# Report

Incident on **2 May 2009**
**on approach to Antalya (Turkey)**
to the **Boeing 737-300**
registered **F-GFUF**
operated by **Europe Airpost**

Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile
Ministère de l'Écologie, du Développement durable, des Transports et du Logement

# *Foreword*

*This report expresses the conclusions of the BEA on the circumstances and causes of this incident.*

*In accordance with Annex 13 to the Convention on International Civil Aviation and with European Regulation n° 996/2010, the investigation was not conducted so as to apportion blame or to assess individual or collective responsibility. The sole objective is to draw lessons from this occurrence which may help to prevent future accidents.*

*Consequently, the use of this report for any purpose other than for the prevention of future accidents could lead to erroneous interpretations.*

## SPECIAL FOREWORD TO ENGLISH EDITION

*This report has been translated and published by the BEA to make its reading easier for English-speaking people. As accurate as the translation may be, the original text in French is the work of reference.*

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# *Glossary*

| | |
|---|---|
| ATC | Air Traffic Control |
| MCP | Mode control panel |
| MLW | Maximum Landing Weight |
| NM | Nautical mile |
| PF | Pilot flying |
| PM | Pilot monitoring |

# *Synopsis*

| | |
|---|---|
| **Events:** | Temporary loss of control, stall with AP and A/T |
| **Consequences and damage:** | No damage |
| **Aircraft:** | Boeing 737- 300 |
| **Date and time:** | 2 May 2009 at 7 h 13 UTC[(1)] |
| **Operator:** | Europe Airpost |
| **Place:** | On approach at about 30 NM north of Antalya (Turkey) |
| **Type of flight:** | Public transport of passengers (charter flight) |
| **Persons on board:** | 2 flight crew - 3 cabin crew - 110 passengers |
| **Meteorological conditions in the event area:** | The satellite[(2)] image shows a steady south-westerly flow as well as the presence of mountain waves |

(1)All times in this report are UTC, except where otherwise specified. Three hours should be added to express official time in Turkey on the day of the event.

(2)The crew did not possess this image. The meteorological file at its disposal did not make it possible to identify a mountain wave phenomenon. The satellite image is shown in Appendix.

## 1 - HISTORY OF FLIGHT

Note: The history of the flight is based on testimony from the pilots and analysis of the FDR parameters. The absence of the CVR recording (communications and aural warnings in the flight deck, in particular) and data from ATC (transcript of communications) along with the non-recording of some airplane parameters (invalid data or not usually recorded[(3)] on the airplane type) affected the precision of the scenario.

(3)Invalid parameters: L and R stick shaker, control column positions, efforts on control column. Non-recorded parameter: MCP speed, control column orders, in particular.

The Boeing B737-300 registered F-GFUF, call sign FPO227, was flying the Marseille – Antalya route.

The crew began the descent at 6 h 55 UTC, after a flight of 2 h 55 min. The copilot was PF.

The cabin manager confirmed to the Captain that the cabin was ready for the landing and the cabin crew has seatbelts fastened.

The crew was using the autopilot and autothrottle A/T. They stated that the onboard weather radar was being used in WX + TURB (weather + turbulence) modes. While the airplane was flying over a broken layer of cumulus with variable development, it intercepted the let-down track of the QFU 18L VOR-DME that it captured about 50 NM from Antalya aerodrome.

The engine anti-icing was turned on at 7 h 09 min 27, descending through FL 130 at 240 kt. A short time later, turbulence was noticed: the speed varied between 225 kt and 252 kt while the vertical accelerations varied between +0.54 g and +1.62 g and N1 between 43% and 77%.

The controller asked the crew to reduce to minimum approach speed. The crew said that they selected 220 kt, that's to say 10 kt more than the clean configuration manoeuvre speed at the estimated weight(4). At 7 h 13 min 12, the autopilot switched to altitude acquisition mode and at 7 h 13 min 19 to altitude hold at 11,000 feet. The crew stated that autothrottle A/T was in selected speed mode. The recorded indicated airspeed was 210 kt.

The crew said that they observed a relatively compact cumulus about 2.5 NM in diameter on the let-down track about 25 NM from the runway threshold; its peak being estimated at about 12,000 ft and in addition it appeared clearly on the onboard weather radar image. While they asked for a left-side avoidance manoeuvre where the sky was less cloudy, the controller cleared them for a right-side avoidance manoeuvre.

A 7 h 13 min 33 and about 30 NM from the aerodrome, the airplane that was level at 11,000 ft in clean configuration at 210 kt started a right-side avoidance manoeuvre. The autopilot was engaged in Heading mode(5) and Altitude modes; the crew stated that bank selected on the MCP was 25°. Autothrottle was engaged in speed hold mode and N1 was about 63.5%.

Between 7 h 13 min 34 and 7 h 13 min 36, the airplane entered an area of turbulence caused by the meteorological situation (vertical acceleration varied between +0.5 g and +1.36 g). At 7 h 13 min 38, when the indicated airspeed was 206 kt, thrust lever retard was recorded, followed by a thrust(6) reduction; N1 reached 36.8% and 32.8% at 7 h 13 min 46 while the indicated speed was 199 kt and bank about 23°.

The thrust levers were moved forward, likely manually(7), a short time after a vertical acceleration of +1.45 g was recorded. The speed continued to decay while the engines responded to the throttle advance.

From 7 h 13 min 51, while the speed was 187 kt, the bank to the right increased with a very high roll rate(8). The crew said that they heard the "bank angle(9)" warning and felt the stick shaker activate. At 7 h 13 min 52 the bank angle was about 57° and increasing and N1 reached about 98% and 87%; a thrust lever retard was recorded.

Autothrottle was disengaged at 7 h 13 min 53 while the pitch decreased notably. The recorded aileron deflection resulted from a full left Wheel deflection in order to counter the roll upset; this input being accompanied by a left deflection of the rudder. The autopilot switched to CWS Roll(10) mode then was disconnected about two seconds later. The bank reached its maximum of 102° to the right and the minimum speed of 181 kt was reached.

(4)47.8 Tonnes.

(5)Heading selected on the MCP (

6)It is likely that this thrust reduction was a reaction associated with an environmental disturbance. Analysis of the recorded parameters did not make it possible to determine if it was an ascendant, a favourable wind gradient or something else.

(7)The manufacturer stated that the throttle lever movement rate is consistent with an autothrottle override by the crew.

(8)At this time the thrust asymmetry was about 9 % (N1 GTR1 above N1 GTR2). The N1 values were recorded every second with a lag of 0.5 seconds between the recording of the values from each engine. The differences were calculated by interpolation.

(9)Trigger threshold of this warning: 35° bank.

(10)The autopilot roll control mode having been exceeded.

Note: Between 7 h 13 min 36 and 7 h 13 min 51, with AP engaged, the “pitch trim“ moved from 5.5 to 6.5[11] while the speed was falling from 210 kt to 187 kt and the pitch was increasing from 7° to 9.5°.

The bank decreased towards 90°, a value that was maintained 3 to 4 seconds, while the pitch reached –24.8°[12] at 7 h 13 min 57 with a nose-up elevator position. The speed increased and the descent rate was of the order of –7,000 ft/min; the crew stated that at that moment they were IMC.

The bank to the right decreased then the airplane banked to the left to about 35°. The elevator deflected to nose down. The maximum recorded descent rate during the event was about 12,000 ft/min. The thrust levers were moved forward manually to maximum.

The roll upset lasted eighteen seconds. The minimum altitude reached during the event was 7,576 ft.

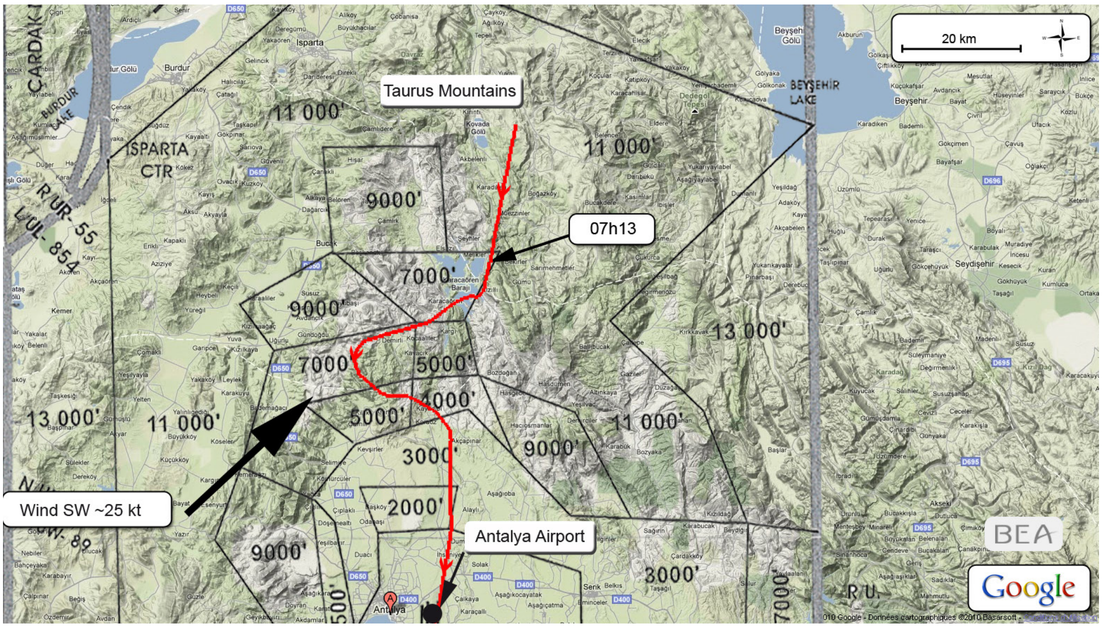
The crew climbed to the initial altitude of 11,000 ft and regained manoeuvring speed in clean configuration increased by 10 kt (220 kt). The autopilot, then autothrottle A/T, was reconnected at the end of the climb.

At the request of ATC, the crew described the violent phenomenon they had encountered. After the landing, at 7 h 27, takeoffs were suspended and airplanes on arrival put in holding for about thirty minutes.

# 2 - ADDITIONAL INFORMATION

## 2.1 Aerodrome Environment

The south-west part of the Taurus Mountains is located north of Antalya aerodrome.




No documentation, official or from the operator, contained any specific instructions relating to the aerodrome, in particular relating to meteorological phenomena concerning the aerodrome environment.

(11) The operator stated that this variation represented about six turns of the wheel at a reduced speed (flaps retracted).

(12) Nose down.

## 2.2 Mountain Waves

A wind equal or superior to about twenty knots and blowing perpendicularly to a ridge line in a sufficiently stable air mass can trigger a mountain wave system. In such a system, in the lower air layer – whose thickness varies between a few hundred and a few thousand metres – the flow of the air is turbulent (turbulent wave under-layer). The air flow in the upper layer is laminar. The turbulent and laminar airflow downwind a mountain is called lee waves.

If there is enough moisture in the air, a characteristic cloud structure develops:

- The high ground that generates the wave can be topped by a "cap cloud" (Sc or Ac). In fact each droplet of water that constitutes it moves with the wind and, once past the ridge line, is subject to compression while descending the slope, thus to warming and drying out, which evaporates it. The sky clears, this is the foehn effect.
- In the airflow under the waves, clouds in the shape of rollers "rotors" (Cu or Sc) can be attached to the transition layer, parallel to the high ground and more or less developed depending on the humidity; their vertical extension revealing the size of the lee wave. Below these rotors severe turbulence can be encountered. Beneath the wind of these clouds there are downdraft movements (as under high ground wind). The vertical speeds near a rotor are around 4 to 8 m/s, sometimes more. The diameter of the rotors can reach 600 metres and accelerations 4 g.
- In the rising air from the lee waves laminar layer, damping frequently causes the formation of Ac type clouds (sometimes As or Ci) with a lenticular aspect.

The vertical amplitude of the waves can reach 2,000 metres with vertical speeds of up to 30 m/s; the max Vz is observed in the first wave downwind.

## 2.3 Extracts from the Manufacturer's Documentation Used by the Operator

The information below is based on the manufacturer's documentation used by the operator.

### 2.3.1 Flight in Turbulent Conditions

The optimal penetration speed in a turbulent atmosphere is 280 kt / M 0.73. If strong turbulence is encountered below 15,000 ft at weight less than the MLW, the speed can be reduced to 250 kt in a clean configuration.

In flight in light to moderate turbulence, the autopilot and/or autothrottle A/T can remain connected as long as their performance is acceptable. Wind or temperature variations as well as large variations in pressure can generate increased thrust lever activity and brief speed variations of 10 to 15 kt.

In strong turbulence, disconnect autothrottle A/T(13) and use AP in CWS. If the trim runs away, disconnect the autopilot. If an approach must be made in an area of strong turbulence, delay flap extension for as long as possible, as the airplane can handle gust loads better in clean configuration.

(13) Use the thrust settings recommended in the FMC.

### 2.3.2 Limitations on Performance of Commercial Transport Airplanes

A wind gradient that improves the performance of the airplane initially becomes noticeable in the flight deck through an increase in indicated speed. This type of manifestation can be a precursor to a windshear that can cause substantial and immediate airspeed decreases and degrade performance. The speed decreases if the tail wind increases or the head wind drops faster than the airplane accelerates. An in-flight upset situation can develop very quickly if this is not countered.

Gradients that exceed the performance capabilities of public transport airplanes have been observed at all altitudes. Crews should be alerted by any indications of the presence of gradient along the desired flight path and avoid all areas with known strong gradients, that's to say those that produce changes of speed greater than 15 kt / attitude of more than 5° / vertical speed variations of more than 500 ft/min, unusual throttle lever positions during a significant period.

Coordination and vigilance on the part of the flight crew are very important. The PM (Pilot Monitoring) should be especially vigilant and call out any deviation from the standards. Avoid any high thrust reduction or change in the trim in response to a sudden increase in speed since that can be followed by a decrease in speed.

### 2.3.3 Airplane Upset

The manufacturer's documentation used by the operator states that an Airplane Upset can generally be defined as:

- Either an unintentional exceeding of one of the following conditions:
  - Pitch attitude greater than 20 deg nose up,
  - pitch attitude greater than 10 deg, nose down,
  - bank angle greater than 45 deg;
- Within the above parameters, but flying at airspeeds inappropriate for the conditions.

The upset recovery techniques ("nose-High" or "nose-Low") assume the airplane is not stalled.

If the airplane is stalled, it is necessary to first recover from the stalled condition by applying and maintaining nose-down elevator until recovery form the stall and stick shaker de-activation.

### 2.3.4 Stall recovery

#### *2.3.4.1 Stall identification*

An airplane may be stalled in any attitude (nose high, nose low, high angle of bank) or any airspeed (turning, in particular). It is not always intuitively obvious that the airplane is stalled.

An airplane stall is characterized by any one (or a combination) of the following conditions:

- ❒ buffeting, which could be heavy,
- ❒ lack of pitch authority,
- ❒ lack of roll control,
- ❒ inability to arrest descent rate.

These conditions are usually accompanied by a continuous stall warning (stick shaker).

#### *2.3.4.2 Automatic systems*

Any time the airplane enters a fully developed stall, the autopilot and autothrottle should be disconnected.

#### *2.3.4.3 Recovery from a fully developed stall*

This part was based on the manufacturer's documentation used by the operator[14].

[14]Reference Boeing 737 CL Flight Crew Training Manual.

To recover from a stall, angle of attack must be reduced below the stalling angle. Nose down pitch control must be applied and maintained until the wings are unstalled. Application of forward control column (as much as full forward may be required) and the use of some nose down stabilizer trim should provide sufficient elevator control to produce a nose-down pitch rate. It may be difficult to know how much stabilizer trim to use, and care must be taken to avoid using too much trim. Stop trimming nose down when you feel the g force on the airplane lessen or the required elevator force lessen.

Under certain conditions, on airplane with underwing-mounted engines, it may be necessary to reduce thrust in order to prevent the angle of attack from continuing to increase.

Once the wing is unstalled, upset recovery actions may be taken and thrust reapplied as needed.

Unloading the wing by maintaining continuous nose-down elevator keeps the wing angle of attack as low as possible, making the normal roll controls as effective as possible.

If normal pitch control then roll control is ineffective, careful rudder input in the direction of the desired roll may be required to initiate a rolling manoeuvre recovery. Warning: Too much rudder applied too quickly or held too long may result in loss of lateral and directional control.

To maintain level flight at bank angles beyond 67 deg requires a larger load factor than 2.5 g Nose-up inputs on the control column at bank angles greater than 60° do not change the pitch attitude appreciably and can lead to loads that can exceed structural design limits and exceed the stall angle of attack of the wing.

At a weight of 48 tonnes as in the case of this event, with wings level, at 10,000 feet, reduced thrust (Idle), a forward CG:

- the manœuvring speed was 210 kt,
- the stick shaker speed was 158 kt,
- the stall speed was 138 kt,
- The speed of stall at 60° bank was 198 kt.

## 3 - LESSONS LEARNED

It was not possible to determine or to precisely quantify the causes of the strong increase in the roll rate that led to the loss of roll control and the airplane stall but the stall margins were reduced by the decrease in speed below of the clean configuration manoeuvring speed and the bank of the airplane.

Shortly after a normal load factor of 1.45 g, associated with the mountain waves situation, was recorded, the combination of the rapid manual increase in the thrust (that led to a nose-up moment and a slight thrust asymmetry causing an increase in the roll rate to the right) and the low speed (187 kt) led to the loss of roll control and to the stall of the airplane. The crew ruled out any asymmetric icing on the airframe as a contributing cause.

In order to restore normal flight conditions the manufacturer recommends to recover from the stall by applying up to full nose-down elevator and consider trimming off some control force and reducing the engine thrust, then roll control may require as much as full aileron and spoiler input and use of coordinated rudder.

Making the crew aware of potential mountain waves meteorological conditions over high ground would have made them more vigilant, especially in relation with:

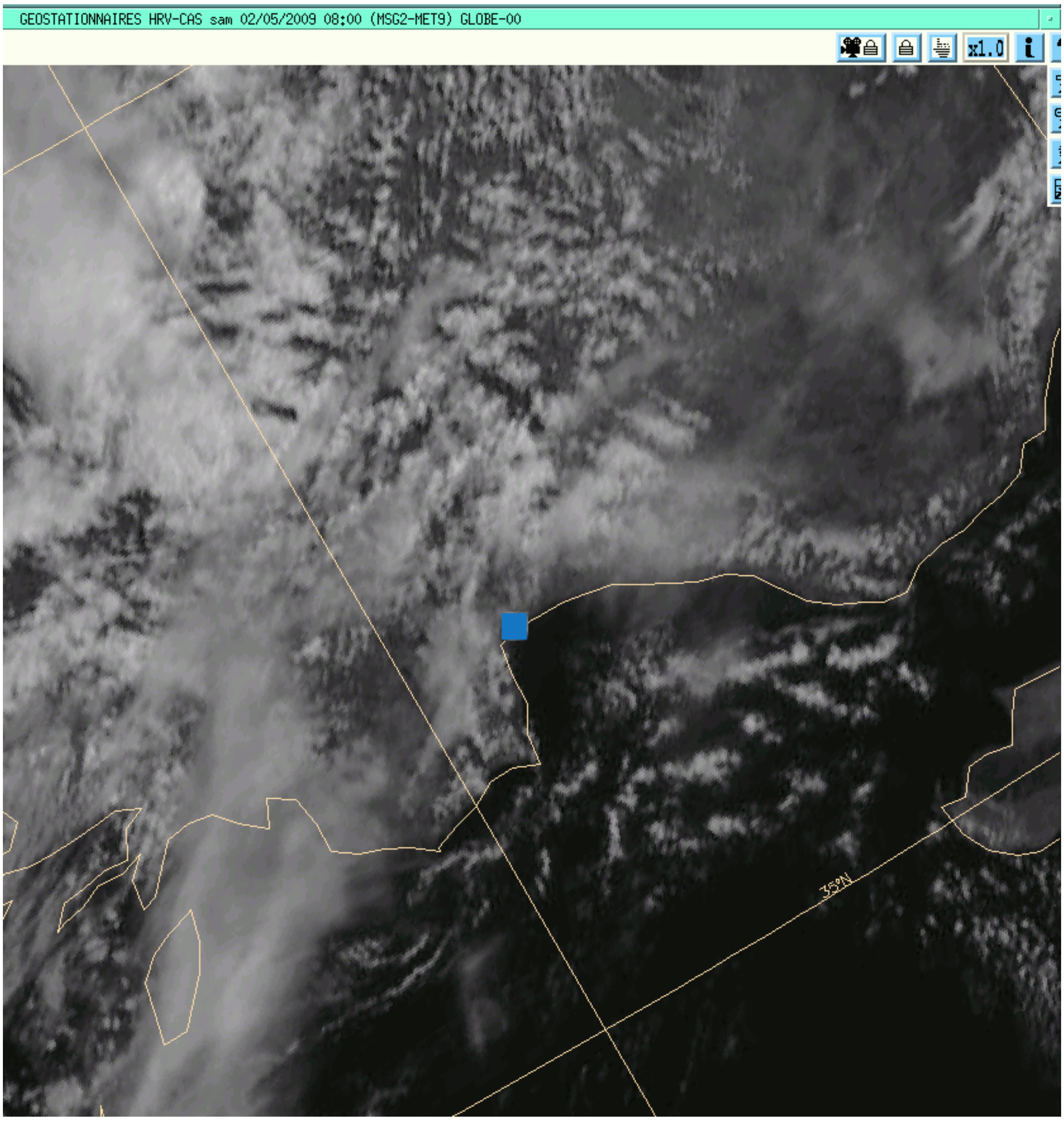
- the behaviour of the automatic systems: autothrottle, stab trim;
- speed, pitch attitude and N1 parameters.

The following steps have been put in place by the operator:

- pilot training by a Météo France meteorologist on meteorological phenomena;
- additional four hour simulator training session for pilots;
- pilot awareness campaign on the suddenness and violence of some environmental phenomena that may exceed the possible responses of the automatic systems and require the flight crew to intervene manually using the flight and thrust controls.

# Appendix

## Satellite image at 7 h 00 UTC



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