



ROMANIA
MINISTRY OF TRANSPORT
CIVIL AVIATION INSPECTORATE

AIRCRAFT ACCIDENT REPORT Nr.31/ 839/21/09 2000

FINAL REPORT
on the Accident of the
Airbus A310-324, YR-LCC
(TAROM Flight ROT 371)
within the area of Balotesti village,
Bucharest-Otopeni Airport
on 31 March 1995.

NOTE

This report was elaborated by the Administrative Investigation Commission appointed by the Minister of Transport Orders, OMT No.110/31.03.1995, amended by OMT No. 170/08.05.1995 and OMT No. 230/20.03.2000, and accomplished with the provisions of Annex 13 to the Chicago Convention on International Civil Aviation.

The Report is based upon the analyses, interpretation and verification of all gathered information.

According to these provisions as well as with the international aircraft accidents investigation practices, the objective of this investigation was not to apportion blame or liability but to prevent further accidents.

ABBREVIATIONS

A	AAIB-UK	Aircraft Accidents Investigation Branch – United Kindom
	AD	Airworthiness Directive
	AI	Airbus Industrie
	AMM	Aircraft Maintenance Manual
	APP	Approach
	ACC	Area Control Center
	ATC	Air Traffic Control
B	ATS	Auto Throttle System
	BC	Briefing Card
C	CVR	Cockpit Voice Recorder
	CNPMNA	National Center of Air Traffic Meteorological Protection
E	EPR	Engine Pressure Ratio Thrust
	EBBR	Brussels Airport
	EBOS	Ostende Airport
F	FADEC	Full Authority Digital Electronic Computer
	FIR	
	FDR	Flight Data Recorder
	FMA	Flight Mode Annunciation
	FMS	Flight Management System
	FMC	Flight Management Computer
H	HIL	Hold Item List
L	LT	Local Time
M	MEL	Minimum Equipment List
	MOE	Maintenance Organization Exposition
	METAR	
N	NTSB-USA	National Transport Safety Board – Unitated States of America
P	PIC	Pilot in Command
	P&W	Pratt & Whitney
	P/N	Part Number
	0	
Q	QNH	
R	RO-CAA	ROmanian Civil Aeronautic Authority

S	SB	Service Bulletin
	SIL	Service Information Letter
	SWISSAIR	
T	TAF	
	TAROM	
	TBO	Time Between Overhaul
	TCC	Thrust Control Computer
	TFU	Technical Follow Up
	TMA	
	TSM	Trouble Shooting Manual
	TRP	Thrust Rating Panel
U	TWR	Tower Control
	UTC	Universal Time Coordinated

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SYNOPSIS

Aircraft Accident Report:	Nr. <u>839/21.09.2000</u> (File:3103199501/1)
Registered Owner:	TAROM
Operator:	TAROM
Aircraft Type:	AIRBUS 310-324
Nationality:	Romanian
Registration:	YR-LCC
Place of Accident:	N44.34.05 and E026.05.02, at 3 km N of RWY 08R
Date and Time:	31 March, 1995 at 06:08:35 UTC

The accident was notified to the Civil Aviation Inspectorate by Romanian Air Traffic Services.

The accident occurred on 31 March, 1995, when the AIRBUS A310-324, registered YR-LCC, was scheduled for a TAROM flight ROT 371 with destination Brussels, took off from Bucharest-Otopeni airport at 06:06:44 UTC. After approximately 2 minutes of flight, the aircraft crashed within the area of Balotesti village, near Bucharest-Otopeni airport.

The investigation commission consider the following causal factors:

- Thrust asymmetry;
- Possible pilot incapacitation (the Captain);
- Insufficient corrective action from the Copilot in order to cover the consequences of the first factors.

Safety Recommendations have been made as a result of this investigation

- After the accident, AI issued two mandatory SBs that were enforced a French DGAC Directive, concerning remedy measures to be taken by all operators for elimination of all probable causes of this malfunction.
- Amendments to AMM and TSM have been issued by AI after the accident and sent to operators for adequate updating of the technical documentation.

1. FACTUAL INFORMATION

1.1 History of the flight

On March 31st, 1995, an AIRBUS A310-324 registered YR-LCC "Muntenia" operated by TAROM Airlines, was planned to perform a scheduled flight ROT371, on route Bucharest (LROP) – Brussels (EBBR) -Bucharest. According to the schedule, the Estimated Time Departure (ETD) was 06:00 UTC (09:00 LT).

At 05:49 UTC during the briefing for take-off the pilot-in-command announced "Standard briefing - right side flying". So, the Co-pilot was designated to be the pilot flying [PF].

At 05:54 UTC, the ROT371 crew contacted Otopeni GND and a start up engines clearance was requested.

At 06:02 UTC, after carrying out the de-icing procedures, a taxi clearance was requested. Otopeni GND cleared ROT 371 for taxi into runway 08R, with a departure clearance via STJ (VOR-DME STJ) and an initial climb to flight level FL260. A squawk A5431 was assigned for the flight ROT 371.

During taxi the pre-takeoff checks were carried out by the crew:

- cockpit checks,
- takeoff configuration with Slats & Flaps 15 / take-off speeds;
- auto-thrust system TRP = 40 deg., were checked;

At 06:04:20 UTC, ROT 371 contacted Otopeni TOWER, which approved its line- up at runway 08R and at 06.06 UTC its take-off and left turn to STJ. ATC communicated the crew all the necessary information, including the last meteorological situation.

At 06:06:44 UTC, the take-off was initiated.

During take-off call-outs were done by the Captain as PNF and at 06.07.08, the Captain requested the Co-Pilot to have both hands on the control wheel. The Captain assumed to guard the engines throttles.

When airborne, the Captain announced positive climb and Co-Pilot requested to retract the landing gear. The maneuver was carried out and followed by associated actions, such as 'lights retracted' and 'aerodynamic brakes disarmed'.

At 06:07:20 UTC the Captain called Otopeni APP and a clearance to proceed direct-to STJ, with a left turn, was received.

The Co-Pilot asked the Captain to select direct STJ on FMS. The Captain confirmed a direct STJ selection on FMS and requested the Co-Pilot to move slightly the control wheel.

At altitude 1700 feet and speed 187 knots, with Flaps 15/Slats 15 and pitch angle of 17.6 degrees, the aircraft was turning left, with a bank angle of 12 degrees, flying to STJ VOR-DME.

At 06:07:36 UTC, when the aircraft crossed 2000 feet at 188 knots, an engines thrust asymmetry started developing with continuous decrease of the left engine thrust, approximately 1 degree TRA /second.

At 06:07:50 UTC the Captain drew the Co-Pilot' attention to the speed. The aircraft crossed the altitude of 3060 feet at 194 knots.

At 06:07:53 UTC, when the aircraft was crossing 3300 ft altitude at 195 kts turning with a bank angle of 20 degrees decreasing, the Co-Pilot called "250 in sight" and asked the Captain to retract flaps. The action was carried out. At that moment, the engines thrust asymmetry reached was 14.5 TRA degrees and 0.19 for EPRs.

At 06:07:58 UTC, the Co-Pilot requested slats retraction, action which was not carried out by the Captain. At this moment the aircraft was passing through 013 degrees magnetic heading, 3800 ft altitude and speed 185 kts decreasing. The aircraft pitch angle was 16,5 degrees decreasing and the left bank angle was 18 degrees also decreasing. At that time the thrust asymmetry reached was 28 TRA degrees and 0.27 for EPRs.

At 06:08:02 UTC, the Co-pilot asked the Captain: "Are you all right? / *Ce ai mǎ?*" The aircraft was passing through 330 degrees magnetic heading, 4200 ft altitude, 181 kts speed decreasing, and 17 degrees left bank angle increasing.

At 06:08:08 UTC, a noise like a human pain or metallic noise was heard. The aircraft was crossing 4460 ft altitude, 179 kts speed and a bank angle of 22 degrees increasing. At that time the engines thrust asymmetry reached 0.36 for EPRs.

At 06:08:10 UTC, FDR recorded an attempt for a radio transmission but there is no confirmation by CVR sound. Some data between 06.08.08 and 06.08.09 are invalid due to lost of synchronization. The aircraft was crossing 4530-ft altitude, at 179 kts speed and an increasing bank angle of 28 degrees. The engine thrust asymmetry reached almost the maximum value, being 0.41 for EPRs.

At 06:08:15 UTC, the Copilot, with a stressed and agitated voice, requested engagement of autopilot no.1. The aircraft was crossing 4620-ft altitude, continuing its turn at an increasing bank angle of 43 degrees and a steadily decreasing pitch angle of 3.5 degrees.

At 06:08:18 UTC, FDR recorded an attempt to engage autopilot no.1. The aircraft was 4615-ft altitude, decreasing, with 45.09 degrees bank angle, increasing, the speed was 191 kts, increasing and the engine thrust asymmetry has reached the value of 0.42 for EPRs, followed by a continuous thrust reduction of engine no.2.

One second later, there was recorded autopilot disengagement followed by the aural warning a level 3 "cavalry charge" lasting several moments. From that moment on, the aircraft attitude was continuously degrading: it started diving, the speed increased and the aircraft performed a complete rotation around its roll axis.

The last radar altitude recorded was 4400 ft. At the next radar interrogation, the aircraft transponder gave a partial answer providing only the aircraft code and call sign with no

altitude information. However, three other spots were recorded, of which the last two, probably virtual ones are the result of an extrapolation of the radar computer, taking into account the last determined position. The third recorded radar position froze thus certifying that the target had been lost.

At 06.08.28 UTC, Copilot cried out "THAT ONE HAS FAILED! / BĂ S-A STRICAT ĂLA!" without any other comments. The aircraft was descending through 3600 ft at 258 kts speed and an increasing nose down pitch angle at 61.5 degrees.

At 06:08:30 UTC, two unidentified consecutive noises are recorded. The aircraft was descending through 2900 ft at 293 kts speed at a maximum nose down pitch angle of 83 degrees, steadily decreasing.

At 06:08:31 UTC, Copilot cried something which is not intelligible. The aircraft was crossing 2000 ft at 324 kts speed and a maximum nose down pitch angle of 64 degrees.

At 06:08:34 UTC, the aircraft hit the ground. The last recorded parameters are nose down attitude of approximately 50 degrees pitch angle, and a magnetic heading of approximately 60 degrees with both engines at idle power.

Beginning with 06.09 UTC, Bucharest APPROACH tried several times to contact ROT 371. At the first call, ROT 371 was asked to confirm crossing FL100, but they did not answer. Another aircraft flying in Bucharest TMA and the TAROM dispatcher were also asked to contact ROT 371.

At 06.13.40 UTC, Bucharest APPROACH declared DETRESFA. All measures taken by air traffic controllers from that moment were in total compliance with the approved Search and Rescue Plan

1.2. Injuries to persons

	CREW	PASSANGERS	OTHERS
FATAL	11	49	
SERIOUS	-	-	-
MINOR	-	-	-

1.3. Damages to the aircraft

1.3.1 *Wreckage evaluation*

The aircraft was totally destroyed, the remains being split into pieces due to the violence of the impact.

1.3.2 *Damages to aircraft parts and components*

At the site of the impact a central crater approximately 6 meters deep was created where there was concentrated the greatest part of the fuselage, the wings and the two engines (the right one at a depth of 5 meters and the left one at a depth of 4 meters).

1.3.3 *Wreckage distribution*

The other part of the fuselage split into pieces and spread over the ground on an almost elliptical, 80 meters wide and 200 meters long area. The wind blowing at a speed of

17 meters/second carried away light fragments of textiles, metal and insulating materials along an approximately 200 meters wide strip, heading 330 degrees, approximately 1 km off the site of the impact.

1.4 Other damages

The impact with the ground occurred on an agricultural field and did not caused any damages to buildings, persons or installations.

1.5. Personnel information

1.5.1. *Cockpit crew*

Captain

	Male, aged 48 years, Married with one child.
Qualifications	1969 graduated from "Aurel Vlaicu" Military Aviation School - Civil Aviation Section.
Licenses and Type Ratings	Licence: Professional Pilot's Licence no. 230 issued on 27 January 1969 and Airline Pilot's Licence no. L-209 issued on 6 April 1976, valid until 17 December 1995. The A310 type rating was issued following the graduation of the conversion training at AEROFORMATION- TOULOUSE, in March 1992, SWISSAIR refresher courses in December 1992. In flight examination on 23 rd January 1993, and the route check on 5 th January 1993.
Flying experience	Total all types: 14,312 flying hours Total transport category planes: 14,268 Total flying experience on IAR 818: 44 hours Total flying experience on LI 2: 79.5 hours Total flying experience on IL 14: 795 hours Total flying experience on BAC 1-11: 6,508 hours Total flying experience on B707: 5,151 hours Total flying experience on A310: 1,735 hours Total flying last 12 months: 725 hours Total flying last 6 months: 372 hours Total flying last 3 months: 212 hours Total flying last month: 66.28 hours Total flying last week: 10.58 hours
Training	The preceding flight was performed on 28/29 March 1995, with a total flying of 5 hours and 08 minutes, on route Otopeni-Tel-Aviv-Otopeni. The last simulating training on type was carried out at Zurich, on SWISSAIR simulator on 12 November 1994. The last flight check was completed on a commercial flight on 17 December 1994 on route Otopeni-Paris The last check for Pilot's license renewal was performed on 17 December 1994 on route Otopeni-Paris. The last flight, before accident, was performed on board A310 YR-LCC, on 27 March 1995, on route Otopeni-Paris-Otopeni.
Medical	PIC had a general psycho-behavior of a superior medium level. He

	encountered no professional adapting difficulties with a steady and reliable development. A high mental condition, slightly emotional excitable, but with an efficient self-control. A positively structured personality, a realist and a good team work capacity. At the last annual medical examination on 20 April 1994, he had been characterized as "fit for long range aircraft flights". Medical fitness certificate valid to 21 April 1995.
Incidents / Accidents History	No incidents or accidents were reported during his activity as a pilot.

First Officer

	Male, aged 51 years, Married with one child.
Qualifications	1968 graduated of "Aurel Vlaicu" Military Aviation School / Civil Aviation Section.
Licenses and Type Ratings	Professional Pilot's Licence no.222 issued on 10 September 1968, and Airline Pilot's Licence no. L-218 valid until 16 April 1995. The type rating on A310 was issued pursuant to conversion training from 10 January 1994 to 5 February 1994, in Bucharest, the theoretical examination also in Bucharest on 8 February 1994 and and route check on 16 th April 1994.
Flying experience	Flying experience: Total of all types: 8.988 flying hours Total commercial planes: 8,945 hours Total flying experience on IL-18: 6,593 Total flying experience on IL-62: 1,425. Total flying experience on A310: 650 hours Total flying last 12 months : 638 hours Total flying last 6 months : 312 hours Total flying last 3 months : 169 hours Total flying last month : 62 hours Total flying last week : 7.23 hours
Training	The preceding flight was performed on 28 March 1995, with a total flying of 7 hours 23', on route Chicago-Shannon. The last simulator training on type was carried out at Zurich on SWISSAIR simulator on 21 September 1994. The last airline flight check was completed on 16 April 1994 on route London-Otopeni. The last check for Pilot's Licence renewal was performed on 16 April 1994, on route London-Otopeni. The last flight performed on A310 YR-LCC was on 19 March 1995, on route Otopeni-London-Otopeni.
Medical	From the psychological point of view, the Co-Pilot had a superior-medium level psychobehaviour. His professional adapting capability was very good all along his carrier. Although he was close to the retiring age, the results of all lab psychological tests revealed a good level of information processing. Very well motivated for flight. A stable personality, with a good self-possession capacity. Adaptable, cooperative with a good team-

		work capacity. The last annual medical-psychological check performed at the Institute of Aeronautic Medicine, on 16 February 1995 characterized him as "long range jet flight fitted". He was under surveillance because of a lombar affliction L 4-15 without functional troubles.
Incidents Accidents History	/	The pilot had an incident recorded on Amsterdam airport, on July 10, 1992 regarding the push back procedure followed by a temporary suspension as instructor for a three month.

1.5.2 Cabin Crew

	the practical examination on an airline flight on 7 January 1993.
Flying experience	Total all types: 11,609 hours Total last 12 months : 722 hours Total last 6 months : 384 hours Total last 3 months: 222 hours Total last month: 76 hours
Training	The last emergency evacuation training was carried out on 24 March 1994, on board A310. The last flight check for licence renewal was completed on 14 September 1994.
Incidents / Accidents History	No incidents or accidents were reported during her activity as a cabin attendant.

Cabin Attendant -2 (CA-2)

	Female, aged 41 years, Married no children
Qualifications	Graduated of Secondary School and flight attendants course organized by the Romanian Aeronautical Personnel Training Center in 1974. Cabin Attendant's Licence no 519 issued on 15 July 1974, valid until 14 September 1995.
Licenses and Type Ratings	Cabin Attendant's rating on A310 was acquired pursuant to the conversion course attended at the SWISSAIR Training Center in July 1992; the theoretical examination on 23 July 1992, and the practical examination on an airline flight on 3 January 1999
Flying experience	Total all types: 14,870 hours Total last 12 months : 648 hours Total last 6 months : 398 hours Total last 3 months: 171 hours Total last month: 66 hours
Training	The last emergency evacuation training was carried out on 30 June 1994, on board A310. The last flight check for licence renewal was completed on 14 September 1994.
Incidents / Accidents History	No incidents or accidents were reported during her activity as a cabin attendant

Cabin Attendant -3 (CA-3)

	Female, aged 44 years, Married no children
Qualifications	Graduated of Secondary School and light attendants course organized by the Romanian Aeronautical Personnel Training Center in 1973. Cabin Attendant's Licence no 491 issued on 15 August 1973, valid until 3 September 1995.
Licenses and	Cabin Attendant's rating on A310 was acquired pursuant to the

Type Ratings	conversion course attended at the Romanian Aeronautical Personnel Training Center in May 1993; the theoretical examination on 24 May 1993, and the practical examination on an airline flight on 9 July 1993.
Flying experience	Flight experience Total all types: 11,066 hours Total last 12 months : 605 hours Total last 6 months : 204 hours Total last 3 months: 171 hours Total last month: 67 hours
Training	The last emergency evacuation training was carried out on 8 December 1994, on board A310. The last flight check for licence renewal was completed on 3 September 1994.
Incidents / Accidents History	No incidents or accidents were reported during her activity as a cabin attendant.

Cabin Attendant –4 (CA-4)

	Female, aged 37 years, Married no children
Qualifications	graduated of Secondary School and flight attendants course organized by the Romanian Aeronautical Personnel Training Center in 1979.
Licenses and Type Ratings	Cabin Attendant's Licence no 699 issued on 15 December 1979, valid until 22 September 1995. Cabin Attendant's rating on A310 was acquired pursuant to the conversion course attended at the Romanian Aeronautical Personnel Training Center in January 1993; the theoretical examination on 29 January 1993, and the practical examination on an airline flight on 22 April 1993.
Flying experience	Total all types: 7,878 hours Total last 12 months : 730 hours Total last 6 months : 322 hours Total last 3 months: 153 hours Total last month: 61 hours
Training	The last emergency evacuation training was carried out on 24 March 1994, on board A310. The last flight check for licence renewal was completed on 22 September 1994.
Incidents / Accidents History	No incidents or accidents were reported during her activity as a cabin attendant.

Cabin Attendant –5 (CA-5)

	Female, aged 41 years, Widow, with 1 child
Qualifications	graduated of Secondary School and flight attendants course organized by the Romanian Aeronautical Personnel Training

	Center in 1979. Cabin Attendant's Licence no 679 issued on 15 December 1979, valid until 16 October 1995.
Licenses and Type Ratings	Cabin Attendant's rating for A310 was acquired pursuant to the conversion course attended at the Romanian Aeronautical Personnel Training Center in January 1993; the theoretical examination on 29 January 1993, and the practical examination on an airline flight on 1 May 1993.
Flying experience	Flight experience Total all types: 6,700 hours Total last 12 months : 602 hours Total last 6 months : 305 hours Total last 3 months: 142 hours Total last month: 75 hours
Training	The last emergency evacuation training was carried out on 24 March 1994, on board A310. The last flight check for licence renewal was completed on 16 October 1994
Incidents / Accidents History	No incidents or accidents were reported during her activity as a cabin attendant

Cabin Attendant -6 (CA-6)

	Female, aged 41 years, Married, with 1 child
Qualifications	graduated of Secondary School and flight attendants course organized by the Romanian Aeronautical Personnel Training Center in 1975. Cabin Attendant's Licence no 615 issued on 27 September 1975, valid until 30 September 1994.
Licenses and Type Ratings	Cabin Attendant's rating on A310 was acquired pursuant to the conversion course attended at the Romanian Aeronautical Personnel Training Center in 27/28 January 1993; the theoretical examination on 29 January 1993, and the practical examination on a commercial flight on 14 April 1993.
Flying experience	Total all types: 8,877 hours Total last 12 months : 359 hours Total last 6 months : 168 hours Total last 3 months: 91 hours Total last month: 67 hours
Training	The last emergency evacuation training was carried out on 9 June 1994, on board A310. The last flight check for licence renewal was completed on 30 September 1994.
Incidents / Accidents History	No incidents or accidents were reported during her activity as a cabin attendant.

Cabin Attendant -7 (CA-7)

1.5.3 *Medical history of the crew*

In the medical records of the cockpit crew there were no evidence that they suffered of any disease that would have endangered the flight safety.

1.5.4. Aerodrome and ATS personnel

All the staff that controlled ROT 371 held valid licenses; valid medical and psychological fitness certificates and they had never been involved in an aviation accident or incident.

All air traffic controllers reactions were correct, appropriate and in accordance with the approved rules and regulations.

1.6 Aircraft information

1.6.1 Airworthiness

The aircraft was an Airbus A310-324, registered YL-LCC, MSN 450, powered by two Pratt & Whitney engines, as follows :

- left engine (no 1) PW4156 A, s/n P724554, programmed to PW4152 thrust level through FADEC programming plug;
- right engine (no 2) PW 4152, s/n P717721, , programmed to PW4152 thrust level through FADEC programming plug;

Since service, the aircraft had logged 31092.53 flight hours (FH) and 6216 cycle (CY), and the engines had logged:

- engine no 1: TSN 7,335.30 FH and 1,980 CY; TSO 454.2 FH and 106 CY, last installation date: 17 February 1995
- engine no 2: TSN 22,877.51 FH and 4,738 CY, TSO 4087.48 FH and 974 CY: last installation date 10 April 1994.

The airworthiness certificate no 806-2007 was issued on 13 April 1994, by Romanian CAA, valid until 13 April 1995.

The aircraft was maintained in accordance with the SWISSAIR maintenance Programme approved by the Romanian CAA on the basis of the Technical Cooperation Agreement signed on 11 April 1994 by TAROM and SWISSAIR.

The aircraft was operated according to the Aircraft Operating Manual (AOM) A310-325/324 (white paper for A310-325 and - 324 but including specifically identified blue pages for TAROM A310-325 and green pages for TAROM A310-324, YR-LCC only) issued by SWISSAIR and approved by the Romanian CAA.

1.6.2 Information on deficiencies known prior to the flight

In accordance with the logbook, no complaint was reported on the last 4 flights.

Three briefing cards were in the logbook at the moment of the accident. The one with no 15937 was relevant to the investigation of the accident. The BC was issued on 10 June 1994 with the following contents:

Quote:

“AFTER T.O. DURING CLIMB ENG. NO 1 MAY GO BACK TO IDLE IN PROFILE WHEN SWITCHING FROM THR TO CLB POWER”.

The B.C. was issued as a result of several complains made by the crew in the logbook, The first one on 28 May 1994, regarding the retarding of no 1 engine throttle due to an unknown reason when automatically switching from takeoff to climb power. After several maintenance actions in accordance with the Trouble Shooting Manual - Chapter 22.30 - and other actions according to operators experience, no future complains were recorded in the aircraft log from August 1994 until 16 March 1995.

Due to malfunction random character and as it could not never be reproduced on ground, the briefing card no 15937 was maintained in the aircraft log to warn on the possible reoccurrence of the malfunction.

From the aircraft history record (obtained from the FAA after the accident) evidences showed that a series of similar malfunctions had been reported during aircraft operation by DELTA AIRLINES. The corrective actions performed by DELTA maintenance staff were those included in TSM and identical to those performed by TAROM.

During the last 25 hours DFDR records, the presence of a similar malfunction has been identified twice:

- first occurrence, on 30 March 1995 at 22.15 UTC, recorded during takeoff on the flight preceding the accident, from Dubai to Bucharest, which was not reported by the crew in the logbook;
- second occurrence during the takeoff procedures for the flight, which resulted in the accident.

1.6.3. *Technical preparation of the flight*

The maintenance tasks performed on 31 March, 1995 at the aircraft prior to the ROT 371 was carried out by the authorized TAROM maintenance personnel, according to the Maintenance Schedule.

According to the Daily Signature Card, all tasks specific to this check type had been carried out and signed for.

No oil top-up for engines and no fluid top-up for hydraulic systems was necessary. After the preceding flight there were no entries (complaints) recorded by the crew in the logbook, that required corrective maintenance actions, (see attached STATION COPY sequence no 64 of the logbook)

The aircraft was refueled with 14,500 kgs. Total fuel on board, before engine start-up, was 20,000 kgs, of which 500 kgs were in the central tank.

The fuel used for refueling was type TH delivered by ROMARC S.A. The analyses bulletin no 353/30 March 1995

The last operation before engines start-up was aircraft de-icing which was performed, on crew's request, by the handling agent LUTAS on Otopeni Airport . About 400 liters of deiceing mixture were used. This operation lasted about 15 minutes, which resulted in a 7 minutes' takeoff delay, from the schedule.

No violation of the pre-flight procedures have been identified.

1.6.4. *Weight and balance*

All weight and balance flight documents were adequated and there is no relevance to the accident.

1.7. Meteorological information

1.7.1 Meteorological briefing

The weather forecast information was provided by the National Center of Air Traffic Meteorological Protection (CNPMPNA) at the Bucharest-Otopeni Airport. The flight weather information en route Bucharest-Brussels, with Ostende Airport as diversion airport were prepared by CNPMPNA for ROT 371 of 31 March 1995.

The MET briefing consisted in consultations with the crew (a dialogue between the meteorological officer and the pilot concerning the actual weather conditions on route to be flown, departure, destination and diversion airport) and the flight weather information for Bucharest-Brussels sector, with Ostende-Airport as diversion airport, contained in the MET File provided to the Co-pilot.

The meteorological information was handed over to the copilot, who signed upon receipt in the register for meteorological files, at 04.15 hrs UTC. The MET File provided contained the following data and charts:

METAR-LROP (Otopeni Airport) - The content of the message in plain English is as follows: *observation time 03.15 hrs UTC wind from 050 degrees with an average speed of 8 m/sec and a minimum gust of wind up to 13 m/sec, visibility over 10 km, light snow lower clouds 1-4/8 at 450 m and medium clouds 8/8 at 2400 m, air temperature on ground +3 degrees, dew point -2 degrees, atmospheric pressure QNH 1012HPA, tendency for the following two hours: nothing significant (NOSIG).*

METAR-EBBR (Brussels Airport) - The content of the message in plain English is as follows: *observation time at 03.20 hrs UTC wind from 210 degrees/9 knots, visibility over 10 km, light rain, lower clouds 5-7/8 at 540 m, air temperature on ground + 5 degrees, dew point 1 degree, atmospheric pressure QNH 1030 HPA, tendency for the following 2 hours: nothing significant (NOSIG).*

METAR-EBOS (Ostende Airport) - The content of the message in plain English is as follows: *observation time 03.20 hrs UTC, wind from 200 degrees/10 knots, visibility over 10 km, lower clouds - the first layer 1 - 4/8 at 450 m, the second layer 5-7/8 at 600 m, air temperature on ground +6 degrees, dew point 3 degrees, atmospheric pressure QNH 1028 HPA, without any tendency in the following 2 hours.*

SIGMET message for FIR Bucharest - The content of the message in plain English is as follows: *issued on 31 March 1995, at 02.00 hrs UTC by CNPMPNA Otopeni, valid for the period 02.00 - 05.00 hrs UTC, the forecast for FIR Bucharest is powerful icing at 120 FL, South of lat. 46N, without intensity changes and removal, the forecast for FIR Bucharest is powerful turbulence between ground level and 070 FL, South of lat. 45 N, without intensity changes and removal.*

TAF-LROP (the forecast for Otopeni). The content of the message in plain English (listed on the cover of the Flight File), *valid for the period 04.00-13.00 hrs, wind from 070 degrees and average speed 9 m/sec and maximum gust of wind up to 14 m/sec, visibility 5,000 m, snow, lower clouds 5-7/8 at 450m, middle clouds 8/8 at 2400 m, temporary between 05.00-09.00 hrs UTC, decreasing visibility up to 1500 m due to the heavy snow and lower clouds 5-7/8 at 150m,*

TAF- EBBR (the forecast for Brussels Airport), *valid between 04.00-13.00*

hrs UTC, wind from 230 degrees/12 knots, visibility over 10 km, lower clouds 5-7/8 at 600 m, temporary between 04.00-13.00 hrs UTC, decreasing visibility up to 6 km due to rain and drizzling rain and lower clouds 5-7/8 at 240 m and 5-7/8 at 240 m and 5-7/8 at 450 m,

TAF-EBOS (the forecast for Ostende Airport), valid between 04.00-13.00 hrs UTC, wind from 230 degrees/15 knots, visibility range over 10 km, lower clouds 5-7/8 at 540 m, temporary between 04.00-13.00 hrs UTC, decreasing visibility up to 6 km due to rain and drizzling rain and lower clouds 5-7/8 at 180 m and 5-7/8 at 360 m.

Meteorological charts contained in the preflight file are:

- the en route significant prognosis chart, at 06.00 hrs UTC, valid between 03.00-09.00 hrs UTC.
- the en route wind and altitude temperature chart for 300FL and 340 FL at 06.00 hrs UTC, valid for the interval 03.00-09.00 hrs UTC.

1.7.2 The meteorological information between the MET briefing and the moment the accident occurred

Between 04:45 – 09:15 hrs UTC, the airdrome regular forecast (METAR) prepared by CNPMNA and circulated through the inside telecommunication system of the airport to TWR, APP and ACC contained additional information such as "MOD TURB IN APCH" (moderate turbulence in approach area).

From the MET briefing time and the moment when the accident occurred, the crew of ROT 371 were advised by radio about the weather conditions in TMA Otopeni, by the OTP GND at 05:55 hrs UTC, that provided information about the atmospheric pressure QNH (= 1015 hPa) and by the TWR at 06:06:15,0 hrs UTC, that provided information about the wind (wind from 070 degrees and speed 10 m/sec, gusting up to 15 m/sec).

Before starting up the engines, the crew had to get the weather information automatically transmitted by Otopeni ATIS frequency.

1.7.3 Characteristics of the meteorological conditions

The meteorological conditions by the time the accident occurred might be considered almost identical to the actual MET conditions in the Otopeni Airport area, taking into consideration the nearly small distance (3-4 km) of the site the accident occurred on and the meteorological observation office at Otopeni Airport, that prepares regular observations every half hour, at h+45 and h+15.

The general meteorological conditions

The Romanian territory was under the influence of a high pressure area, located North of Romania and a Mediterranean low depression area with centers in Greece and West of the Black Sea, moving towards South/East- North/East. In the Southern parts of Romania, including the place of the accident, an intense baric variation area was created with high humidity and as a consequence the wind reached speeds up to 20 m/sec from North-East; the clouds being distributed on several layers with lower ceilings around 100-300 m, snow falls being the predominant phenomena.

The altitude meteorological conditions

During the period preceding the accident, the South and South-East part of

Romania, including the place of the accident, was covered by a thick layer of stratiform clouds (Altostratus, Nimbostratus). Its ceiling decreased continuously, from about 2,400 m, at about 04:15 hrs UTC, to 750 m at about 05:45 hrs UTC, the moment that preceded the accident. Later on, the ceiling maintained itself at a steady level at about 750 m for approximately two hours, after which it started to increase again, reaching about 2,400 m at 09:45 hrs UTC. The upper wind, considered from the ground to FL 50, was steady at 15-20 m/sec from North-East.

For the given period, the meteorological radar images pointed out the existence of a cloudy nucleus of a great extent (range 80-100 km) centered over Bucharest, almost motionless, having the superior level at about 3,000-4,000 m and with potential precipitation at 0.1-0.3 mm/hr, in the same area.

The ground meteorological conditions

Closely connected with the existence of the cloud layers at altitudes and the intense baric variations, especially for South and South-Eastern parts of Romania, the meteorological conditions on ground, between the moment the flight weather information report was given to the crew (04:15 hrs UTC) and the moment the accident occurred (06:08 hrs UTC), deteriorated. The visibility decreased from 8 km at 04.15 hrs UTC to 1,200 m at the moment the accident occurred. At the same time, there were observed snow precipitations between 05:45-06.15 hrs UTC, turned into heavy snowfalls. The surface wind varied between 10 and 13 m/sec, with gusting up to 15-18 m/sec.

1.7.4 Meteorological conditions on site of the accident

In accordance with the meteorological observations data available at Otopeni Airport MET office and the meteorological analysis of the data available at CNPMNA, the meteorological conditions at the site of the accident and at the moment it occurred, were as follows:

- in the significant layer, between the ground and up to 1,500 m, the wind speed reached 15-20 m/sec, blowing to the North-East; between 2500 feet and FL 100-130, there was a compact layer (100% coverage) of Nimbostratus base determining heavy snowfalls and, at 1000 feet, a superficial layer of lower clouds with a cloud amount of 1-4 /8 (up to 50% coverage);
- temperature at FL 50 was around -8 degrees Celsius with a relative humidity around 75-100% .

1.8 Aids to Navigation

The navigation aids status is not relevant to the accident. Following means were operating:

- TMA SCALA radar was serviceable. There are available video records of the information received from the aircraft transponder, code A543;
- Alenia monopulse secondary radar, installed at Buciumeni, worked in normal parameters; there are available both video recording and graphical presentation made by plotting the track followed by the aircraft and using information recorded by radar, that received an initial response by C5431 code, (recognition and altitude response) and towards the end by A5431 code (recognition response only).
- There also exists primary non-decoded information recorded on the magnetic support of the aircraft flight track.
- All other air navigation aids were as follow:

- ILS 26 L LLZ/GP equipment- on test;
- ILS 26 R GP equipment- on test;
- SRE DRL 7S radar- on test;
- PAR 08L- 26R radar - prophylactic maintenance work.

1.9 Communications

Following means were in operation:

- VHF radio stations, performing legible magnetic recordings of the operational frequencies: GROUND 121.7 MHz, TWR 120.9 MHz, TAXI 172.0 MHz, APP 120.6 MHz, ACC North 129.4 MHz;
- the TWR/APP/ACC coordination interphone, the magnetic recording being legible;
- the phones were serviceable.

1.10. Aerodrome information

At time when the A310, YR-LCC accident occurred the Bucharest- Otopeni airport was opened to the international traffic.

At 05:02 UTC, the radio communications recordings on generally used airport frequency of 172 MHz proved that the lighting of 08R runway had been checked and was according to standards. Deputy commander of the airport performed the cleaning inspection of 08R runway before ROT 371 took off

1.11. Flight Recorders

The aircraft was equipped with CVR and DFDR.

The CVR was FAIRCHILD A 100, P/N 93 A 100-30, S/N 2700 and was recovered from the crash site on 1 April 1995 and the first readout was processed on 2 April in Bucharest.

Two broken sections of about 4 cm each, have been found and bonded to the rest of the tape. Two copies of the tape were made. One was given to the French BEA and the other to the Commission. A transcript of the CVR was made. A list of the recorded noises on the CVR was made on 4 April 1995, in order to be further evaluated.

The DFDR was a LOCKHEED model 209 F, P/N 10077(A500-803), S/N 4622 and was recovered on the crash site on 1 April 1995. The tape was found broken and the last part of the tape was broken and scratched. Two readouts have been made:

- first between 3-9 April 1995 at AAIB-UK.
- second between 1-16 April 1995 at NTSB-USA.

Flight Data from the damaged portions of the tape were recovered using NTSB facilities. There still is an unrecoverable period of 0.71 seconds.

The plots made using NTSB facilities are attached on the Annex....

1.12. Wreckage and impact information

The crash site is a flat soft ground about 300 meters away from Balotesti railway station, three kilometers off the runway 08R center line. There was no obstacle on the airplane trajectory. The access to the area is quiet difficult because there are no roads or easy access ways, including railway crossing.

Most of the wreckage fragments were spread over an elliptical area about 200 meters long and 80 meters wide from East to West. Light weight and small size pieces mainly consisting of carbon fiber, honey comb structure and insulation materials, most of them revealing traces of fire were found on an about 200 meters wide and 1000 meters long surface on a magnetic heading of 250 degrees originating at the center of the accident site. The fragments were found in the direction of the wind at the time of the accident.

The aircraft flight direction at impact was approximately from west to east. The impact was concentrated on a single point.

Main airframe parts (center wing section and fragments of the wings) revealed an angular position of around 50 degrees pitch down. The right wing was found deeper into the ground than the left wing. The front part of the left engine was 4 meters deep in the ground and the right one 5 meters deep. Both engines were severely damaged.

However, there were no indications of engine inner damages or engine fire prior to the impact with the ground.

The high level of destruction and the position of the wreckage parts in the ground indicated a high energy involved and a steep nose down angle of descent at the time of the crash.

The fuselage, the wings and the tail were disintegrated. The fin and the rudder were separated from the horizontal tailplane. The whole surrounding terrain and the area below the supposed flight trajectory of the aircraft were searched both by helicopter overflight and ground activity and aircraft fragments were found only on the crash site. All the flight control surfaces, or fragments of them were found on the crash site.

The examination of some fragments, especially those of the tail, did not revealed any in-flight fire traces.

The moment and aircraft position at the time of impact

The analysis of DFDR recordings and the studies made at the site of the accident proved that the aircraft hit the ground at 06.08.35 UTC (09.08.35 LT), at a pitch angle of about 80 degrees on direction from West to East. The impact point is at about 3 km North off 08R runway end, on a flat terrain with the following coordinates: N44.35.54,5 and E026.06.23,2 .

The aircraft configuration and deterioration at impact

Configuration at impact and damages to aircraft: at the moment of impact, the aircraft had a speed of over 330 kts, a pitch angle of about 50 degrees and a weight of about 104,000 kg (of which more than 19,000 kg represented the fuel).

Due to this fact, at the moment of the impact a huge energy developed which resulted in the disintegration of the fuselage as well as in the rapid compression of the wing structure and the integrated fuel tanks. As a result, the fuel from the tanks exploded the greatest part of it burning up in the explosion. This conclusion is backed both by the statements of those who heard and saw the explosion, and by the fact that the fire that started on ground immediately after the impact affected only a part of the distribution area of the aircraft debris and was

extinguished within a relatively short period by the fire brigades.

Fragments of the fuselage and tail spread over a surface (160 m x 60 m), and the engines, the wings and the landing gear remained on site of the impact, thrust at 3-5 meters deep into the ground. A detailed presentation of the site of the accident and of the fragments of the aircraft is attached (Report SE-E42/954.1431/95).

1.13 Medical and pathological information

Human remains were examined by the Romanian Forensic Institute under the surveillance of the General Attorney who issued corresponding certificate.

From the analysis of the certificates issued by the Forensic Institute on the causes of the decease, the following conclusion might be drawn: the decease of all aircraft passengers and crew members was caused by the shock generated by the aircraft impact with the ground.

There was no physical autopsy possibility for the Captains and Copilots bodies, as well as for all other bodies.

The compulsory medical examination was performed before the flight.

1.14. Fire

There is no evidence of any fire on board the aircraft prior to the impact. A fire started just after the impact and was extinguished by the firemen in a short period of time.

1.15 Survival aspects

Ambulances and fire fight brigades arrived at the accident site in approximately 30 minutes after the A310, YR-LCC accident happen and found no survivors.

Human remains and material fragments of aircraft components led to the conclusion that, when the aircraft violently hit the ground, there was an explosion and choking smoke emanated from the crater for 1 hour and a half after the impact.

Measures were immediately taken to preserve the evidence, to collect and preserve human remains and belongings.

When the DETRESFA message was announced at minute 14 by the Approach executive controller, all the units (ATS and others) located at Otopeni International Airport acted in accordance with the search and rescue plan in force at this airport.

Ambulances and fire brigades from airport and town, RO-CAA, ROMATSA headquarters, Ministry of Transport, Military Control Units and Military Aviation Authority were immediately advised by Otopeni TWR, Bucharest APP and Bucharest ACC.

The search and rescue actions mentioned in Search and Rescue Plan were initiated and a joint team of civil and military units together with ambulances and fire brigades went to the site of the plot observed on radar screen.

Military surveillance units were asked to join the forces and to try to locate the aircraft for which the DETRESFA message was issued. Due to the bad weather conditions the helicopters

could not take off immediately.

After the phone call from the Balotesti Railway station which announced the crash, all the forces were instructed to move towards the place of the impact. The first team reached the site in around 25 minutes after the DETRSFA message was issued.

1.16. Test and Research

All equipment recovered from the accident site in acceptable conditions were tested at the manufacturer facilities, in order to establish possible malfunction or to gain additional evidences. There were not found failures or significant evidences for the accident, except that the throttle bearings were 'unsealed' type.

1.17. Organizational and management information

must be deleted.

Based-on the above mentioned procedure, if the case, the maintenance personnel issue a Briefing Card (BC) in order to draw the crew's attention containing a significant information for the operation and flight activity (deficiencies postponed for which MEL specifies operational procedures, important modifications, etc.).

In this respect, BC no 15937 of 10 June 1994 was issued and maintained in the aircraft log, in order to warn the crew against the possibility that some intermittent deficiency might appear in the ATS system.

In conformity with the Agreements in force, copies of the aircraft log pages have been transmitted to AI and SWISSAIR representatives for information, on a continuous base.

Trouble Shooting

Trouble shooting activities are regulated at TAROM - Maintenance Department - through a specific procedures contained in the Maintenance Organization Exposition (MOE) and approved by the RO-CAA.

The ATS deficiency that had occurred several times is covered by the provisions of these procedures (MOE revision 2/1994, Procedures 6.6.8 and L.2.3).

The analysis of the records, trouble shooting procedures and associated corrective actions in respect to YR-LCC aircraft, in general, and the above mentioned deficiency, in particular, proves the compliance with the respective procedures provisions.

1.18. Additional informations. measures taken after the accident

1.18.1 Airbus Industrie

a) by AI/EA-S 413/0825/05 AOT of 11 April 1995, AI recommended all A 300/A310/A300-600 operators to verify the ATS functioning during takeoff and transition from TAKEOFF mode to CLIMB mode by manual guarding of throttles;

b) by AI/SE-E21/947.1648/95 and AI/SE-E21/947.1761/95 messages issued in May 1995, AI recommended all A300/A310/A300-600 operators whose ATS throttle levers are equipped with unsealed bearings (pre SB A310-76-2013) to check effort required to move the throttle levers and replace the bearings as necessary.

c) on 18 December 1995, there were issued service bulletins A310-76-2013 (replacement of lever bearings) and A310-76-2014 (replacement of lever rollers); their accomplishment eliminates some of the causes that could result in differences of friction coefficients in cinematic chain of throttle levers. AI mentioned that, failure to replace the bearings (A310-76-2013) or rollers (A310-76-2014) may result in asymmetric thrust condition. This condition, if not corrected by the flight crew, may lead to difficulty in the control of the flight path;

d) 1 December 1995 revision of AMM introduces procedures of replacing throttle lever bearings and lever rollers;

e) 1 December 1995 revision of TSM added the verification of the throttles within ATS trouble shooting procedure:

f) TFU 76.11.00.084 to February 1997 revision indicates the mandatory character of SB A310-76- 2013. TFU 76.11.12001 to February 1997 revision indicates the mandatory

character of SB A310-76-2014.

1.18.2 Direction Generale de l'Aviation Civile (DGAC -France)

Airworthiness Directive no 96-270-209 (B) issued on 20 November 1996 renders SB A310-76-2013 and A310-76-2014 enclosure mandatory.

1.18.3 Romanian Civil Aeronautic Authority (ROCAA)

Airworthiness Directive DN 95-04-104 issued on 12 April 1995 specified airworthiness and operational measures to ensure the safe operation of Automatic Thrust System of PW 4000 engines installed on A310 aircraft of TAROM fleet.

1.18.4 TAROM airlines

a) Although messages AI/SE-E21/947.1648/95 and AI/SE-E21/947.1761/95 mentioned above do not apply to YR-LCA and YR-LCB aircraft where the gas throttles are provided with seal bearings, since manufacture, on 17 May 1995, the gas throttles torque was measured on TAROM A310-325 aircraft; this check was repeated on 25 May 1995 to both aircraft in order to get a new data set and, again, on YR-LCB on 29 May and 8 June 1995, pursuant to a complaint referring to uncontrolled reduction tendency of one throttle lever (although it was ultimately proved that the cause was not ATS);

b) gas throttle bearings, although in compliance with manufacture standards (after SB A310-76-2013) were replaced on YR-LCB on 13 June 1995, pursuant to the above mentioned complaint and preventively on YR-LCA on 9 October 1996;

c) gas throttles follow-up rollings were preventively replaced on YR-LCA, on 9 October 1996, and on YR-LCB on 16 October 1996, in compliance with SB A310-76-2014 provisions and Airworthiness Directive 96-270-209(B) issued by DGAC of France.

2. ANALYSIS

2.1. Operation Analysis

Phase I - 06.06.44 - 06.07.38 UTC

DFDR recorded data indicate a normal evolution of flight. During the last three seconds of this phase, after receiving the clearance to directly proceed to STJ, the aircraft was crossing a 1,800 ft altitude that corresponds to "Climb power" thrust setting for Otopeni Airport.

It is presumed that the Captain used his right hand to operate in FMS, so that when thrust decreasing started and he would have had the chance to apprehend, in an initial phase, the engine throttles asymmetry, his hand was not on the engine throttles.

Phase II - 06.07.38 - 06.08.10 UTC

It is the phase the thrust asymmetry starts and develops at a rate of approximately 1° TRA/sec. During this phase, after "250 in sight" call-out, flaps reaction was carried out and "Slats - in" command was given but not carried out and not confirmed by the Captain.

It is presumed that during this phase, because of the delay, to carry out the order, the Co-pilot starts to doubt the Captain's state and at 06.08.02 asks: "What's wrong with you?".

According to DFDR and CVR data, two other events prove to be interesting during the same phase:

1. At 06.08.08, CVR recorded a noise which seems to indicate human pain. In that moment the aircraft had a banking of 22 degrees, $\Delta EPR=0.40$.
2. At 06.08.10, on DFDR, a VHF transmission attempt is noticed which is not to be found on CVR.

During the last two seconds of this phase, the banking angle of the aircraft on the left hand is modified with $4^{\circ}/\text{sec}$, reaching a 28,18 degrees value.

During this phase, co-pilot does not observe the thrust difference, probably relying on the briefing accomplished by the Captain that he would monitor engines, as well because of the turbulence that implies side movements to ward off wind gusts. According to meteorological data, the wind was NE, with gusts from 15 m/s to 20 m/s.

Phase III - 06.08.10 - 6.08.14 UTC

It is the phase during which co-pilot seems preoccupied to determine the Captain state, sharing his attention between flying the aircraft and determining the Captain's state.

During this interval he was not conscious about the Captain condition (incapacitated) and did not notice the engines asymmetry which according to take-off briefing, were under the Captain's control.

Phase IV - 06.08.14 - 06.08.20 UTC

This is the phase when the co-pilot seems to be convinced of the Captain's incapacitation.

At 06.08.15, co-pilot requests autopilot engagement. It is to be presumed that the Captain's not carrying out the command confirmed the pilot incapacitation condition.

Consequently, at 06.08.15, autopilot was engaged for one second or less, and then disengages itself. During the following two seconds, DFDR data indicate a modification of the control surfaces deflection. The explanation might be that, for the autopilot engagement drill, co-pilot probably looked away from PFD indications, believing that autopilot had been engaged. During this period the banking increased to 57.42 degrees.

Phase V - 06.08.20 - 06.08.34 UTC

The phase in which the aircraft dramatically changes its attitude. The pilot's maneuvers and the control surfaces position cannot be explained on the basis of the data and elements available.

It is to be mentioned that from 06.08.08 till the moment of impact, at 06.08.34, CVR has recorded no word of the Captain, thing which leads to the presumption that he was unable to seize the situation and to carry out his tasks.

2.2. Technical analysis*2.2.1. Investigation of engines and FADEC*

The aircraft was equipped with P&W engines with FADECs programmed to PW4152 thrust level. The behavior of the engines from start up to impact with the ground was determined based on the analysis of the FDR parameters, the investigation of engine debris and technical examinations.

Although both engines were greatly damaged at the impact with the ground, and FADECs were destroyed 60-70%, the analysis of all pieces of information available to the commission shows that there had been no intrinsic deficiencies of the engines prior to the impact (i.e. failure, fire, foreign objects ingestion) the two engines running normally until the moment of the impact with the ground (Report SE-E42/954, 1431/95 ch.II c and III b, Report 5-TRB-2593/August 1995).

2.2.2 Automatic Thrust System

ATS is mainly composed of up of (Report AI/E-fs 420.0221/95):

- one Thrust Control Computer (TCC);
- one Thrust Rating Panel (TRP);
- one single autothrottle actuator, common to both engines;
- one coupling unit for each engine throttle;
- links (cables and rods) between throttles and couplings;
- rollers and bearings;
- throttle position detector for each throttle;
- two tension regulators for cables;
- dynamometric rod for each throttle.

TCC calculates the engine pressure ratio (EPR) limit value according to several parameters and depending on the thrust mode. When the AUTO mode is selected, the thrust mode is computed by the FMC.

Thrust control with PROFILE mode engaged before takeoff

At the beginning of takeoff with ATS engaged (FMA- green THR) both coupling units are engaged as a result of TCC order and allow actuator to move the throttles forward, towards the calculated position for the takeoff mode.

When take off position is reached, TCC will send a "disengage" message to each coupling unit (FMA - cyan THR). The process described above ends long before V1 speed is reached in order to prevent that throttles move from this position during takeoff and initial climbing. After takeoff, when the landing gear is retracted, both couplings are engaged again in order to allow small thrust adjustments (FMA - green THR).

Transition from takeoff thrust to climb thrust

When reaching the thrust reduction altitude (default value in FMS is 1500 ft), thrust mode is changed from take off-thrust to climbing thrust.

When the PROFILE mode engages at the thrust reduction altitude (1500 ft), the AUTO mode engages and the FMS sets the thrust mode to CLIMB. **Until the actual EPR (the greatest between EPR engine no 1 and EPR engine no 2) is higher than the EPR target , the TCC will continue to order a throttles reduction.**

When actual EPR reaches the EPR target value, TCC stops throttles movement. CLIMB thrust is maintained until the desired flight level is reached or until a mode change is initiated.

During this period , each engine full authority digital electronic computer (FADEC) receives an input signal from the throttle's position detectors setting engine thrust, similar to the manual operating mode.

Dynamometric rods, connected to each throttle, allow pilot to manually adjust the throttle lever any time, causing coupling unit disengagement during the manual setting of the throttles, without disengaging the TCC. As soon as the manual load is released, the ATS resumes control and maintains the two throttle lever settings.

ATS operation with one throttle not responding to the ATS command

At the moment the thrust reduction altitude is reached, when the ATS is engaged in PROFILE mode, the following sequence of events will occur in case one engine throttle does not normally respond to the ATS command:

- a) when reaching thrust reduction altitude, the TCC acquires the CLIMB mode from FMS. The EPR target value is set by TCC according to climb thrust;
- b) TCC orders a throttle rate so as to decrease the actual EPR and to achieve the new EPR target;
- c) the throttle operating normally will therefore reduce and the EPR of that engine will decrease;
- d) the throttle having a malfunction (due to abnormal friction in elements that transmit

the movement from the coupling unit to the throttle or in case the throttle is obstructed) will either *not move* at all or *will move* at a rate smaller than the normal one;

e) as long as the malfunctioning throttle is in a position giving an EPR greater than EPR target, TCC will continue to command a throttle rate. Since there is one single actuator common to both throttles, this throttle rate will be commanded to both throttles;

f) if malfunction continues long enough and the crew does not take any corrective action, this situation may lead the engine corresponding to the throttle functioning normally to be reduced to idle; this abnormal functioning is not provided by specific warning systems;

g) In case one of the throttles does not respond according to ATS command, the crew has the following remedy measures:

- disengage ATS using one of the instinctive disconnect switches located on each throttle and manually adjust the thrust (engine manual control), or

- override the auto-throttle by applying manual input to the throttles, then manually adjust the thrust, without disengaging ATS; if abnormality persists, ATS can be disengaged as specified before.

3. CONCLUSIONS

3.1. Findings

3.1.1. System Operation

An analysis of automatic throttle system of engine thrust (ATS) was made on the bases of FDR data as well as of the technical documentation and technical records.

On the site of the accident there have been identified and preserved only three components of this system: the two coupling units and the tension regulator from no 2 engine coupling which have been seriously damaged.

Results of technical examinations performed by the manufacturers to these components show evidence of normal operating condition just before the impact (Report SEXTANT AVIATIQUE DQ/AC no 96/0084 and Report SARMA no 700601/96 Rev. A)

In connection with the auto-throttle system malfunction occurrences prior to the accident, the following conclusions have been drawn:

a) Airbus Industrie (AI) was aware of similar malfunctions in the ATS System of A300, A300-600 and A310, some even earlier than the manufacture date of aircraft MSN 450 (YR-LCC). The consequences of the defects were either the jamming of both throttles and ATS disconnection, or one throttle moving to idle while the other remained above climb power, without ATS disconnection;

b) the most probable cause of these malfunctions has been the excessive friction (binding) in the cinematic linkages between the throttles and the ATS couplings units;

c) Until the date of the accident AI issued the following technical documents with reference to the ATS system anomalies:

SIL 76-013 dated March 1987, revised in December 1988 is a Service Information Letter that lists four recommended actions to prevent the occurrence of such defects: two of these (that is no 1 and no 4) have no relevancy to the investigated case, another one (no 2) had already been embodied in YR-LCC aircraft during the manufacture process; the last one (no 3) recommends replacement of the throttle lever bearings in case of seizure was not embodied;

TFU 76.11.00.084 of December 1986, re-issued in April 1988, refers to case no 3 presented in SIL 76-013;

TFU 76.11.12.001 of February 1992, re-issued in September 1992, informs about the modification of the throttle lever roller to prevent wear and, consequently, ATS system anomalies.

- until the moment the accident occurred, the actions suggested by AI had not been formalized in Service Bulletin form to correct the configuration. On the a/c registered YR-LCA and YR-LCB, this modification was embodied already during manufacturing. At that time the TSM had no indication whatsoever that the seizure of throttle lever bearings or the wear of the rollers might have been a probable cause of ATS malfunction.

-TFU documents are issued by AI in order to monitor the remedy process of a technical problem, recommending certain actions (TFU 76.11.00.084) or informing about modifications introduced in the production line (TFU 76.11.12.001). When a final solution has been reached, the TFU indicates the SB that has to be embodied (TFU 76.11.00.084 to February 1997 revision states that the accomplishment of SB 76-2013 is mandatory, and respectively TFU 76.11.12.001 to February 1997 revision states that the accomplishment of SB 76-2014 is mandatory) and all other manuals are revised accordingly (TSM 22 30-05, figure 101, revision 1 of December 1995 and TSM 76-00-40, figure 106/2).

d) At the time of the accident, Flight Crew Operating Manual (FCOM) issued by AI did not include the standard operational procedures to cope with the consequences of ATS malfunctions. However, the Aircraft Operational Manual AOM A310-300 in force at the time of the accident issued by SWISSAIR and used by TAROM, in ch.3.3.2, item 2.6 includes the following recommended procedure for Initial Climb, in order to verify the automatic thrust change from takeoff to climb: "The assisting pilot must guard the throttles until CL thrust setting has been verified".

e) AI issued three months after the accident revisions of AMM and TSM that provide supplements to ATS maintenance and trouble-shooting. The SB A310-76-2013 (replacement of lever bearings) and A310-76-2014 (replacement of lever rollers) meant to eliminate the causes that might generate ATS malfunctions, were issued on 18 December 1995;

f) DGAC- France issued on 20 November 1996 the AD 96-270-209(B) that renders mandatory the accomplishment of SB A310-76-2013 and A310-76-2014.

g) during YR-LCC operation by TAROM (13 April 1994- 30 March 1995) the crew reported 23 ATS malfunctions in the Aircraft Log (see Annex). These may be divided into :

- 12 complaints concerning reduction of engine no 1 thrust after takeoff and 3 complaints referring to engine no 2 not reducing the thrust after takeoff;

- 8 separate complaints reporting other malfunctions of the system;

h) the analysis of the first group of complaints relevant to the investigation reveals the following:

- of the 15 complaints, 14 were recorded within a 3 months' period (28 May-31 August 1994), the first one being written down by the Captain who performed ROT 371 flight on the day of the accident;

- the last complaint (the accident not included) was recorded after almost 7 months, on 16 March 1995;

- FDR records containing the last 25 flying hours before the accident revealed one similar malfunction during the preceding ROT 371 flight (during take-off from Dubai), which was not recorded by the crew in the Aircraft Log;

- the malfunction could never been reproduced on ground, and the corrective actions were taken in accordance with the AMM and TSM provisions in force at that time, respectively ; in addition, as a result of the information exchanged with Airbus Industrie and SWISSAIR, besides TSM recommendations, lubrication of the throttle levers linkages up to the coupling units had been performed and both ATS coupling units had been replaced long before the accident;

- due to the random character of this malfunction occurrence, the impossibility of reproducing it on ground and the uncertainty of definitive remedy, the Briefing Card no 15937 had been maintained in the Aircraft Log, as a supplementary warning measure for the crew;

I) identical malfunctions had been recorded in the technical documentation of DELTA AIRLINES all along the period it had operated this aircraft (1 August 1991 - 13 March 1994, see Annex). The corrective actions taken at that moment were limited to TSM recommendations.

j) Aircraft reception and airworthiness certificate issue were made according to PINAC procedures, (Part 21/2 - Airworthiness certification of civil aircraft engine and propellers imported in Romania); several inspections, beginning with the technical documentation and ending with ground inspections and inflight test of the aircraft had been performed.

All non-conformities ascertained during this period had been corrected before the airworthiness certification. During the period the aircraft had been registered in USA, before having been leased by TAROM airlines, there was no evidence that the aircraft had undergone

a flight incident. The above mentioned ATS deficiency had not been noted during test flight for the airworthiness certification of the aircraft, and TAROM knew nothing of this type of deficiency which had never occurred on its own A310 aircraft.

3.1.2. Flight controls

The analysis of FDR records did not reveal any abnormalities of flight controls operation. Warning messages linked to failures of flight controls have not been recorded, and the aircraft performance was in accordance with the control surface movements.

The components of the flight controls system, found on site of the accident, were seriously damaged. Despite this fact, the technical examination performed by the manufacturer on the most important of these (aileron servo controls, rudder servo actuator, roll and yaw A/P actuator, trim actuator, yaw damper) reveal no abnormal in functional parts (Report SAMMDSC/4005AERO/96; Report AVIAC TECHNOLOGIES DAV 430; Report LUCAS AEROSPACE).

Referring to the anomaly between the rudder pedal position recorded by FDR and the rudder deflection, the most probable cause is a wrong installation of the rudder pedal transmitter (90 degrees shifting of the transmitter 74TU).

This anomaly was also observed by AI after the accident on other three aircraft, with s/n close to YR-LCC (Report AI/E-fs 420.0354/95). AI consider that after applying a correction to the recorded rudder pedal position compensating for this anomaly, the evolution of the rudder surface and the rudder pedals indicates a full consistency.

3.1.3. Autopilot

According to FDR records, the Autopilot was not engaged during the flight, with the exception of one second at 06.08.19. FDR records the engagement status of the A/P from the FCC (engaged/not engaged) once per second.

Before the moment of 06.08.19, the recorded bank angle was below 45 degrees, at 06.08.19 the bank angle recorded on FDR is 45.09 degrees, and the next record is 50.37 degrees. The FDR record also indicates that before and after 06.08.19, when the crew attempted to engage the A/P, the crew applied input to the elevator.

3.1.4 Warning and protection systems on board

After Autopilot disengagement, CVR records the aural warning for Autopilot disengagement ("cavalry charge") lasting until the end of the recording, but there are no records of aural warnings for overspeed and GPWS when the speed and altitude of the aircraft reached the triggering values.

At 06.08.28, the airspeed reached the maximum value for the slats 15 configuration. At 06.08.29, the airspeed reached 258 kts, which is 10 kts above the maximum allowable speed in that configuration, situation in which, the overspeed warning is activated.

However, due to the fact that, by design, the A/P disconnection warning (cavalry charge) has priority over aural warning of overspeed, the latter was inhibited.

Analyzing the engine thrust reduction rate (approx. 1.6 degrees/second at engine no 1 and

approx. 7.15 degrees/ second at engine no 2), it results that the retard of throttles to idle might be attributed to the starting up of the overspeed protection system ; this throttle motion is consistent with an automatic mode reversion of the A/THR to the SPEED mode, as a result of the airspeed above VFE (Report AI/E-fs 420.0318/95).

Although there is no relationship between A/P disengagement warning and GPWS aural warning , the latter is not recorded (either on FDR or CVR), despite the fact that the aircraft was heading at high speed towards the ground.

However, due to the aircraft attitude to the ground (bank and pitch) and due to the radio altimeter antenna position on the fuselage, it is reasonable to presume that the radio altitude measured was higher than the real altitude of the aircraft.

This is also confirmed by the fact that for barometric altitude of the aircraft less than 4,500 ft, radio altitude parameter is recorded on FDR as NCD (Not Computed Data). In the case that GPWS warning would have been activated, this warning would have been recorded (Report AI/E-fs no 420.0318/95).

3.1.5. Flight control unit

Since two days before the accident an event that might be linked to a FCU failure had been reported, on the purpose of this investigation, this possibility has also been considered.

The results of DFDR and CVR information analyses, in connection with the FCU functional principles, do not support the hypothesis of a FCU failure (even a short time one) during the flight (Report AI/E-fs 420.0328/95).

3.2. Summary of findings

3.2.1 From all aircraft systems, the only one that can be considered to have a direct implication on YR-LCC accident occurrence is ATS.

3.2.2 A history of reported ATS random malfunction occurrence at YR-LCC started with the previous operator of the aircraft.

3.2.3 This kind of malfunction occurred during the previous flight and was not reported.

3.2.4 AI had had information about the occurrence of this type of deficiencies in ATS designed and mounted on board of A300, A300-600 and A310 aircraft constructed before 1986 which made it issue informative technical documentations (see item 2.7.3.2) recommending remedy measures.

3.2.5 The technical measures recommended by AI (design, construction, modifications) for the elimination of the above-mentioned deficiency, have been integrated in the construction process of new aircraft, without being extended to aircraft already in operation (aircraft s/n 450) through mandatory SB issue.

3.2.6. TAROM never met such deficiency until the operation of aircraft s/n 450 YR-LCC.

3.2.7. Until the accident occurred, there had been no AMM and TSM provisions concerning

this type of deficiency and its trouble shooting, however there were issued TFUs. TAROM did not receive any additional troubleshooting or required actions from SWISSAIR, neither from AI.

3.2.8. There was a lack of reaction of the Captain, probably due to an incapacitation.

3.2.9. The Captain decided to guard the engine throttles.

3.2.10. The altitude that corresponds to climb power thrust settings was reached when the Captain, probably, was operating in the FMS the ATC clearance. This led him to leave the throttles unattended.

3.2.11. The Copilot was not aware from the beginning of the thrust asymmetry development.

3.2.12. There was no call-out for climb thrust setting recorded on the CVR.

3.2.13. At a certain moment, the Co-pilot lost the control of the aircraft.

3.2.14. The DFDR of the accident aircraft indicates that the correlation between the recorded position of the rudder pedals and the recorded position of the rudder is not correct. The rudder pedals position was not correctly recorded in the DFDR due to a wrong installation of the sensor which detects the position of the pedals.

3.3. Causes

The investigation commission consider the following causal factors:

- Thrust asymmetry;
- Possible pilot incapacitation (the Captain);
- Insufficient corrective action from the Copilot in order to cover the consequences of the first factors.

4. SAFETY RECOMMENDATIONS

4.1. After the accident, AI issued two mandatory SBs that were enforced a French DGAC Directive, concerning remedy measures to be taken by all operators for elimination of all probable causes of this malfunction.

4.2. Amendments to AMM and TSM have been issued by AI after the accident and sent to operators for adequate updating of the technical documentation.

Sorin Sorescu
Investigator-in-charge
Chairman of the Investigation Commission

A N N E X 1
SYNCHRONIZATION
OF DFDR AND CVR RECORDS
