ATC, terrain at departure from Malabo.

### 2.2.3 Relief pilot

The relief pilot had carried out the CDG - Douala flight as PF and had then been relief pilot for the two Douala - Malabo and then Malabo - Douala legs.

The Malabo departure briefing had insisted on the weather conditions, the short flight and the radio communication difficulties, in particular because of the absence of radar coverage. The captain had asked him to be his "eyes and ears".

He explained that the flight preparation had been marked by the uncertainties relating to the meteorological conditions. There were large storms at Douala with heavy rain. The pilots had therefore searched for the most accurate and most recent meteorological information possible. HF contact with Douala had not been possible. They had had contact with Air France by satellite telephone to obtain information. The person they had had on the phone read the satellite chart to them and called the Douala station manager in order to pass on the information to them. The storm was travelling towards Douala but was getting smaller and planes were landing at Douala.

Shortly after the departure from Malabo, the Douala controller asked the crew numerous questions about the flight. These exchanges kept the PM busy for several minutes.

The Douala arrival sheet was not to scale (Malabo was in an insert) so the notion of distance was a little lost. Their representation of the threat posed by the terrain was erroneous.

He indicated that he was surprised by the EGPWS call. At this point, they were in a right turn to approach Douala and avoid a return on the weather radar. He thought that this return, to the north of the flight path, was the terrain of Mount Cameroon. During the emergency manoeuvre, he indicated that they climbed to FL130; the threat then disappeared from the ND.

The rest of the flight went well and they jointly decided to continue the rotation to CDG. This last flight went normally with good communication between the crew members throughout the flight.

He considered that the emergency manoeuvre training was effective.

#### **2.2.4 Cabin crew member present in cockpit**

The cabin crew member was sat in the jumpseat behind the co-pilot's seat (PF). He was not, however, wearing a headset and thus could not hear the conversations between the three members of the flight crew nor the exchanges with the ATC. He did not hold a pilot licence.

He noted that during the flight, the crew followed a route which was "further left" than the planned path and he observed that the three members of the flight crew were bent over and very concentrated on the weather radar.

Just before the first alert was activated, he had seen a dark mass on the right which he thought was the coast. He indicated that he saw the aeroplane take a high pitch attitude and then observed that the second co-pilot was watching the PF's inputs. He heard him shout, level the wings, you'll climb quicker. He recognised the shape of trees on the ground (it was a full moon and the clouds were at a distance).

### **2.3 Weather radar display on Boeing 777 ND**

Each of the aeroplane's NDs can display either EGPWS terrain information or weather radar information.

In the Boeing 777 Flight Crew Training Manual (FCTM), it is recommended that one pilot monitor the terrain display and the other pilot monitor the weather radar display when terrain or obstacles are near the intended flight path. The use of the *Terrain* display during night, or IMC operations when in proximity to terrain and obstacles and at all time in non-radar environments is also advised in the Boeing publication.

The Air France Flight Crew Operating Manual (FCOM) does not specify a division of information between the PF's and PM's ND. It is recommended to adapt the displays according to needs. The operator indicated that in practice, one ND displays the terrain data and the other, the weather radar data.

The principle of the weather radar is based on the reflectivity of the precipitation in the atmosphere. A colour scale characterizes the cloud activity, from green for zones of lesser intensity to red for zones of great intensity.





Source: Air France

Figure 5: Example of a radar return display on the ND

The weather radar system is capable of filtering out ground returns, however it is still possible for the radar to capture a ground return under certain conditions. In this case, due to the reflectivity of the ground, this return appears in red on the ND in *Weather* mode in the same way as an active storm cell.

To differentiate between a ground return and a cloud mass return, it is possible to change the ND mode to *Terrain*. The information displayed is then that from the EGPWS database and the cloud cells are erased. However, the screen refresh takes several seconds so it is important to keep this mode active for the time required to completely constitute and update the image. Simulator tests found that around eight seconds were required before the ND display in *Terrain* mode was complete.

It should be noted that when the ND display is in *Weather* mode, the precipitation returns can be represented with similar symbols to the terrain return when the ND is in *Terrain* mode. However, in *Terrain* mode, solid amber or red colours are only displayed when the aeroplane is lower than 2,000 feet above terrain and the associated caution or warning alert is active.

During the incident flight, the PF observed red returns on his ND in *Weather* mode and switched the display to *Terrain* mode in order to reliably determine their nature.

He did not observe terrain ahead of the aeroplane and considered that the moving oblong return was a false return which did not correspond to any reality. This understanding encouraged him to follow the captain's indication to turn right.

## 2.4 EGPWS on Boeing 777

### 2.4.1 Display on ND

The terrain information displayed is based on the data in the EGPWS database. It is not data detected by the aircraft systems.

When the height of the aeroplane with respect to the surrounding terrain is more than 2,000 ft, the latter is displayed in shades of green according to the estimated clearance margin. When the height of the aeroplane is less than 2,000 ft, the same terrain is displayed according to the clearance margin:

- in a green dot pattern for obstacles between 2,000 ft and 500 ft below the aeroplane's altitude;
- in an amber dot pattern for obstacles between 500 ft below and 2,000 ft above the aeroplane's altitude;
- in a red dot pattern for obstacles situated more than 2,000 ft above the aeroplane's altitude.

*Note: the dots are replaced with a solid colour for terrain associated with the specific alert if an EGPWS alert is activated.*

If an EGPWS audible alert is activated when neither ND has *Terrain* selected, each ND changes to *Terrain* mode in order to display the terrain near the aeroplane (see illustration below).



Source: BEA

Figure 6: Example of an EGPWS TERRAIN alert display on the ND

## 2.4.2 Emergency manoeuvre associated with EGPWS “PULL UP” warning

The activation of a “PULL UP” type EGPWS warning is associated with the execution of the following emergency manoeuvre:

Call out : “PULL UP”	
Pilot Flying	Pilot Monitoring
<ul style="list-style-type: none"> <li>Disengage autopilot</li> <li>Disconnect autothrottle(s)</li> <li>Aggressively apply maximum* thrust</li> <li>Simultaneously roll wings level and rotate to an initial pitch attitude of 20°</li> <li>Retract speedbrakes</li> <li>If terrain remains a threat, continue rotation up to the pitch limit indicator or stick shaker or initial buffet</li> </ul>	<ul style="list-style-type: none"> <li>Assure maximum* thrust</li> <li>Verify all required actions have been completed and call out any omissions</li> </ul>
<ul style="list-style-type: none"> <li>Do not change gear or flap configuration until terrain separation is assured</li> <li>Monitor radio altimeter for sustained or increasing terrain separation</li> <li>When clear of the terrain, slowly decrease pitch attitude and accelerate</li> </ul>	<ul style="list-style-type: none"> <li>Monitor vertical speed and altitude (radio altitude for terrain clearance and barometric altitude for a minimum safe altitude)</li> <li>Call out any trend toward terrain contact</li> </ul>

Source: Air France FCOM

Figure 7: Emergency manoeuvre associated with “TERRAIN AHEAD PULL UP” warning

Note: the immediate application of and compliance with the emergency manoeuvre does not guarantee that the terrain which triggered the activation of the warning will be cleared.

At Air France, in the 2012-2016 period, training in the "PULL UP" emergency manoeuvre was carried out using different scenarios. In particular, the aeroplane could be in level flight or in a turn. When the co-pilot (PF) carried out this training, the aeroplane's wings were level.

## 2.5 Aids to navigation

### 2.5.1 Safety altitudes

The route MORA is an altitude which guarantees an obstacle clearance margin of at least 1,000 ft<sup>(7)</sup> up to 10 NM around the planned route. A route MORA is thus calculated for each segment of the flight plan and is indicated in the crew's flight file.

For the incident flight, the most critical route MORA was 10,700 ft due to the terrain close to Malabo and close to the take-off path. As the planned route was more than 10 NM from Mount Cameroon (13,202 ft), the latter did not affect the route MORAs of the other segments of the flight plan.

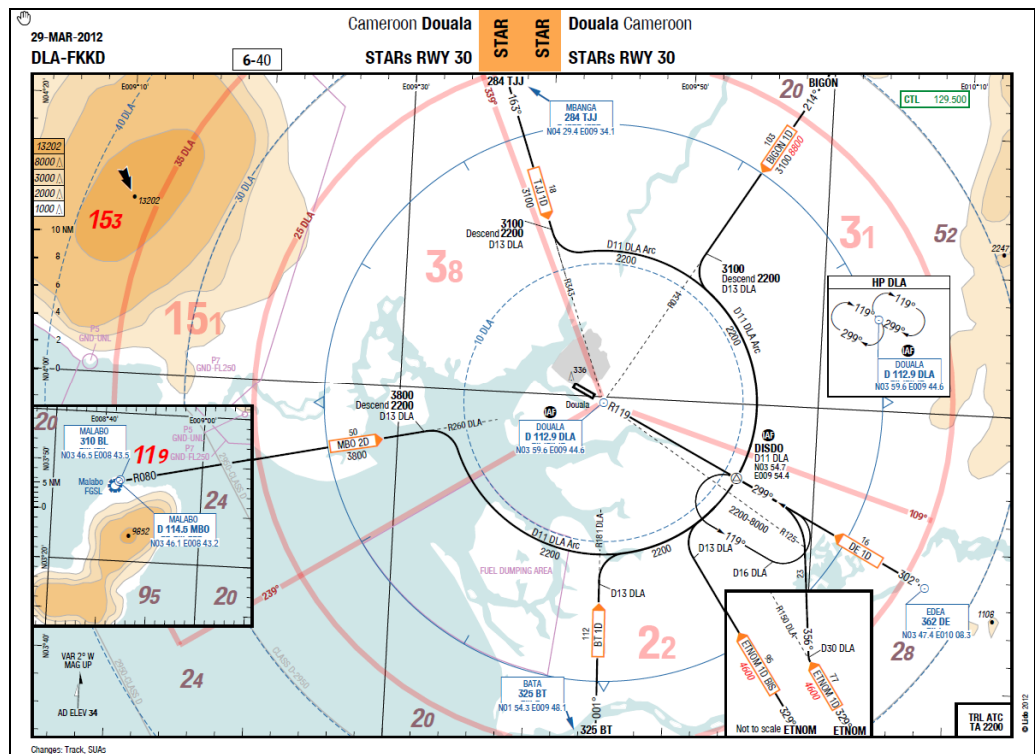
The grid MORA is a safety altitude given for a zone delimited by two parallels and two meridians 1° apart. The grid MORA in the sector of Mount Cameroon is 15,300 ft and 2,400 ft above sea level south of Mount Cameroon.

Note: Neither the MORA nor the grid MORA are displayed on the ND of the Boeing 777.

### 2.5.2 Charts and flight monitoring

Due to the short distance between Malabo and Douala, the crew decided to carry out their briefing and monitor the flight with the Douala arrival chart (see Figure 8).

<sup>(7)</sup> This margin is 2,000 ft in the event of terrain above 5,000 ft.



Source: Air France

Figure 8: LIDO chart used by crew to monitor their flight

This chart shows the Malabo airfield in an insert, placing this airport on the correct bearing with respect to the Douala airfield but at a distance which is not to scale. In reality, it is situated at around 40 NM to the south-west.

The day of the incident, the right turn immediately after take-off avoided the threat posed by the terrain on the ile de Malabo. The representation of the Douala arrival chart might then have led to the belief that the flight passed south of Mount Cameroon and that the path would not be affected by the terrain.

The chart shows in particular:

- ❑ the terrain around Malabo airport with a peak at 9,852 ft;
- ❑ Mount Cameroon and the altitude of its peak at 13,202 ft;
- ❑ Grid MORAs rising to 15,300 ft around Mount Cameroon.

Once in flight, the crew used the information from the weather radar displayed on the ND to fly around the storms.

## 2.6 Malabo-Douala route

The Malabo-Douala route was opened by Air France on 30 June 2008. Prior to starting flight operations on this route, Air France carried out a route study based on a risk analysis of Malabo and Douala airfields. This analysis was used to quantify an overall risk level according to the particularities of each aerodrome. A risk assessment of the en-route phase of the given route does not exist.

For this type of particularly short flight, the en-route phase is carried out at unusually low altitudes and in particular, below the altitudes of the terrain present between Malabo and Douala and requires high MORA. Furthermore, this region is known for intense meteorological phenomena (rain, storms) which can significantly affect the paths of aeroplanes en route. The absence of a study of the en-route phase when carrying out the route study prior to starting flight operations meant that the threat represented by this terrain was not identified, meaning that no countermeasure could be implemented.

Over the 2015-2017 period, a total of 15 ASRs were recorded by Air France on this route, not counting the ASR of this occurrence. The study of the 15 ASRs did not bring to light problems specifically related to Mount Cameroon. One event had required the crew to avoid cumulonimbus in the direction of Mount Cameroon. The crew had identified the safety altitude to be complied with (15,300 ft) and had entered a fix in the FMS so as not to risk undetected proximity with this terrain. Two other events were linked to a risk of collision with the peak close to Malabo airport.

## 3 - CONCLUSIONS

*The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation. They are not intended to apportion blame or liability.*

### Scenario

During the flight preparation, the threats linked to the terrain on departing from Malabo, to the weather conditions and to the numerous ATC exchanges were identified and led the captain to ask the relief pilot to pay particular attention for all of the flight.

After the briefing and before departure, the crew were attentive to changes in the weather and sought up to date information several times in order to decide on the best time to leave. The information indicating that two aeroplanes had been able to land led the crew to start the flight.

Shortly after take-off, the crew turned right to join the flight plan route, making sure that the turn avoided the Malabo terrain. The two pilots had set their Navigation Displays (ND) to *Weather* mode which was different to the division of modes specified during the pre-flight briefing. This choice of setting may have reflected the captain's (PM) concerns about avoiding the cumulonimbus, the en-route phase being over water and the Malabo terrain having been avoided after take-off. This choice was consistent with the threats identified during the briefing.

In order to avoid the storm cloud masses, the crew significantly departed from the flight plan route. Although the proximity of Mount Cameroon was mentioned during the briefing, the risk of dangerous proximity with this terrain was not identified.

The crew managed their flight path, preoccupied with avoiding the cloud masses and with the exchanges with the air traffic controllers. Their distance from the flight plan route increased and they drew closer to Mount Cameroon situated to the north of the planned route.

The co-pilot (PF) tried to clarify the nature of the large red returns displayed by the weather radar by temporarily setting his ND to *Terrain* mode. Although technically appropriate, this action was carried out for too short a period (five to six seconds) for the aeroplane radar to build a complete image of the situation. This led the PF to think that Mount Cameroon was ahead of them

When the captain (PM), a few moments later, suggested turning right to join the start of the DME arc, he thought that they were south-south-east of Mount Cameroon. This representation error was furthered by the presentation of the paper chart used to navigate.

The PF was still not sure of their exact position and the nature of the return on the right but did not verbalize this. After momentarily hesitating, he complied with the captain's (PM) suggestion. These doubts were shown by the PF slowly entering the turn.

About 30 s after starting the turn, the EGPWS "*TERRAIN AHEAD*" caution and then "*PULL UP*" warning sounded and the two NDs changed to *Terrain* mode.

The activation of these warnings made the PF aware of the presence of Mount Cameroon. The reaction to the warning was quick. While carrying out the emergency manoeuvre, the PF initially kept the plane banked which led to a call from the relief pilot.

During the manoeuvre, worried about the risk of collision with another traffic, the captain (PM) observed the outside environment and asked the PF to stop climbing at FL110 and then at FL120 although the peak of Mount Cameroon was higher than these altitudes. This concern was based on the occurrence of an in-flight collision with another traffic during a simulator session followed by the captain a few months before the incident.

The air traffic controller, whose role, in particular, is to prevent collisions between aircraft, was not informed of the manoeuvre and that they had left the assigned altitude.

The climb was stopped at FL130, below the grid MORA safety altitude, and the flight was continued, without further incident, to landing. During the approach, the captain questioned the co-pilot in order to find out if he felt able to continue as PF. This request, made in a calm voice, helped the latter to remain concentrated on managing the flight to landing.

## Analysis

### Positioning error and awareness of terrain

The chart used, with an insert to show Malabo, contributed to the difficulty in having an exact representation of the situation. It did not facilitate the representation of the flight plan with respect to elements present on the chart, notably Mount Cameroon. The short flight distance encourages the use of this chart which simultaneously shows the departure and arrival airports. Furthermore, the grid MORA is not displayed on the ND; it might have alerted the crew to the safety altitudes of the area being flown over. All of these factors led the crew to incorrectly identify the actual position of the aeroplane with respect to the terrain. The safety altitudes indicated in the flight file did not allow the crew to identify other terrain-related risks on the planned route. This could have resulted in the crew not being aware that the altitude of the surrounding terrain was higher than their en-route altitude, usual for this leg, but exceptional for a “standard” en-route phase on a Boeing 777.

Using the two NDs in weather radar mode, the crew interpreted the return generated by the cloud mass ahead of the aeroplane as a return from Mount Cameroon. The return from Mount Cameroon was considered as a false return.

These factors led to a positioning error which led the crew to turn the aeroplane towards Mount Cameroon when they thought they were joining the DME arc of the approach chart.

### Crew cooperation and task sharing

The crew were composed of a captain and two co-pilots, one being a relief pilot due to the delayed departure of the aeroplane.

The captain asked the relief pilot to particularly monitor the flight, acting as his eyes and his ears. The relief pilot shared in the subjects of concern imposed by the management of the flight, namely avoiding the storms, as indicated by the cabin crew member in the cockpit who explained that he saw the three crew members “bent over” the weather radar. In this context, no crew member detected the fact that avoiding the cumulonimbus had led them to significantly deviate from their flight plan, making the safety altitudes specified therein, null and void.

The PF temporarily used the *Terrain* mode of the ND due to doubts about the identification of a red mass on the right side of the path. These doubts were not explicitly mentioned and were therefore not cleared up. The crew thus remained in their position error, contributing to them approaching Mount Cameroon. The PF’s careful start of the turn was symptomatic of his continuing hesitation as to the nature of this red mass.

### Route study

The operator carried out a route study prior to flight operations between Douala and Malabo. This study was based on the risk analysis at the departure and destination airports. This analysis resulted in the identification of risks linked to the presence of terrain at both Malabo and Douala. However, there was no risk assessment of the en-route phase. On short routes, the en-route phase can be carried out at low altitudes, potentially below that of the terrain, as illustrated by this incident.

The en-route phase can thus present particular risks which on being identified by the operator, can allow crews to better take them into account. The route study, carried out beforehand by the operator, should identify these risks, bring them to the crews' knowledge and propose mitigation measures. The crews' situational awareness would thus be reinforced, this being all the more important in that keeping flight threats up to date cannot be guaranteed in a dynamic phase such as avoiding storm cells.

### Carrying out emergency manoeuvre

Immediate compliance with the emergency procedure associated with an EGPWS "PULL UP" warning is primordial to maximize the terrain avoidance manoeuvre. The emergency manoeuvre does not guarantee, however, that the terrain will be cleared, which is why it is important to benefit from the steepest climb gradient possible. The procedure allows the stick to be pulled until the stick shaker or *buffet* appears, significantly reducing the stall margins. These will be all the more preserved when the aeroplane's wings are level. It is possible to continue a turn when this type of warning occurs, when the crew has good situational awareness, notably in the day when the terrain which caused the warning is visible.

The emergency manoeuvre was carried out without delay by the PF and monitored, in particular, by the relief pilot who reminded him to level the wings. Not all the training scenarios provide for this manoeuvre to be carried out in a turn, meaning that levelling the wings is not part of the systematic checks made by the instructors.

### Contributing factors

The following factors may have contributed to the loss of situational awareness concerning the position of the aeroplane with respect to the terrain and to the proximity with Mount Cameroon:

- The crew's concern to avoid storm cloud masses and the reporting with the ATC, to the detriment of monitoring the flight path. The crew significantly deviated from the filed flight plan which made the safety altitudes mentioned therein obsolete.
- The simultaneous use of both radars in *Weather* mode.
- The representation of Malabo airport on a chart not to scale, which did not facilitate the identification of the position of the planned route with respect to the terrain.
- The MORA safety altitudes or *grid MORA* not being displayed on the ND of the Boeing 777s.
- The absence of a study of the en-route phase when the operator carried out the risk assessment prior to opening the route between Douala and Malabo, leading to the risk of dangerous proximity with terrain en route not being identified.

The activation of the EGPWS alerts and the immediate reaction of the crew meant that the collision with the terrain was avoided.

### Measures taken by operator

Following an internal safety investigation, recommendations were made concerning, notably:

- ❑ Improvement in the possibilities of consulting weather information at stopover. This was made possible by the use of a new flight preparation tool and by the crew's direct access to a new application concerning the weather data.

- ❑ Modification of the Malabo and Douala aerodrome sheets.

The operator's instructions on the aerodrome sheets were modified in March 2016. The Douala STAR procedures sheet (used by the crew at the time of the incident) has been modified to show Malabo airport without an insert and at the correct distance from Mount Cameroon.