



**MINISTÉRIO DAS OBRAS PÚBLICAS, TRANSPORTES E COMUNICAÇÕES**

GABINETE DE PREVENÇÃO E INVESTIGAÇÃO DE ACIDENTES COM AERONAVES  
GPIAA

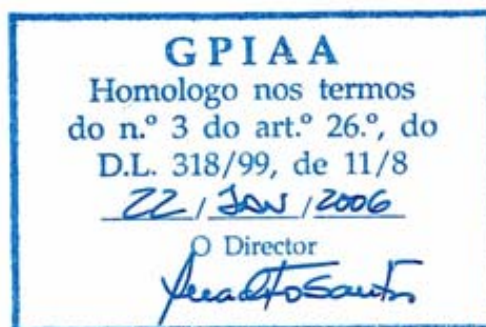
**FINAL ACCIDENT INVESTIGATION REPORT**

**AIRBUS A321-211**

**G-VOLH**

**FUNCHAL AIRPORT**

**18<sup>TH</sup> APRIL 2001**





## FOREWORD

This report expresses the technical conclusions determined by G.P.I.A.A. Investigation Commission about facts and causes involved in this occurrence.

According to Annex 13 to the International Civil Aviation Organization Convention (Chicago 1944), to the Council Directive nr. 94/56/EC (21<sup>st</sup> November 1994) and to nr. 3, 11<sup>th</sup> article of Decree-Law 318/99 (11<sup>th</sup> August), it is not the object of this report to determine blame or liability but solely to identify causes and deficiencies capable of undermining flight safety and to gather information for preventing further occurrences of similar circumstances.



## SYNOPSIS

On 18th April 2001, at 07:26 UTC hours, the AIRBUS A321-211 G-VOLH departed Manchester, with 7 crew and 167 passengers on board, for a charter flight with Funchal Airport (Madeira Island) as destination.

The flight was an uneventful transit until the landing. The aerodrome was clearly visible and the commander made a visual approach in accordance to the aerodrome STAR charts.

The approach was stabilized, despite the aircraft encountering a windshear at GELO. At 30 feet RA the commander noticed that the aircraft had developed a high sink rate and he attempted to decrease the rate of descent with full aft side stick but the aircraft landed heavily and bounced. At the second touch down the aircraft tail contacted the runway.

The aircraft had suffered tail structural damage. There were no personal injuries.

The landing occurred at 10:46 UTC hours.



# 1. FACTUAL INFORMATION

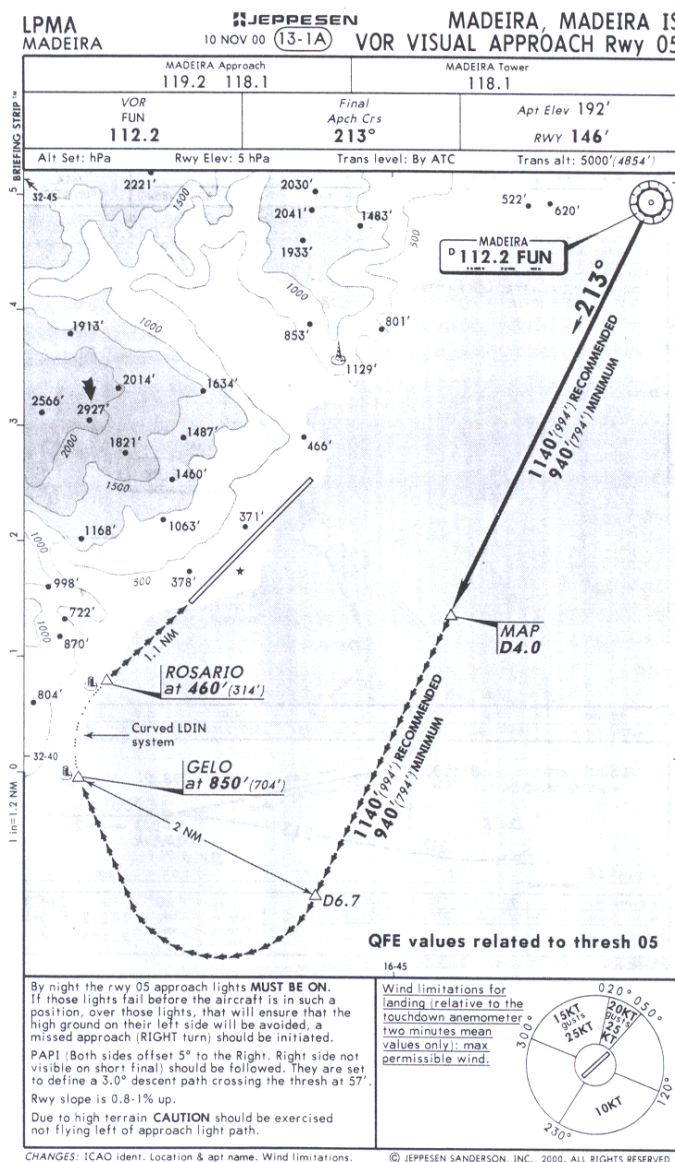
## 1.1 History of the flight

The aircraft had departed Manchester at 07:26 hours<sup>1</sup> and made an uneventful transit to Funchal Airport Madeira.

The surface wind at aerodrome was 020° at 12 kts, the direction varying from 350° to 050°.

The aircraft commander was the handling pilot and although it was his third flight into Funchal in the A321, he had regularly operated there in the A320.

The commander carried out a comprehensive brief for a VOR/Visual approach to Runway 05 at Funchal. The procedure was to pass over the Madeira VOR/DME, located approximately 5 nm to the northeast of the airfield. The aircraft was then to proceed out-bound on the 213° radial descending to an altitude of 1,140 feet recommended but no lower than 940 feet minimum. This was the downwind leg with the Missed Approach Point 4 nm from the VOR/DME abeam the aerodrome.



**Figure 1**

<sup>1</sup> The time in this report refers to UTC hours.



The aircraft was descended to 1,700 feet using the autopilot and autothrust. At that altitude the autopilot was disconnected but the autothrust remained in. The aircraft passed over the Madeira VOR at 1,500 feet and continued to descend to 1,200 feet at which altitude it was flown level.

The aerodrome was clearly visible and the commander continued the approach visually in accordance with the procedure. The aircraft was configured for landing, with the base turn initiated at 6.5 nm from the Madeira DME.

The PAPIs at Funchal were offset 5° to the right in order to permit the pilot to acquire the 3° descent path in the turn onto final approach which was assisted by a curved approach lighting system of lead-in lights to the Runway 05 threshold.

The approach crossed two reporting points, Gelo at 850 feet and Rosario, 1.1 nm from the runway threshold, at 460 feet. The aircraft approach was stabilized despite a windshear encounter at Gelo.

The commander stated that the approach appeared to be normal with automatic calls at 50 feet, 30 feet, 20 feet and retard. Coincident with the automatic 30 feet call, the commander closed the thrust levers as the rate of descent increased. He attempted to arrest the rate of descent with full aft side stick but the aircraft landed heavily and bounced. During the bounce he reduced aft side stick but still maintained a reduced pitch up demand; pitch attitude continued to increase. At the second touch down (the point at which the tail contacted the ground) the commander, conscious of the nose landing gear, re-applied and maintained full aft side stick in order to prevent it impacting heavily with the runway surface.

The aircraft was taxied to its parking stand where it was inspected. Another aircraft confirmed the crew's suspicion that they had suffered a tail strike.

The aircraft landing weight was calculated at 71,483 kg with Vref 137 and Vapp 142.

### **Initial Approach**

Whilst in an initial descent from cruise altitude the commander had given a comprehensive briefing about the approach and landing at Funchal.



15 DEC 00

10-0

AIRFIELD BRIEF

MADEIRA, MADEIRA IS

Madeira  
FNC - LPMA

**CATEGORY C**

**RWYs 05/23 (2781m)  
NO ILS. NO RADAR  
ELEV 192ft.**

A comprehensive brief on the special requirements is included with the Jeppesen Flight Guide. See page 10-6.

**AIR TRAFFIC CONTROL**

Procedural control only, expect to be held at 'FUNOR' inbound. In the event of a Go-Around be prepared to re-enter the visual circuit pattern.

**SPECIAL REQUIREMENTS**

**CAPTAINS ONLY APPROACH AND LANDING.**

All TAKE-OFFS and LANDINGS require VMC. No NIGHT landings for Airtours aircraft. When landings for Airtours aircraft.

RWY 05. It is recommended that aircraft approach "GELO" (identified by the large white banana packing sheds) on a curved track in order to facilitate line-up and to avoid the rising ground. Note the curved approach lights on poles; these should be to the left of the aircraft as the westerly limit.

Due to the nature of the runway extension, expect up draughts on short final for RWY 23 with southerly winds.

Use of SELECTED SPEED / AUTOTHURST and AUTOBRAKE MED is recommended.

**GENERAL**

On departure due to the short taxi time Cabin Crew should be advised to commence their passenger briefing as soon as the doors are closed.

**Figure 2**

The briefing included reference to the check heights of 850 feet and 460 feet at Gelo and Rosario respectively.

The possibility of encountering positive windshear on late finals was also discussed. Medium autobrake was selected. The first stage of flap was selected at 3,800 feet followed by subsequent stages at 3,200 feet and 2,800 feet; the landing gear was lowered prior to the selection of the third stage.

At 1,700 feet, autopilot 1 was disconnected but autothrust remained engaged with a selected speed of 156 kts. The aircraft passed over the Funchal VOR twenty seconds later at 1,500 feet amsl. Movements in the FDR recordings of the relevant sidestick indicated that the commander was the handling pilot. The aircraft lev-



elled at 1,200 feet and maintained a track of approximately 212° M. Typical wind directions and speeds of 015°/28 kts were recorded during this period of level flight together with aircraft drift angles in the order of 2° left. At a distance of one mile still to run on the downwind leg, ATC advised that the aircraft was clear to land on runway 05 and that the wind was 020° at 9 knots. At a point 6.5 nm past the VOR the aircraft commenced a right turn and final descent.

### **Final Approach**

During the right turn the final stage of flap and a reduced speed of 142 kts were selected; ground spoilers were armed. The first officer called out the pre-briefed check height of 850 feet but the recorded data showed that this call was made whilst the aircraft was still 1 nm short of Gelo. Twenty five seconds later, just as the commander stated that he had the PAPIs in sight, a GPWS warning of 'Terrain Ahead' was recorded on both FDR and CVR. This was immediately followed by a warning of "Windshear, windshear, windshear" as the aircraft passed over Gelo whilst descending through 660 feet. During the initial period that the windshear warning was active, the FDR recorded normal acceleration values in the order of 1.27g. Engine power increased as the rate of descent decreased to zero and the aircraft began to climb. The commander applied forward sidestick, lowering the pitch attitude of the aircraft. The climb ceased at 700 feet and the aircraft began to descend again. During this latter period, normal accelerations down to 0.75g were recorded.

Whilst the aircraft was in the right turn towards Rosario the commander commented on how positive the windshear had been. The aircraft briefly levelled at 540 feet before descending once again over ROSARIO at an approximate flight path angle of 3°. During the initial part of this final descent airspeed fluctuations between 141 kts and 148 kts, ground speeds ranging from 123 kts to 127 kts and typical wind parameters of 010° to 030° at 15 kts to 20 kts were recorded.

ATC reported the touchdown wind as 020°/11 kts as the aircraft descended through 400 feet and a corresponding automatic height call was made. From 350 feet radio altitude down to 218 feet radio altitude (the last point that the aircraft was over the sea), both airspeed and ground speed remained relatively constant at



values of 140 kts  $\pm$  2 kts and 125 kts  $\pm$  1.5 kts respectively. Just after the automatic height call of “three hundred” was made, the commander commented “wait for it...”. In discussion with the crew after the event, the commander stated that the comment was made with the expectation of encountering further positive windshear at that time. The recorded wind parameters showed wind speed slightly decreasing from 18 kts to 15 kts and wind direction had become more northerly but was still giving a headwind component.

During the ensuing two seconds, the aircraft passed over the road that ran around the south west end of the airfield and then over the end of the elevated airfield at radio altitudes of 147 feet and then 57 feet.

Pitch attitude (approximately 5° nose up) and ground speed (126 kts) remained unchanged over the next four seconds but airspeed decayed from 141 kts to 131 kts. A one-second reduction in values of normal acceleration to a minimum of 0.92 G was observed during this period with the lowest value occurring as the aircraft descended through 34 feet radio altitude. Additionally, the recorded values of angle of attack increased. The commander muttered an exclamation at the time of the reduction in normal acceleration, closed the throttles (thus disconnecting the autothrottle system) and, at 23 feet radio altitude, applied nearly full aft sidestick for 0.5 seconds before briefly relaxing to neutral. Descent rate had increased to a calculated value of 720 ft/min. Maximum aft sidestick was reapplied as the aircraft descended through 11 feet radio altitude with the sink rate then reducing through 660 ft/min.

The recorded wind values at the end of this four-second period showed a decrease in wind speed to 12 kts and a change in direction to 336°. These values are consistent with a reduction in headwind component of 10 kts and correlate well with the observed reduction in airspeed over that period.

### **Touchdown**

Pitch attitude had started to increase with the application of full aft sidestick and the aircraft contacted the ground just over one second later at 132 kts; a normal acceleration of 2.04 g's was recorded at touchdown. Other parameter values recorded at touchdown were; pitch attitude increasing through 7.7° nose up and roll



attitude was wings level. Automatic height calls of “fifty”, “thirty”, “twenty” and “retard” had been announced and were recorded on the CVR during the final seconds of flight. Windshear alerts were inhibited below 50 feet and none were recorded.

At touchdown both main gear squat switches closed and ground spoilers deployed within one second as the aircraft made a low bounce. At touchdown, the commander relaxed the sidestick input from full aft to approximately 30% of aft travel. He maintained that position for the first one and a half seconds of the bounce as pitch attitude continued to increase. The sidestick was neutralised for the remaining one second of the bounce. The maximum pitch attitude of 10.9° nose up was recorded 0.25 seconds before the aircraft made a second touchdown at airspeed of 129 kts; a normal acceleration of 1.47 g was recorded at the moment of contact. From the geometry of the aircraft it is considered likely that the tail section contacted the runway during this second touchdown.

As the aircraft pitched down, full aft sidestick was re-applied for four seconds by which time the nose gear had contacted the runway. Thrust reverse and medium autobrake was used to slow the aircraft down to 50 kts at which point the reversers were stowed and the crew reverted to manual braking.

### **Post Landing**

As the aircraft taxied to the stand, another aircraft on the frequency asked ATC if the crew of the G-VOLH knew that the tail had contacted the ground. From conversation recorded on the CVR it was apparent that the crew realised that the tail-strike had occurred. The commander asked the first officer not to start the APU and instead to request a GPU on the stand. Once on stand, engine 2 was shut down first to facilitate the aircraft being connected to the GPU.

Whilst discussing the landing, the commander stated that the 'aircraft sank at 30 feet' and that he had been expecting positive windshear instead.

Graphical traces of pertinent parameters recorded during the approach and landing are shown in Figures 3 and 4.

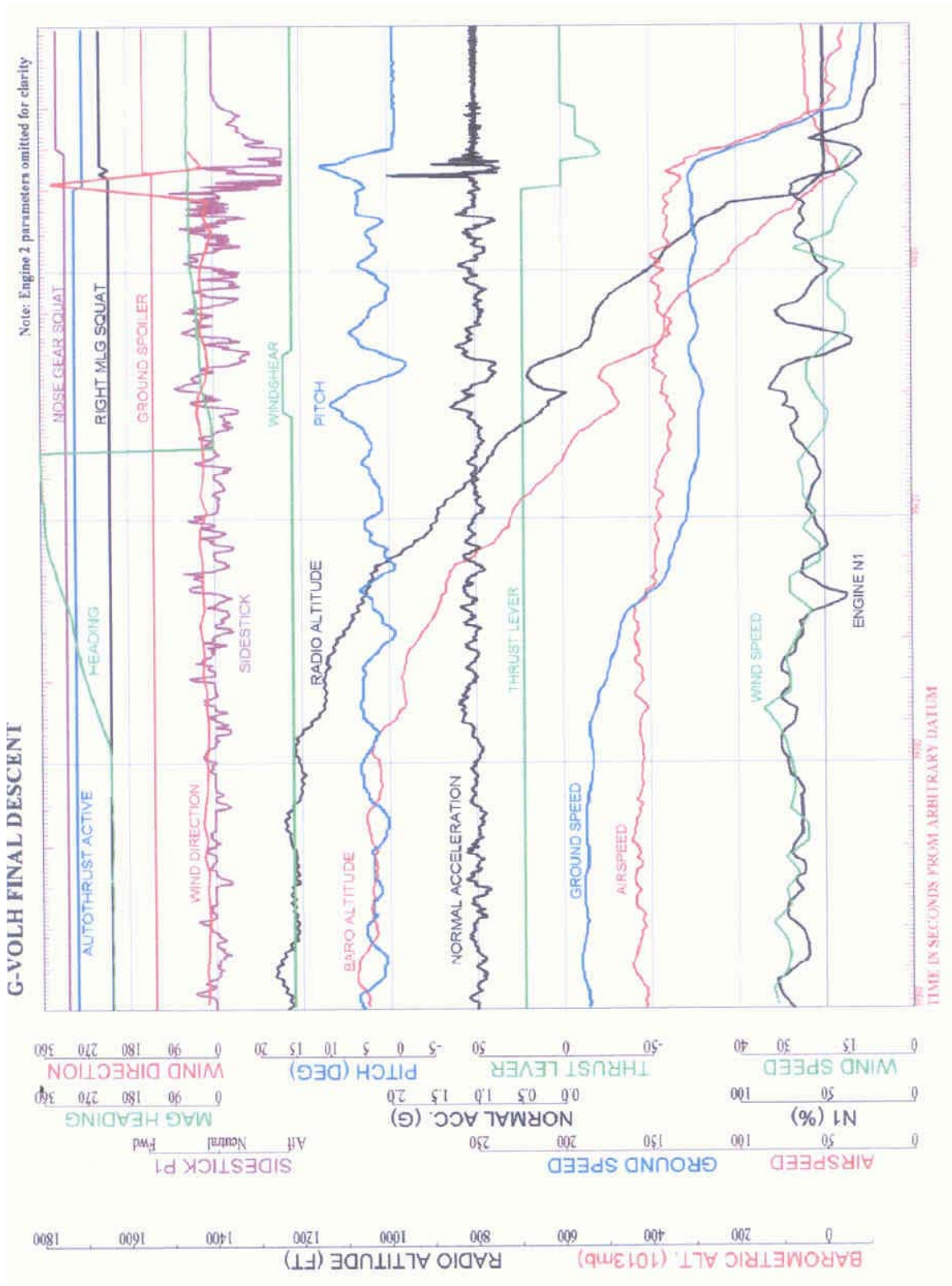


Figure 3

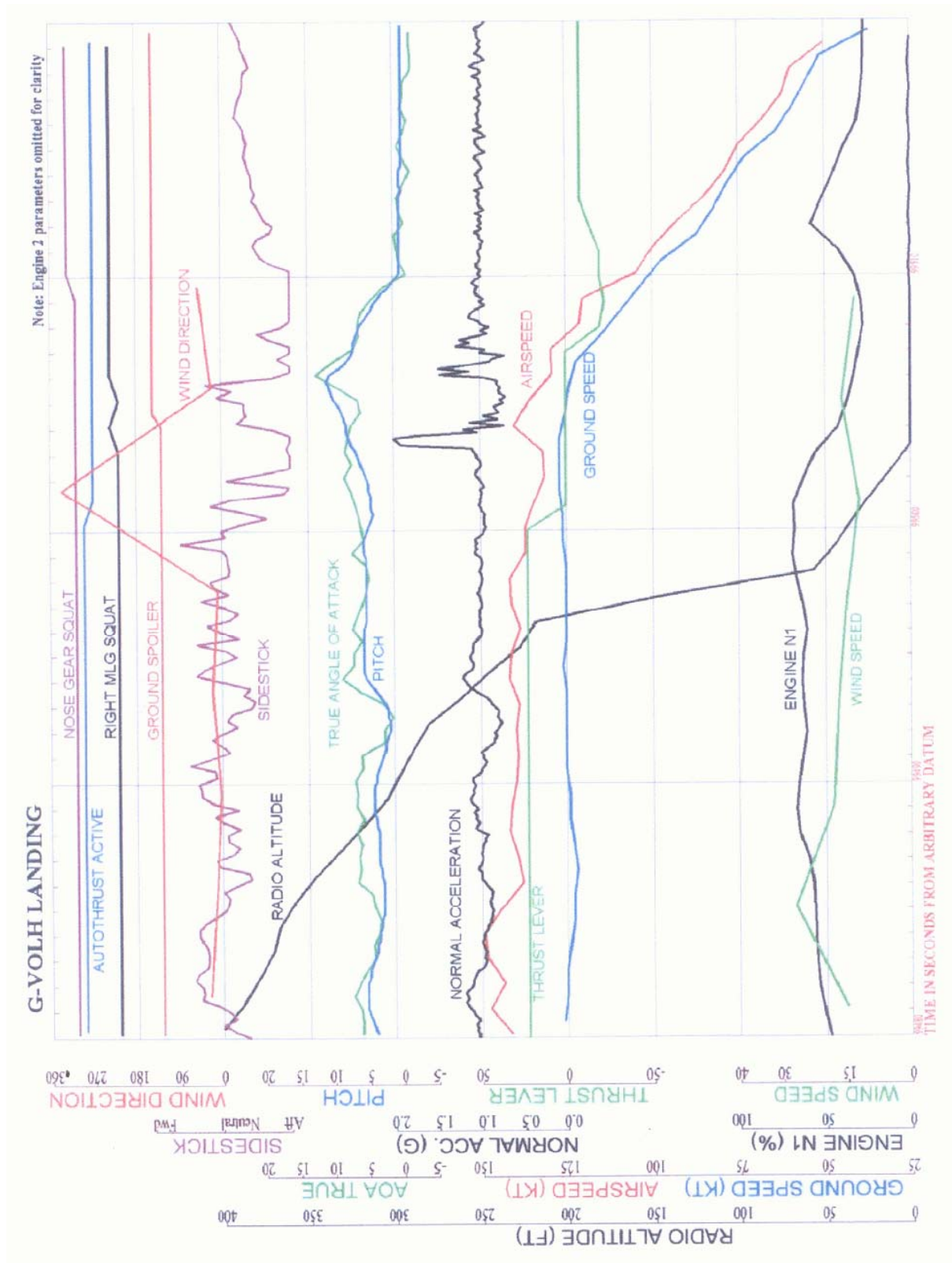


Figure 4

## 1.2 Injuries to persons

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	-	-	-
SERIOUS	-	-	-
MINOR/ NONE	7	167	

## 1.3 Damage to the aircraft

### *Engineering Report*

Examination of the aircraft at Funchal showed extensive damage to the lower fuselage over a distance of some 5 metres. The lower skin was deeply abraded from Frame 61 (near the bulk cargo door) to around Frame 70 (rear pressure bulkhead). Within this area of abrasion a number of the fuselage frames (61 to 69) had suffered structural damage from the vertical loads applied in the contact with the runway. The abrasion marks were parallel with the fuselage axis, showing that there was negligible aircraft yaw at contact.



**Figure 5 – Lower fuselage**

## 1.4 Damage to third parties

None.



### 1.5 Pilots Information

INFORMATION	COMMANDER	COPILOT
<b>Identification</b>		
Sex:	Male	Male
Age:	43 years	39 years
Nationality:	British	British
<b>Licence Details</b>		
License held:	ATPL	ATPL
Nr.:	AT/234744K/A	AT/231103H/A
First issued:	06 APR 1995	28 JAN 1998
Expire date:	06 APR 2005	28 JAN 2008
Ratings:	A319/320/321 SAAB 340 PIPER PA23/34/44	A319/320/321 B757/767 SAAB 340
Instrument rating renewal date:	30 NOV 2001	31 MAR 2002
Flight radio-telephony license nr.:	AT/234744K	RT/231103H
First issued:	06 APR 1995	28 JAN 1998
Expire date:	06 APR 2005	28 JAN 2008
<b>Qualifications</b>		
Funchal last visit date:	04 APR 2001	Unrestricted to Copilots
Validity:	6 months from last visit	Unrestricted to Copilots
<b>Currency</b>		
Proficiency check (date):	23 NOV 2000	24 MAR 2001
Line check (date):	30 NOV 2000	17 MAR 2001
Safety/Emergency check (date):	14 NOV 2000	02 MAI 2000
<b>Medical Certificate</b>		
Class:	1	1
Date issued:	14 FEB 2001	13 FEB 2001
Limitations:	None	None
<b>Experience</b>		
Total flying hours:	5.050:00	8.000:00
Total hours on type:	300:00	486:00
Hours in last 90 days:	120:00	78:85
Hours in last 28 days:	55:00	9:25
Hours in last 24 hours:	3:45	3:35
<b>Duty Times</b>		
Start of duty:	06:20 hours	06:20 hours
Planned end of duty:	18:25 hours	16:10 hours
Length of preceding rest period:	> 12:00 hours	20:00 hours



## 1.6 Aircraft Information

<b>Aircraft</b>	<p>Designation of aircraft: AIRBUS A321-211</p> <p>Serial nr.: MSN 823</p> <p>Date of Manufacture: 15 MAY 1998</p> <p>Nationality and Registration marks: G-VOLH</p> <p>Registered Owner and Operator: Airtours International Airways, Ltd</p> <p>Certificate of Airworthiness: CAA issued on 20<sup>th</sup> MAY 1988, valid until 14<sup>th</sup> May 2001</p> <p>Total Time: 12.619:31 hours</p> <p>Total Cycles: 4.496</p> <p>Previous Inspection: 2C, C, 4A, 2A, A on 7<sup>th</sup> APR 2001</p> <p>Next Inspection Due: 2A due by 15<sup>th</sup> JUL 2001</p> <p>Total Time: 12.619:31 hours</p> <p>Total Cycles: 4.496</p> <p>M.T.O.W.: 89.000 kg (196 210 lb)</p> <p>A.T.O.W.: 80.774 kg</p> <p>C. of G. at Take-off: 24.1%</p> <p>Landing Weight: 71 483 kg</p> <p>C. of G. at Landing: 25,5%</p>
<b>Engines</b>	<p>Constructor: General Electric</p> <p>Type: 2 x CFM56-5B3/P</p> <p>Date of Manufacture: N/A</p> <p><u>Engine # 1</u></p> <p>S/N: 779383</p> <p>Total Time: 134:39 hours</p> <p>Time Since Last Inspection: New</p> <p>Time Since Overhaul: New</p> <p><u>Engine # 2</u></p> <p>S/N: 779374</p> <p>Total Time: 134:39 hours</p> <p>Time Since Last Inspection: New</p> <p>Time Since Overhaul: New</p>

### 1.7 Meteorological information

Weather at the aerodrome was surface wind 020° at 12 kts, the direction varying from 350° to 050°, visibility 10 km, cloud BKN at 1,600 feet and SCT 3.300 feet with OAT 16° C and Dew point 11° C. Aerodrome QNH was 1019 mb.

### 1.8 Aids to navigation

Not relevant to the investigation.

### 1.9 Communications

There was a standard and indubitable communication between aircraft and tower.

### 1.10 Airport Information

#### *Madeira International Airport*



**Figure 6**

Funchal Airport is located on the eastern side of the island of Madeira. The high ground to the west of the airport rises to 6,110 feet. As a result of turbulence cre-



ated by the adjacent terrain when landing on Runway 05, wind limitations were promulgated on the Jeppesen approach charts. At the time of the incident these were: With winds from the sectors 300° to 020°, 15 kts with gusts up to 25 kts and from 020° to 050° 20 kts gusts to 25 kts.

The Jeppesen airport briefing pages (10-6 & 10-6A) also carry the following information:

### ***Turbulence***

Attention should be paid to the WIND DIRECTION INDICATORS located on the south side of the runway, near each touch-down area. They will reflect unexpected wind changes.

Occasionally they will indicate wind from opposite directions.

When landing on rwy 05 wind differences higher than 5 kts, between Rosario and Tower, may indicate turbulence on final. Headwind or nearly so, up to 15 kts will cause “**WEAK**” turbulence on final;

Wind of 15 kts from sector 020° to 050° MAG (clockwise) may cause “**MODERATE**” turbulence; Wind of 15 kts or even less from sector 300° to 020° MAG (clockwise) may cause “**SEVERE**” turbulence;

Down or updrafts are to be expected near the threshold of runways 05 and 23.

## **1.11 Flight recorders**

The two solid state recorders fitted to the aircraft (two-hour CVR and 25 hour FDR) retained a record of the entire event. In the following narrative all quoted barometric altitudes are above mean sea level and have been corrected to reflect the applicable QNH of 1018 mb.

## **1.12 Information on the local of the accident**

The examination of the runway showed a single mark from the contact with G-VOLH, some 13 metres long, within the normal touchdown zone and close to the runway centre line (Figures 7, 8 & 8-A).



**Figure 7**



**Figure 8**



**Figure 8-A**

From the geometry of the impact damage, the aircraft pitch attitude would have been between 10° and 11° relative to the runway.

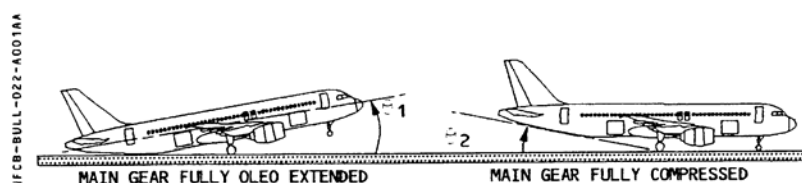
The FCOM Bulletin (Nr. 22/2 April 99) from Airbus Industries shows the corresponding tail contact angles, with oleos fully compressed, to be 9.7° for the A321 and 11.7° for the A320.

**A/C GEOMETRY LIMITS**

A consideration for avoiding a tail strikes is to be aware of the aircraft geometry limits.

Two limits are critical :

- the geometry limit corresponding to main gear oleo fully extended ( $\Theta_1$ )
- the geometry limit corresponding to main oleo gear fully compressed ( $\Theta_2$ ).



	A319	A320	A321
$\Theta_1$	15.7°	13.7°	11.4°
$\Theta_2$	13.9°	11.7°	9.7°

*Note : On A321, the installation of a TFS antenna decreases these values.*

**Figure 9**

FCOM Bulletin N° 22 Page 1 of 5

Examination of the aircraft's technical records showed no previous entry which would have had a bearing on this accident.

**1.13 Medical and pathological information**

Both pilots possessed valid medicals and indicated no restrictions on their capabilities. There were no personal injuries to all aircraft occupants.

**1.14 Fire**

No fire broke out as a result of the incident.

**1.15 Survival aspects**

No-one was injured.

**1.16 Tests and research**

FDR and VCR analysed.



## 1.17 Organizational and management information

There are strict requirements placed on commercial airlines operating to Funchal with regard to both training and recentness.

LPMA
**JEPPESEN**  
10 NOV 00 **10-6**
MADEIRA, MADEIRA IS  
MADEIRA

---

**AIRPORT BRIEFING**

---

**SPECIAL PROCEDURES AND OPERATING LIMITATIONS**

**Operating at Madeira Aerodrome**  
The aerodrome is located on a plateau on the East coast and the ground raises rapidly very close to the aerodrome. This generates wind variations and turbulence. Severe low altitude wind shear conditions and microbursts are to be encountered.  
STRAIGHT-IN APPROACHES ARE NOT AUTHORIZED FROM MADEIRA VOR TO RWY 23.

1. Applicability  
The following items 2 & 3 are mandatory to scheduled and non-scheduled revenue flights involving aircraft with a capacity in excess of 10 passengers.
2. Minimum Experience Requirements  
To operate at Madeira aerodrome the Pilot-in-Command must meet the following requirements:
  - At least 200 flying hours as captain on that type of aircraft;
  - recent operation to Madeira aerodrome, which means to have performed there at least one landing and take-off in the last 6 months. If not, at least a flight to Madeira assisted by a qualified pilot on the right seat is mandatory.
3. Minimum Training Requirements  
In order to operate to Madeira Airport, the operator must establish and accomplish beforehand a training program concerning the type of aircraft he is going to use. This training must include at least a local flight with landings and take-offs by day and night in both directions emphasizing:
  - the take-off flight path to rwy 23;
  - the take-off flight path to rwy 05;
  - the balked landing (go around initiated in landing configuration from very low height) in both directions;
  - the let-down and approach to both runways;
  - the operational effect of rwy slope, reduced dimensions and associated safety margins.

The above mentioned training on actual type of acft may be substituted by a specific simulated flight training program for Madeira if previously accepted and certified by the operator's Civil Aviation Authority and approved by the Portuguese Civil Aviation Authority on a case by case basis.
4. Procedures to accomplish in simulator training programmes:  
RWY 05 and RWY 23:
  - Take-off with engine failure after V1
  - Relight failed engine
  - VOR approach
  - Balked landing an GO AROUND
  - Visual approach
  - Landing
  - Weather Conditions - Winds: The maximum winds indicated as wind limitations in paragraphs 1.b. & 1.c. (Operating procedures and limitations). Severe turbulence, windshear and up and downdrafts must be included in the different approaches
  - One landing at night must be executed for each runway.
5. After the accomplishment of the simulator training programme, one landing and Take-off in Madeira Airport as Pilot Flying on the left seat with the qualified captain in Madeira Airport on the right seat is mandatory before operating as a qualified captain.
6. The captain qualified in Madeira Airport in one type of aircraft changing to another type must do the simulator training mentioned in paragraph 4. and land and take-off himself (and not seating on the right seat) in the first flight in the new type of aircraft. Or, instead of the simulator training, he will land and take-off in both runways without passengers on board.

**Responsibility**  
Compliance with operating limitations is mandatory. Any landing or take-off performed above stated wind limits will be reported by Madeira Airport authorities to the Portuguese Civil Aviation Authority for appropriate action.

**Operating Procedures and Limitations**

1. \*Wind/Turbulence
  - a. Wind Information  
On downwind and final approach to rwy 05 the Control Tower will provide two minute mean winds at Rosario and touch-down. Instantaneous wind read out will be provided at pilot's request. For greater wind intensity and gust than those mentioned in paragraph 1.b. (see 10-6A), the Control Tower will:

CHANGES: ICAO ident. Location and airport name. © JEPPESEN SANDERSON, INC. 1993, 2000. ALL RIGHTS RESERVED.

Figure 10

The operator had fully complied with these and the flight crew were properly qualified and experienced to undertake the flight.



**1.18 Additional information**

Not relevant.

**1.19 Useful or effective investigation techniques**

None.



## 2. ANALYSIS

For a given aircraft configuration the lift generated by the wings is proportional to a function of their true angle of attack and to the square of the airspeed. The angle of attack function is essentially parabolic in nature with the positive slope section of the graph being the area of relevance in this case. The negatively sloping section is applicable to stalled airflows at very high angles of attack.

From information obtained from the aircraft manufacturer and the flight data it can be shown that, to have maintained the same rate of descent during the final stages of flight, the 10 kts reduction in airspeed observed would have required the aircraft to be pitched up to increase the true angle of attack by approximately  $2.7^\circ$ . To reduce the rate of descent, as can normally be expected during the flare before touchdown, the angle of attack would have to increase still further. The possibility that the reduction in recorded airspeed values was an artefact of position errors within the pilot/static system was discounted by comparison with the recordings of previous landings and the fact that the pitch attitude did not change significantly over the period of the reduction.

As stated in former reports made on previous A321 tailstrike occurrences, the A321 has an increased fuselage length over the similarly designed A319 and A320 series aircraft leading to a reduced ground to tail clearance for a given pitch attitude. The FDR showed that the pitch attitude of the aircraft during the final stages of the accident approach was higher than that recorded during other similarly configured landings. It can be seen from the recorded data that, with an initially high pitch attitude, any required increase of pitch attitude due to a reduction in headwind in addition to that needed to reduce the rate of descent just prior to touchdown; the tailstrike clearance margin is eroded.

However, it should be noted that the pitch attitude at the first touchdown was insufficient to result in tail-to-ground contact. In common with two previously reported occurrences, it was the subsequent bounce and application of full aft sidestick to cushion the second touchdown that resulted in the pitch attitude continuing to increase and resulting in the tail striking the ground.



Despite the earlier positive windshear encounter at GELO, the commander had regained a stabilised approach with some light turbulence. The aircraft was correctly positioned on the 3° flight path from ROSARIO with the air speed fluctuating between 141 kts and 148 kts with a Vapp speed required of 142 kts.

At the point where the commander closed the thrust levers and began to flare the aircraft, there was a coincident loss of 10 kts of head wind component. This loss was significant and despite the flare, rate of descent momentarily increased. At such a late stage of the approach, the only action available to the pilot to arrest the rate of descent was to raise the nose. The full aft side stick applied began to reduce the rate of descent but the aircraft touched down heavily at 131 kts.

The tail did not at that point contact the runway but, by maintaining approximately 30% of aft side stick, the aircraft nose had continued to pitch up. The nose up pitch increased from 7.7° on the first touchdown to 10.9° in .25 seconds before the second touch down.

The manufacturers FCOM Bulletin No 22/3, states that the aircraft geometry limit with the main gear oleo uncompressed for the A321 is 11.2°. This compares with 13.5° for the A320, which the commander normally operated into Funchal.

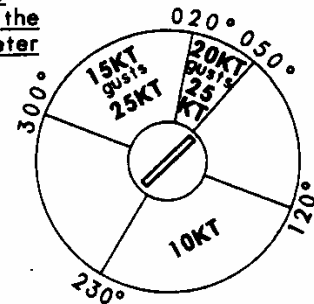
### 3. CONCLUSIONS

#### 3.1 Findings

- Both pilots possessed airline transport pilot's licences and had valid medicals issued by the appropriate authorities;
- Limits concerning crew time, flying time and rest time were complied with;
- The flight crew were properly qualified and experienced to undertake the flight.
- The Commander was qualified for Funchal Airport operation;
- The operator had fully complied with the strict requirements placed on commercial airlines operating to Funchal.

- The meteorological conditions were suitable for the required visual approach as settled at Funchal approach charts. Wind surface at RWY 05 was 020° at 12 kts, varying from 350° to 050°.

Wind limitations for landing (relative to the touchdown anemometer two minutes mean values only): max permissible wind.



#### 3.2 Causes

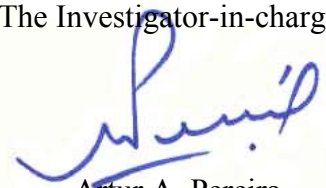
The investigation concluded that the marked backing of the wind, probably due to turbulence from the adjacent high ground, had caused the loss of headwind component.

The application of full aft side stick had reduced the vertical speed of the initial touch down. In an attempt to cushion the second touch down by maintaining a degree of aft side stick during the bounce, the aircraft had continued to pitch up beyond the aircraft geometry limit causing the tail section to contact the runway.

#### 4. SAFETY RECOMMENDATIONS

This Report does not sustain any Safety Recommendations.

The Investigator-in-charge



Artur A. Pereira

Lisboa, 11<sup>th</sup> January 2006.



## TABLE OF CONTENTS

	Page
FOREWORD .....	3
SYNOPSIS .....	5
<b>1. FACTUAL INFORMATION</b> .....	<b>4</b>
1.1 History of the flight .....	4
1.2 Injuries to persons .....	12
1.3 Damage to the aircraft .....	12
1.4 Damage to third parties .....	12
1.5 Pilots Information .....	13
1.6 Aircraft information .....	14
1.7 Meteorological information .....	15
1.8 Aids to navigation .....	15
1.9 Communications .....	15
1.10 Airport information .....	15
1.11 Flight recorders .....	16
1.12 Information on the local of the incident .....	16
1.13 Medical and pathological information .....	18
1.14 Fire .....	18
1.15 Survival aspects .....	18
1.16 Tests and research .....	18
1.17 Organizational and management .....	19
1.18 Additional information .....	20
1.19 Useful or effective investigation techniques .....	20
<b>2. ANALYSIS</b> .....	<b>21</b>
<b>3. CONCLUSIONS</b> .....	<b>23</b>
3.1 Findings .....	23
3.2 Causes .....	23
<b>4. SAFETY RECOMMENDATIONS</b> .....	<b>24</b>
TABLE OF CONTENTS .....	25
ABBREVIATIONS .....	26



## ABBREVIATIONS

<b>Aft</b>	Aftward
<b>AMSL</b>	Above Mean Sea Level
<b>APU</b>	Auxiliary Power Unit
<b>ATC</b>	Air Traffic Control
<b>AT</b>	Airline Transport
<b>ATP</b>	Airline Transport Pilot
<b>BKN</b>	Broken
<b>CAA</b>	Civil Aviation Authority
<b>CVR</b>	Cockpit Voice Recorder
<b>DME</b>	Distance Measurement Equipment
<b>FAA</b>	Federal Aviation Administration
<b>FCOM</b>	Flight Crew Operational Manual
<b>FDR</b>	Flight Data Recorder
<b>Ft/min</b>	Feet per minute
<b>GPIAA</b>	<i>Gabinete de Prevenção e Investigação de Acidentes com Aeronaves</i> (Portuguese Air Accident Investigation Branch)
<b>GPU</b>	Ground Power Unit
<b>GPWS</b>	Ground Proximity Warning System
<b>IR</b>	Instrument Rating
<b>Kg</b>	Kilograms
<b>Kts</b>	Knots
<b>M</b>	Magnetic
<b>MAG</b>	Magnetic
<b>Mb</b>	Millibars
<b>MEL</b>	Multiengine License
<b>NM</b>	Nautical Miles
<b>OAT</b>	Outside Air Temperature
<b>PAPI</b>	Precision Approach Path Indicator
<b>RA</b>	Radio Altimeter
<b>RWY</b>	Runway
<b>SCT</b>	Scattered
<b>STAR</b>	Standard Arrival
<b>UTC</b>	Universal Time Coordinated
<b>Vapp</b>	Velocity approach
<b>VOR</b>	VHF Omni Directional Range
<b>VHF</b>	Very High Frequency