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MINISTÉRIO DAS OBRAS PÚBLICAS, TRANSPORTES E COMUNICAÇÕES

GABINETE DE PREVENÇÃO E INVESTIGAÇÃO DE ACIDENTES COM AERONAVES

GPIAA

FINAL INCIDENT INVESTIGATION REPORT

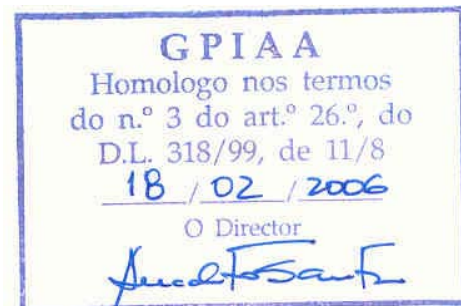
MONARCH AIRWAYS

AIRBUS A321-231

G-OZBE

FARO AIRPORT

14TH JUNE 2004



REPORT NR 16/INCID/2004

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 (21st November 1994) and to nr. 3, 11th article of Decree-Law 318/99 (11th 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.

Following ICAO Recommendation, Chapter 6 §6.7 (Note), this report has been prepared in English.



SYNOPSIS

On 14th June 2004 at 16:08 UTC, the Airbus A321-231, marks G-OZBE, departed London (Gatwick), with 2/7 crew and 33 passengers on board and made an uneventful transit to Faro Airport.

The first officer was the pilot flying (PF) throughout the flight.

Flight conditions were VMC, wind surface 280° at 10 kt. When the aircraft was fully stabilized with fully flaps for landing, the autopilot was disconnected. The autothrust was left engaged. The touchdown was smooth, the spoilers deployed and the pitch attitude started to reduce but then the nose reared up quickly upon sides-tick nose-up demand. In spite the commander took over the aircraft control and put the stick forward to reduce the pitch attitude, the aircraft tail struck the runway.

The landing time was 18:18 hours UTC.

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



1. FACTUAL INFORMATION

1.1 History of the flight

The Airbus A321-231, marks G-OZBE, departed London (Gatwick), on 14th June 2004 at 16:08¹, with 2/7 crew and 33 passengers on board and made an uneventful transit to Faro Airport.

This was a line training flight, being the 27th sector for a new first officer. The first officer was the pilot flying (PF) throughout the flight.

i. Initial Approach

The crew carried out a briefing, before the top of descent point, for an ILS R28 approach and manual landing at Faro. Autobrake medium was selected. Prior to descent ATC requested that the aircraft reduce to minimum speed for traffic spacing. Accordingly, Mach 0.74/250 kt was entered for the descent speed in the FMGC. The aircraft was initially given clearance to position to 20 nm final approach Runway 28 and then re-cleared to 7 nm final.

ii. Final Approach

Flaps 1 was selected prior to intercepting the localiser course and, when established inbound, flaps 2 was selected. Flight conditions were VMC with the sun low on the horizon beyond the runway. The approach continued and when the aircraft was fully stabilised with full flaps the autopilot was disconnected. Autothrust remained engaged and flight directors were on. The aircraft was slightly high on the glide slope at some point but, by 200 feet AGL, the PAPIS indicated on the correct approach path.

iii. Touchdown (at 18:18 hours)

At 50 feet AGL the descent rate was checked, (reduced) at 30 feet the thrust levers were closed and a landing flare carried out. A 5 feet RA callout was heard followed by a smooth touchdown. The spoilers deployed and the pitch attitude started to reduce but then the nose reared up quickly. The commander called out

¹ All times referred in this report are UTC hours.



"I HAVE CONTROL" (he cannot recollect whether he used the side-stick take-over push button) and put the stick forward to reduce the pitch attitude. He lowered the nose to the runway and completed the landing roll vacating the runway at the second to last turnoff.

iv. Post Landing

During the taxi to stand the crew was alerted to the possibility of a tailstrike having occurred by ATC. Neither the pilots or the cabin crew had heard any significant noise on touchdown although one passenger made a comment **"WHAT WAS THAT?"** and one of the rear crew members had felt a movement of the floor beneath her feet.

Following shutdown and disembarkation of the passengers the commander inspected the aircraft and discovered the damage.

1.2 Injuries to persons

| INJURIES | CREW | PASSENGERS | OTHERS |
|----------|------|------------|--------|
| FATAL | - | - | - |
| SERIOUS | - | - | - |
| MINOR | - | - | - |
| NONE | 2+7 | 333 | |

1.3 Damage to the aircraft

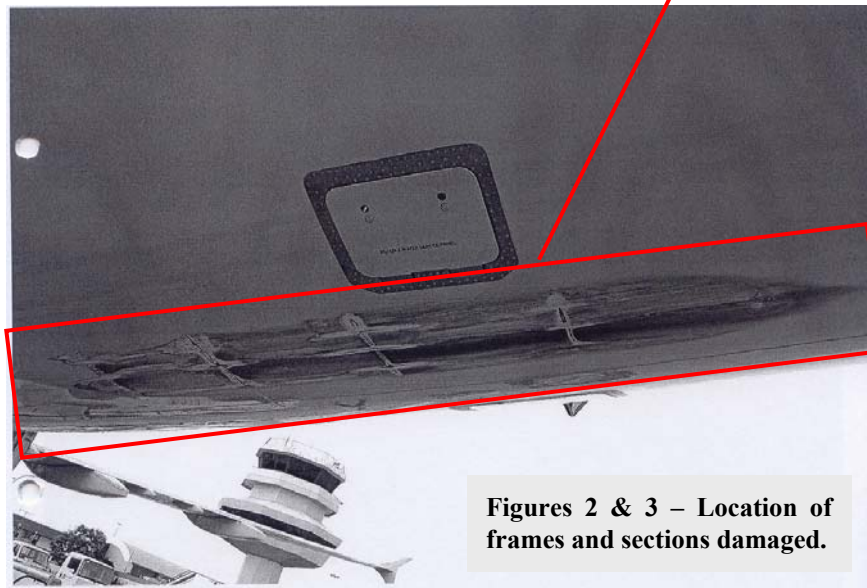
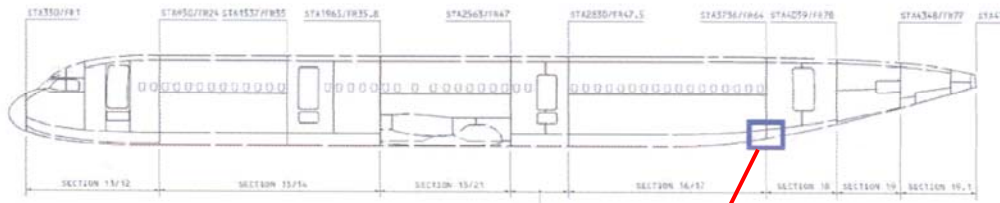
Engineering Report

Examination of the aircraft at Faro Airport showed damage to the lower fuselage. The visual inspection carried out by maintenance revealed an extension of 2 meters, approximately, of exterior skin paint abrasion under the tail section.



Figure 1 – Tail strike area.

The lower skin was abraded from Frame 63 to around Frame 67 between Stringer 42 L/H and Stringer 42 R/H.



Figures 2 & 3 – Location of frames and sections damaged.

Within this area of abrasion, it seems there were no structural damages from the vertical loads applied in the contact with the runway. Nevertheless, this area was to be, latter on, the object of an accurate inspection to determine any sustaining structural damage as the result of the tail scrap during landing.

The Engineering Report still informs that also the Galley/Lavatory drain mast sustained minor damage burns during fuse contact.

Temporary repair has been carried out accordingly with IAW Airbus Technical Disposition 942-031144/012/2004 issue with minor deviations regarding alternative fasteners IAW SRM guidelines, so the aircraft could be approved for a single unpressurised ferry flight from Faro to Luton.

1.4 Damage to third parties

There was no damage to third parties.



1.5 Pilots information

| INFORMATION | COMMANDER | COPILOT |
|----------------------------------|--|--------------|
| Identification | | |
| Sex: | Male | Male |
| Age: | 43 years | 26 years |
| Nationality: | British | British |
| Licence Details | | |
| License held: | ATPL | CPL |
| Nr.: | AT/221231E/A | CP/347628F/A |
| First issued: | 08 NOV 1999 | 12 MAI 2003 |
| Expire date: | 07 NOV 2009 | 11 MAI 2003 |
| Ratings: | A318/319/320/321 - IR A330 IR (Val. 04/06/05) | A320 - IR |
| Instrument rating renewal date: | 17 FEB 2005 | |
| Currency | | |
| Proficiency check (date): | 12 DEC 2003 | 16 MAI 2004 |
| Safety/Emergency check (date): | 30 NOV 2003 | 11 MAR 2004 |
| Medical Certificate | | |
| Class: | 1 | 1 |
| Date issued: | 24 FEB 2004 | 04 FEB 2004 |
| Limitations: | None | None |
| Experience | | |
| Total flying hours: | 10.700:00 | 287:00 |
| Total hours on type: | 6.171:00 | 68:20 |
| Hours in last 90 days: | 134:20 | 68:20 |
| Hours in last 28 days: | 60:15 | 67:47 |
| Hours in last 24 hours: | 5:18 | 5:15 |
| Duty Times | | |
| Start of duty: | 15:00 hours | 15:00 hours |
| Planned end of duty: | 23:10 hours | 23:10 hours |
| Length of preceding rest period: | 17:55 hours | 17:55 hours |



1.6 Aircraft Information

| | |
|-----------------|---|
| Aircraft | <p>Designation of aircraft: AIRBUS A321-321</p> <p>Serial nr.: 1707</p> <p>Date of Manufacture: 01 FEB 2002</p> <p>Nationality and Registration marks: G-OZBE</p> <p>Registered Owner: Monarch Airlines, Ltd</p> <p>Operator: Monarch Airlines, Ltd</p> <p>Certificate of Airworthiness: Issued on 27th MAR 2002, valid until 26th MAR 2005</p> <p>Total Time: 7.722:25 hours</p> <p>Total Cycles: 2.952</p> <p>Previous Inspection: A7 on 18th MAY 2004</p> <p>Next Inspection Due: A8 due by 02nd JUL 2004</p> <p>Total Time: N/A</p> <p>Total Cycles: N/A</p> <p>M.T.O.W.: 89.000 kg (196 210 lb)</p> <p>A.T.O.W.: 71.430 kg</p> <p>C. of G. at Take-off: 21,2%</p> <p>Landing Weight: 65,697 kg (estimated)</p> <p>C. of G. at Landing: 17,7% (estimated)</p> |
| Engines | <p>Constructor: IAE – International Aero Engines</p> <p>Type: 2 x V2533 – A5</p> <p>Date of Manufacture (Both): 23 JAN 02</p> <p><u>Engine # 1</u></p> <p>S/N: V11214</p> <p>Total Time: 7.726:00 hours</p> <p>Time Since Last Inspection: 329:40 hours</p> <p>Time Since Overhaul: 7.726:00 hours</p> <p><u>Engine # 2</u></p> <p>S/N: V11207</p> <p>Total Time: 7.724:00 hours</p> <p>Time Since Last Inspection: 329:40 hours</p> <p>Time Since Overhaul: 7.724:00 hours</p> |

1.7 Meteorological information

METAR for Faro airport, at 16:00 hours was surface wind 180° at 05 kts, the direction varying from 130° to 230°, visibility 10 km, cloud FEW at 2,500 feet with OAT 27°C and Dew Point 17°C. Aerodrome QNH was 1015 mb.

At the time of the incident surface wind was 280 at 10kt, OAT 26°C.

1.8 Aids to navigation

Runway 28, equipped with an ILS and a PAPI, was used for landing.

1.9 Communications

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

1.10 Airport Information

Faro International Airport

Faro Airport is located on the south side of Algarve, in a predominantly flat area.

The airstrip is aligned East-West (QFUs 28/10), and it is 2.490 meters long, 45 meters wide and has no slope.

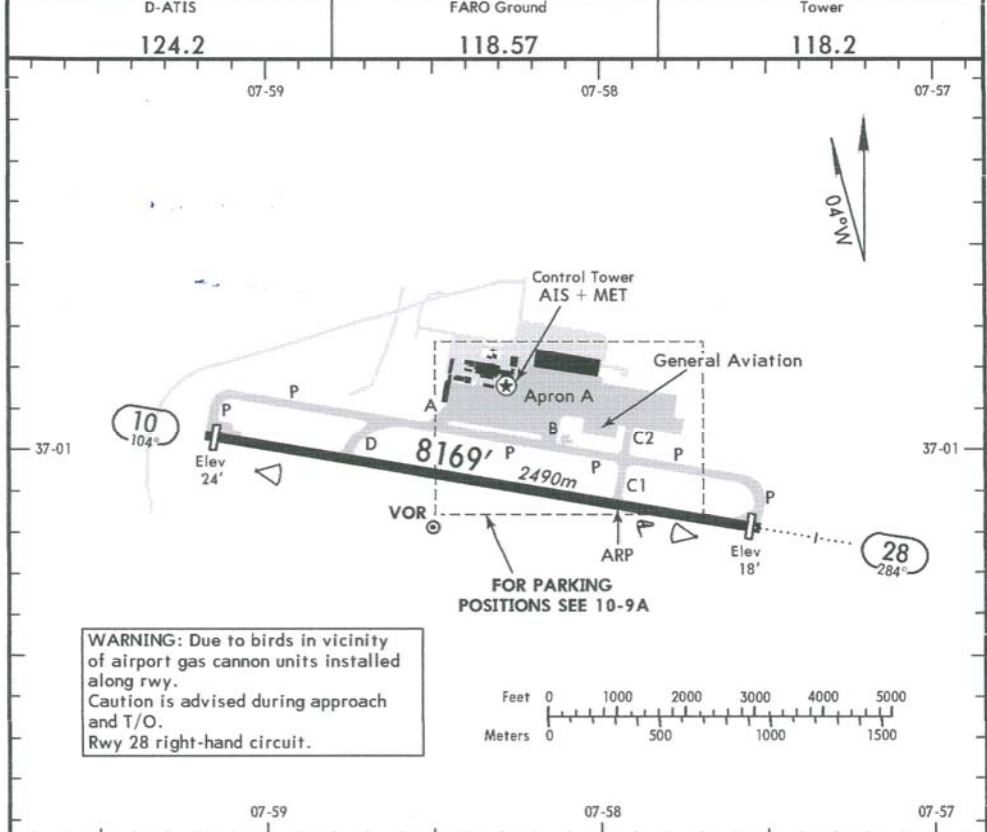


Figure 3 – FARO International Airport



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 Notice: After 05/08/2004 0901Z this chart should not be used without first checking JeppView or NOTAMS.

LPFR/FAO **JEPPESEN** **FARO, PORTUGAL**
 Apt Elev **24'** 18 JUN 04 **(10-9)** FARO
 N37 00.9 W007 58.0



| RWY | ADDITIONAL RUNWAY INFORMATION | | | |
|-----|---------------------------------------|----------------|----------|-------|
| | USABLE LENGTHS | | TAKE-OFF | WIDTH |
| | Threshold | Landing Beyond | | |
| 10 | HIRL (60m) CL PAPI (angle 3.0°) | RVR | 8022' | 148' |
| 28 | HIRL (60m) CL HIALS PAPI (angle 3.0°) | RVR | 2445m | 45m |

ARRIVAL INFO

Speed adjustments for FMS RNAV arrival routes (unless otherwise cleared by ATC):

- MAX IAS 210 KT when initiating the intermediate approach.
- MAX IAS between 200 KT and 180 KT on base leg or when receiving final vector to intercept the final approach segment.
- MAX IAS 160 KT when intercepting the final approach segment at FAF and maintaining until 4 NM from threshold.

If unable to comply with this adjustment advise ATC.

| | JAR - OPS TAKE-OFF I | | | |
|---|------------------------|---------|-----------------------|-----------------------|
| | LVP must be in Force | | All Rwys | |
| | RL, CL & mult. RVR req | RL & CL | RCLM (DAY only) or RL | RCLM (DAY only) or RL |
| A | | | | NIL (DAY only) |
| B | 150m | 200m | 250m | 400m |
| C | | | | |
| D | 200m | 250m | 300m | 500m |

Figure 4 – Airport Chart



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 Notice: After 05/08/2004 0901Z this chart should not be used without first checking JeppView or NOTAMS.

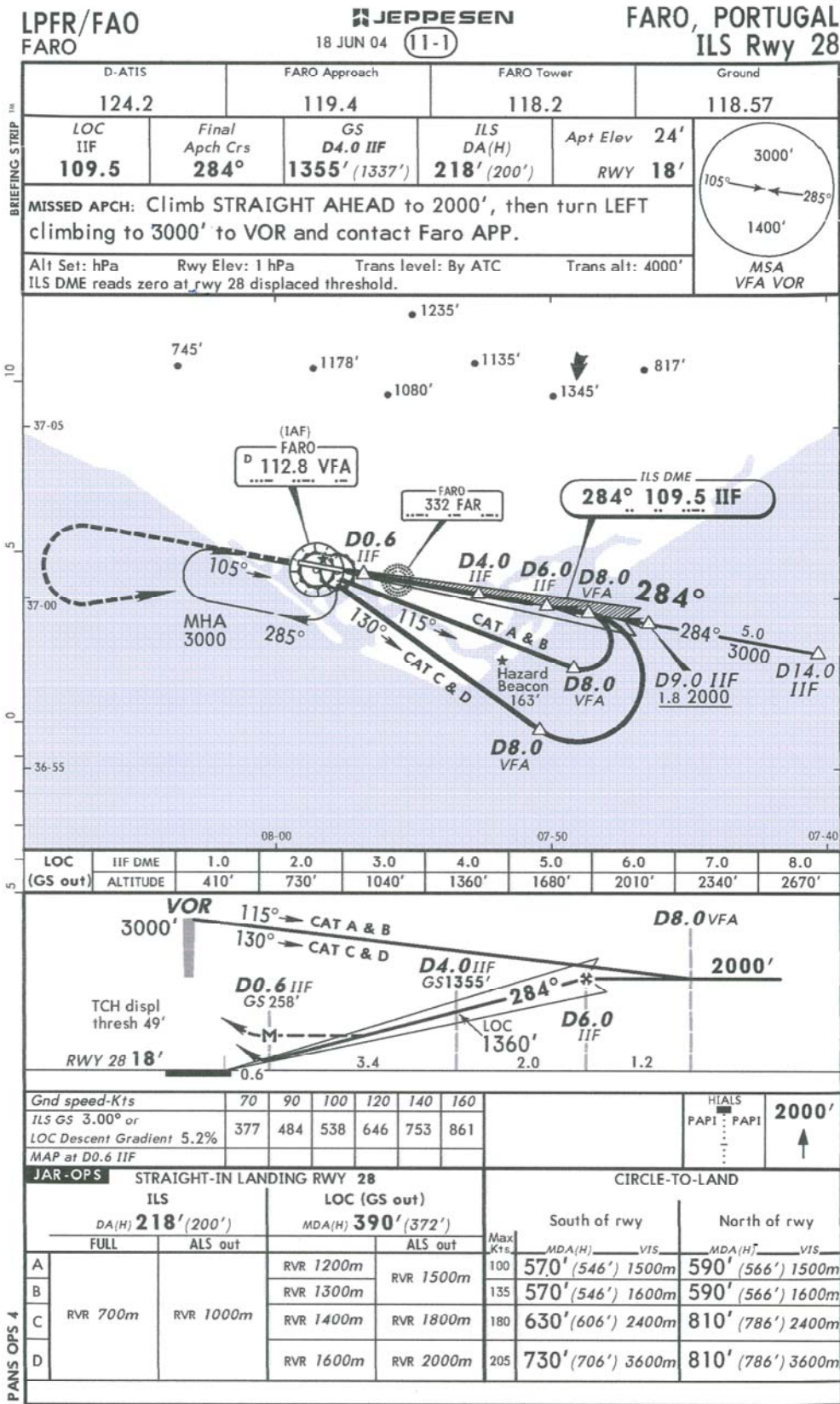


Figure 5 – Rwy 28 ILS approach chart

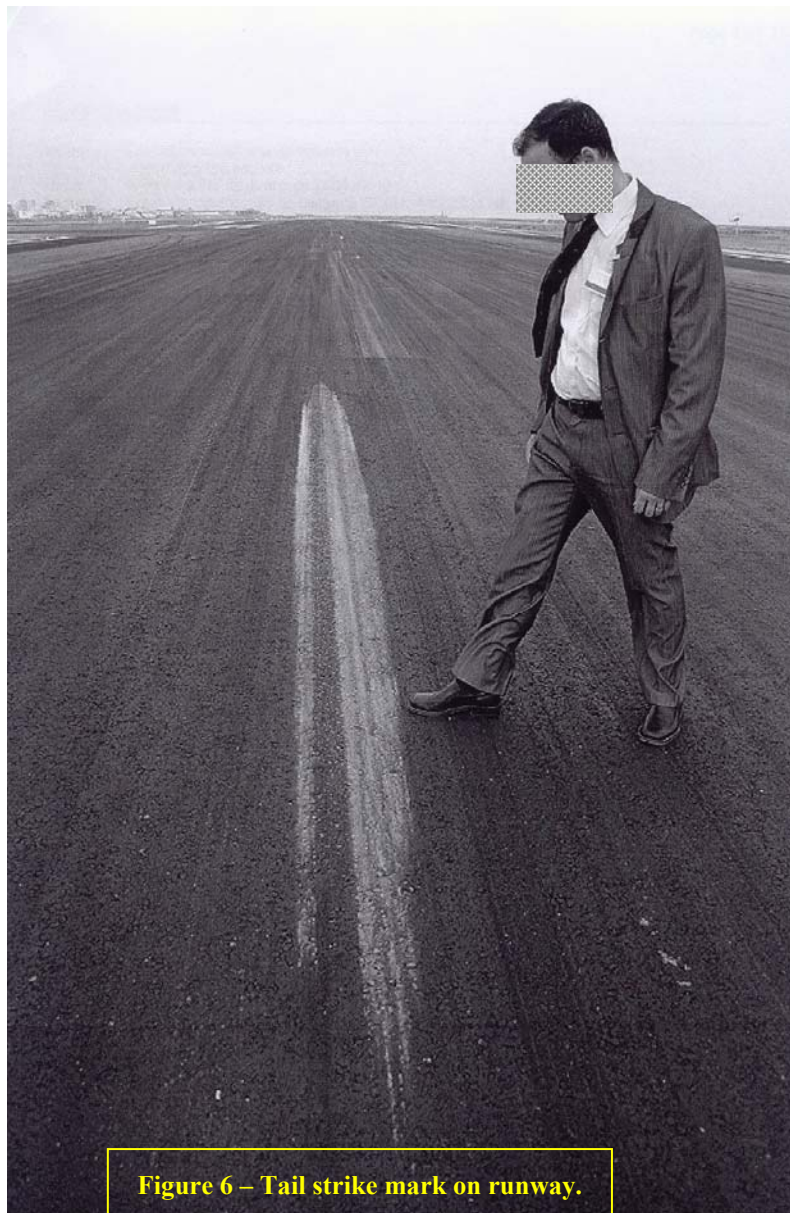
1.11 Flight recorders

The aircraft was equipped with a CVR and a DFDR. A copy of the DFDR has been provided to Airbus for analysis.

1.12 Information on the local of the incident

The examination of the runway showed a single mark from the contact with G-OZBE, some 5 metres long, within the normal touchdown zone and close to the runway centre line.

The abrasion marks were parallel with the fuselage axis, showing that there was negligible aircraft yaw at contact.



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

1.16.1 FCOM

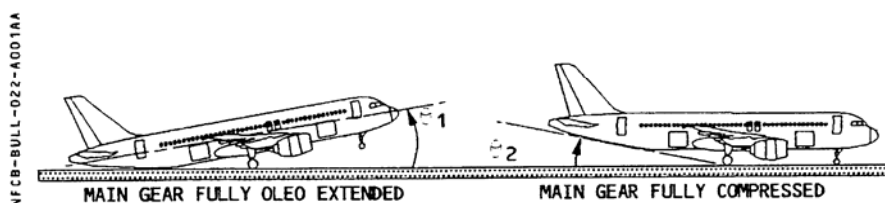
The FCOM Bulletin from Airbus shows the corresponding tail contact angles, with oleos fully compressed, to be 9.7° for the A321.

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 (Θ_1)
- the geometry limit corresponding to main oleo gear fully compressed (Θ_2).



| | A319 | A320 | A321 |
|------------|-------|-------|-------|
| Θ_1 | 15.7° | 13.7° | 11.4° |
| Θ_2 | 13.9° | 11.7° | 9.7° |

Note : On A321, the installation of a TFTS antena decreases these values.



CLEARANCE AT TOUCHDOWN

The following table provides the ground clearance in degrees for the A319, the A320, and the A321 at landing (all numbers are mean values).

| Aircraft | Geometry limit at Touchdown | Pitch attitude at Vapp (VREF + 5) (1) | Pitch attitude at Touchdown (Vapp - 8) (2) | Clearance (3) |
|----------|-----------------------------|---------------------------------------|--|---------------|
| A319 | 15.5° | 3.4° | 7.7° | 7.8° |
| A320 | 13.5° | 3.3° | 7.6° | 5.9° |
| A321 | 11.2° | 2.4° | 6.6° | 4.6° |

Notes : (1) Flight path in approach = - 3°

(2) Mean value of pitch attitude at touch down assuming a deceleration of 8 kt during flare (VAPP - 8), and a flight path of - 1° at touch down (approximately 3 ft/second).

(3) Clearance = Geometry limit - Pitch attitude at touchdown.

When the approach speed is decreased by 5 knots, clearance decreases by approximately 1.3° (attitude at touchdown increases by 1.3°).

Figure 8 – Idem, ibidem – Clearance at touchdown

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

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

1.16.2 Comments/observations regarding the F/O

The F/O was recruited as a cadet having completed basic flying training but with no commercial experience. During his basic instrument flying training (before joining Monarch, Piper Seneca) the emphasis was on instrument flying and landings were rarely completed.

The F/O had experienced earlier in his Airbus training a firm nose wheel de-rotation following a landing.

Type conversion training, at Monarch's, was completed in a simulator followed by circuit flying in the aircraft until the standard was reached. He completed 14 landings during circuit flying.



The training records indicate that he was making good progress in all areas except that he needed to improve his landing technique.

Monarch's pilots have access to their training reports during training. The F/O was aware that while his progress was good in most areas he still needed to improve his landings.

The minimum requirement for completion of training for a cadet is 30 sectors with the average being 36. This was his 27th sector on the A321 aircraft, the first sector was flown as PNF and all further sectors as PF.

1.16.3 F/O statement

The PF stated Faro Control asked the aircraft to reduce speed for traffic separation. The aircraft slowed down and was cleared to a 20 nm final and then a 7 nm final. The aircraft flew to a 12 nm final to allow plenty of time for the approach to stabilize (training). Heading mode was used to turn the aircraft onto the final approach course for the localiser. The aircraft was established at 7 nm with flaps 2. The visibility ahead was restricted by haze so the runway was not in sight at this time. When established on the glide slope and the runway came in sight the visual aspect appeared to him that the descent was steep. At 200 to 100 feet the pitch was reduced slightly in response to being "**HALF A TRIANGLE**" high on the glide slope and just before landing the glide slope pointer was central and the vertical speed indicated 700 fpm down. At 50 feet AGL he gave a slight 'tweak' to slow the descent and at 30 feet started the flare. The aircraft came down to a good touchdown, he selected reverse and saw the nose pitch up. (He had planned to use full reverse). He was not conscious of having made any aft side-stick input but when he heard the commander say "**I HAVE CONTROL**" he took his hands off the controls.

1.16.4 Crew Resource Management

The Flight Crew Operating Manual from Monarch Airlines, in the *Standard Operating Procedures – General Information* section, mentions the requirement to the PNF to call clearly "**I HAVE CONTROL**" if a take-over becomes necessary.



| | | | |
|---|---|---------|--------|
|  A319/A320/A321 Monarch Airlines FLIGHT CREW OPERATING MANUAL | STANDARD OPERATING PROCEDURES GENERAL INFORMATION | 3.03.01 | P 5 |
| | | SEQ 001 | REV 24 |

The prime concern for the flight crew should be :

- is the aircraft flying as expected NOW ?
- what is the aircraft expected to fly NEXT ?

If any doubt is raised about the aircraft current trajectory, or proposed target speed..., the PF must immediately select the appropriate modes and targets on the FCU (which automatically disengages the managed modes). Subsequently and if time permits, the PNF will analyze and correct whatever might have gone wrong on the MCDU.

| |
|---|
| GENERAL RULES FOR GOOD USE OF THE FMGS <ul style="list-style-type: none"> - Monitor the AP/FD/ATHR modes and engagement status on the FMA - Any FMA modification must be announced. - Monitor the result of any target selection performed on the FCU, on the related scales of the PFD (e.g. SPD target, on SPD scale) - Monitor the AP/FD/ATHR resulting guidance, on the basic flight instrument scales of the PFD (HDG, SPD, ALT, attitude...) - If the PF is not satisfied with the guidance he must : <ul style="list-style-type: none"> · REVERT TO BASICS · FLY THE AIRCRAFT where he wants to go. |
|---|

The FMGS description and procedures are provided in the FCOM VOL 4 called FMGS PILOT'S GUIDE.

| |
|---|
| TAKING OVER THE FLIGHT CONTROLS <p>Because of the nature of "fly by wire" and "side stick" systems, the PNF should not make control inputs to correct the PF's handling of the aircraft. If a take-over becomes necessary during flight, the PNF must call clearly "I have control", and press the sidestick priority pushbutton, keeping it pressed until the transfer of control is clearly established.</p> |
|---|

Figure 9 – FCOM, Standard Operating Procedures, page 5.

1.17 Organizational and management information

The operator had fully complied with crew training and the pilots were qualified to undertake the flight.

1.18 Additional information

None.

1.19 Useful or effective investigation techniques

None.



2. ANALYSIS

2.1 DFDR

- The Copilot was the PF.

2.1.2 Approach from 1000 ft to flare

- The approach was carried out with:
 - Autopilot off;
 - Both flight directors engaged;
 - Autothrottle engaged;
 - Slats and flaps were full extended;
 - Vapp was selected to 138 kt (which is Vref + 8).
- The average wind direction was 260°, with a wind speed rather constant (slight variations between 10 and 13 kt);
- The average aircraft heading was 283°;
- The runway 28 heading is 284°;
- Consistently with the wind speed and the wind direction recorded, the difference between the ground speed and the true air speed indicates that the approach was performed with 11 kt average headwind;
- The aircraft remained well aligned on the glide slope and localizer beam, with a slight correction of a "half a triangle" high on the glide slope when about 200 ft, and just before landing the glide slope pointer was central and the vertical speed indicated 700 fpm down).

The DFDR analysis indicated that:

- The aircraft had a mass weight of 65,5 tons registered for landing;



2.1.3 From flare to main landing gear touchdown

Flare was initiated at 50 ft RA with a sharp half back stick input (7° nose up) maintained for 5 seconds. The pitch attitude was stabilized at about 5° then slightly released to be again applied half stick nose-up.

The RH gear touched first the runway, followed 2 seconds later by the LH gear, in a smooth touchdown.

Ground spoilers start deployed. In between the RH and the LH gears touchdown, ¼th of side-stick nose down (+ 4°) was applied, leading to a negative pitch rate. As this input occurred at the same time the ground spoiler extended, the result was an aircraft sinking.

Just prior to the RH gear touchdown the PF applied full aft stick (-16° nose up).

2.1.4 From touchdown to tail strike

The PF maintained full stick nose up for one second from RH gear touchdown, and then progressively reduced his input. Stick was however kept deflected nose up for an additional second. This large nose up demand went simultaneously with the ground spoilers extension which resulted in the pitch attitude building up from about 5° to 9.9°, with the aircraft nose rearing up quickly.

The strike prevention requires flying the nose wheel into the ground without delay but the PF had the side-stick fully pulled after touchdown.

At this point the Commander became conscious of the inconvenient aircraft nose up pitch attitude, called “***I HAVE CONTROL***” and took over the flight controls. However, the resulting pitch-up rate did not allow him to take over early enough to correct the attitude and the tail struck the runway because there was no clearance to the ground with such pitch when gear is compressed.

2.2 Flight Officer

This was the F/O's 27th sector (of 30 planned) on his line training Syllabus, being 36 sessions the cadets average to a trainee pilot be considered fitted for the airline flight.



In spite of the fact he was making good progress in all areas, he showed some tendency for a nose wheel de-rotation following a landing, predisposition he already exhibited on Airbus training sessions.

2.3 Airbus Fly By Wire

The side-stick controls very powerful control surfaces through only a small range stick of movement.

It is impossible for one pilot to know what side-stick inputs the other pilot has made until he observes the response of the aircraft because their movement is not linked together.

Each side-stick input is normally additive, (sum of the two inputs) although there is a pushbutton disconnect switch which allows one pilot to override the other.

All these features mean that it can be difficult for the PNF to make corrections during the landing phase.



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 operator had fully complied with crew training and the flight crew were properly qualified to undertake the flight;
- Aircraft's technical records showed no previous entry which would have had a bearing on this incident;
- The meteorological conditions were not factor to the incident.
- The manual approach was carried out correctly established;
- Full nose input has been applied at the moment of the touchdown;
- This large nose up demand in conjunction with the ground spoilers extension resulted in the aircraft nose to rise up quickly;
- The Commander took over the flight controls and applied a nose down input;
- The tail strike occurred with a pitch attitude of 9.9°.

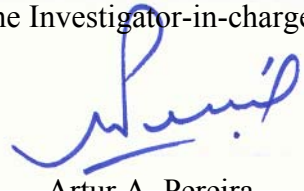
3.2 Causes

The investigation concluded that the F/O action of maintaining a full aft stick input after the landing led the aircraft to pitch up beyond its 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, 5th June 2006.



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ACRONYMS

| | |
|---------------|--|
| A | Aeroplane |
| Aft | Aftward |
| AGL | Above Ground Level |
| AT | Airline Transport |
| ATC | Air Traffic Control |
| ATPL | Airline Transport Pilot Licence |
| CPL | Commercial Pilot Licence |
| CVR | Cockpit Voice Recorder |
| FDR | Flight Data Recorder |
| FCOM | Flight Crew Operating Manual |
| F/O | Flight Officer |
| Ft/min | Feet per minute |
| GPIAA | <i>Gabinete de Prevenção e Investigação de Acidentes com Aeronaves</i> (Portuguese Air Accident Investigation Branch) |
| IAW | Indications, Analysis & Warnings |
| ILS | Instrument Landing System |
| IR | Instrument Rating |
| Kg | Kilograms |
| Kt | Knot |
| L/H | Left Hand |
| NM | Nautical Miles |
| OAT | Outside Air Temperature |
| PAPI | Precision Approach Path Indicator |
| PF | Pilot Flying |
| PNF | Pilot Not Flying |
| RA | Radio Altimeter |
| R/H | Right Hand |
| RWY | Runway |
| SRM | Structural Repair Manual |
| UTC | Universal Time Coordinated |
| Vapp | Velocity approach |
| Vref | Velocity reference |
| VMC | Visual Meteorological Conditions |