INSTITUTO NACIONAL DE AVIAÇÃO CIVIL
PORTUGAL

GABINETE DE PREVENÇÃO E SEGURANÇA AERONÁUTICA

REPORT ON THE ACCIDENT TO ANTONOV AN-12BP,
REGISTRATION LZ-SFG
OCCURRED AT LAJES AIR BASE, AÇORES
ON 04-FEBRUARY-1998

NON-OFFICIAL TRANSLATION
In case of conflicting text, the Portuguese report is the valid document

REPORT No. 04/ACCID/GPS/98

CONTENTS

FOREWORD

This report presents the technical conclusions reached by the Investigation Commission on the circumstances and causes of this accident.

In accordance with Annex 13 to the Convention on International Civil Aviation and with the EC directive 94/56, the analysis of the facts, conclusions and safety recommendations contained in this report are intended neither to apportion blame, nor to assess individual or collective responsibility.

The sole objective is to draw lessons from this occurrence which may help to prevent future accidents or incidents.

This report has been translated and published to make its reading easier for English speaking people. As accurate as the translation may be, please refer to the original text in Portuguese.

GLOSSARY

ATIS	- Air Traffic Information Service
BA4	- Air Force Base No.4
CTA	- Air Traffic Controller
CVR	- Cockpit Voice Recorder
DGAC	- Direcção Geral da Aviação Civil
FAP	- Portuguese Air Force
FDR	- Flight Data Recorder
FUS	- Accident Investigation Bureau - Germany
GPS	- Accident Investigation Bureau - Portugal
INAC	- Instituto Nacional de Aviação Civil
QNH	- Altimeter Setting
RG	- Overhaul
SAI	- State Aeronautical Inspectorate - Bulgaria
TG16	- APU (Auxiliary Power Unit)
USAF	- United States Air Force

SYNOPSYS

Date of the accident:	4 February 1998 - 22:17 UTC
Place of the Accident:	Lajes Aerodrome, Air Base No.4 Latitude: 37° 45' 35"N Longitude: 27° 05' 25"W Elevation: 67,20 m
Nature of the Flight:	Non Scheduled Cargo Transport (Mail)
Flight Number:	LXR 513
Owner:	AIR SOFIA
Operator:	AIR SOFIA
Occupants:	Cockpitcrew: 5 + 2 Load Masters
Results:	7 killed (cockpitcrew) Aircraft destroyed damage and contamination of soil on the impact site

NOTIFICATION OF THE ACCIDENT TO NATIONAL AND INTERNATIONAL AUTHORITIES

According to Annex 13 of ICAO, on 09 February 1998, at approximately 11H45 local time, notification of the accident was transmitted to the following Authorities:

- Bulgarian Ministry of Transport
- Russian Accident Prevention and Investigation Board
- Ukrainian Department of Air Transport
- International Civil Aviation Organization - ICAO

ORGANIZATION OF THE INVESTIGATION

According to Annex 13 to the International Civil Aviation Convention, Portugal, as the State of Occurrence, started the investigation into the circumstances and causes of the accident with the aircraft ANTONOV 12 BP, registration LZ-SFG, occurred on 04 February 1998.

In accordance with the provisions of Annex 13, officials of the State Aeronautical Inspectorate of Bulgaria collaborated with this Commission, with the Status of accredited representatives.

For the purpose of the gathering of elements, tests and research, specialists of the following organizations and Companies participated as well:

- State Aeronautical Inspectorate of Bulgaria (SAI)
- Zapowzhie Design Bureau - Ukraine
- Antonov Design Bureau - Ukraine
- Air Sofia
- German Accident Investigation Department (FUS)
- Polícia Judiciária - Portugal
- Laboratório de Análises da Força Aérea Portuguesa (SOAP)

COMPOSITION OF THE INVESTIGATION COMMISSION

In accordance with article 26 of the International Civil Aviation Convention and articles 2 and 4 of Decreto-Lei no. 121/94 of 14 May 1994, by decision of the Director-General of Civil Aviation, the following Investigation Commission was appointed:

ENG.

ENG.

TECH

MAJOR

CAP

CAP

CAP

The Commission was appointed to investigate the causes of the accident as well as to establish the Conclusions and necessary Safety Recommendations.

SUMMARY OF THE WORK OF THE COMMISSION

The Bureau of Accident Prevention of Air Base no. 4 was notified of the accident at approximately 22:19 UTC.

the Civil Authorities were immediately contacted as well as the Airport Authorities, Air Traffic Services (Air Traffic Control and Meteorological Services), General Inspection of Air Force and a list of visual witnesses was compiled.

The Accident Investigation Bureau (DGAC) was notified on 04 February 1998 at 22:19 UTC.

Photographs of the wreckage were taken and a video registration was produced during the fire fighting operations.

On 05 February1998, at approx. 09:55 UTC, another video registration and photographs of the accident site were taken from a PUMA helicopter flight.

The Investigation Commission traveled to Lajes on 05 February, arriving at approx. 12:50 UTC.

The general examination of the wreckage was immediately initiated and the Flight Data Recorder and the Cockpit Voice Recorder were recovered on this day.

On this same day, four visual witnesses were interviewed (two Portuguese Air Force pilots, a Post official and the Portuguese Air Traffic Controller on duty at the time of the accident).

On the following day, the examination of the wreckage proceeded and detailed photographs were taken. At approx. 15:00, local time, the removal of the aircraft components, considered relevant to an ulterior skillful investigation, was initiated.

On this same day the recorded ATC communications were listened to and its transcription was performed by military Air Traffic Controllers.
The second Air Traffic Controller (American) on duty at the time of the accident was also interviewed.

On 07 February at approx. 19:00 UTC, the Commission met with the accredited representatives of Bulgaria, showing the video registrations and providing the available elements at the moment. Working groups were formed in order to proceed the detailed examination of the wreckage.

As it was not possible to decodify in Portugal the "Flight Data Recorder Type MSRP 12-96" and the "Cockpit Voice Recorder Type MS61B", due to lack of appropriate equipment, the collaboration of the "FUS-Fluggunfalluntersuchungsstelle beim Luftfahrt-Bundesamt, Braunschweig, Germany, was requested.
The decodification was performed on 05MAR98, at the headquarters of FUS in Braunschweig, Germany.

The transcription of the recordings of the "Cockpit Voice Recorder" was performed by SAI. This transcription was not performed in DGAC due to the fact that the aircraft crew spoke Bulgarian in the most part of the conversation.

Collaboration was requested to SAI on the investigations related to AIR SOFIA flight operations, as well as to crew data, especially:

- flight experience;
- qualifications;
- medical history.

On request of the Commission, SAI ordered from the aircraft and engines Manufacturers a technical study on the behavior of the engines and fuel system.

1. FACTUAL INFORMATION

All times in this report are UTC times.

1.1 HISTORY OF THE FLIGHT

On 04 February 1998, the aircraft, ANTONOV 12 BP, registration marks LZ-SFG, was operating a non-scheduled cargo flight (flight number LXR 513). It took off from Lajes Airport at 22:15:54, with the destination to Lisboa Airport. This was the third segment of the flight initiated in Lisboa (LPPT) in the same day, having made a technical stop (mail loading/unloading) in Ponta Delgada (LPPD)

The aircraft was refueled in Lisboa with 17.500 liters (14.070 kg), and no refueling was requested in any of the other stops.

The cockpitcrew of five persons was composed by: Captain, Copilot, Navigator, Radio operator and Flight Engineer. In addition there were two licensed technicians performing functions of load masters.

In the Lajes stop (LPLA), the crew did not go to the Operations Service to hand the flight plan or to receive the weather forecast.

The Pilot in command occupied the left hand seat.

At take-off from Lajes, the aircraft had on board 1693,5 Kg of cargo.

The Commission estimated the take off weight was approximately 46.700 Kg.

The departure of the flight LXR 513 was delayed for about four hours due to commercial reasons.

At 22:06:48, the flight LXR 513 requested clearance from Lajes Control tower to start up the engines, having later informed, at 22:06:57, that it was starting up the engines. The flight engineer announces the start up of engine #1.

At 22:09:33 the tower informed that the LXR 513 was cleared.

At 22:09:44 the tower transmitted the clearance to LXR 513. "LIMA X-RAY ROMEO FIVE THREE, CLEARED FROM LAJES TO LISBON, VIA LAJES TWO DEPARTURE, BRAVO, RADAR COORDINATES THREE NINE NORTH, TWO ZERO WEST, GUNTI, FLIGHT PLAN ROUTE. ON DEPARTURE CLIMB AND MAINTAIN FLIGHT LEVEL TWO SEVEN ZERO, SQUAWK FOUR THREE ONE THREE, DEPARTURE FREQUENCY ONE THREEE FIVE DECIMAL ZERO."

At 22:10:06, the LXR 513 confirms the clearance.

At 22:10:21, the flight engineer announces engine #4 in low speed small ground idle.

At 22:10:27, the Captain authorized the start up of engine #3.

At 22:10:29, the flight engineer confirmed the he was starting up engine #3.

At 22:10:33, the radio operator announces that the generators are on.

At 22:10:43, the navigator announces the cargo door is closed and that the door switch is in neutral position.

At 22:10:46, the Captain ordered the start up of engine #2.

At 22:10:48, the flight engineer announces the start up of engine #2.

Afterwards the flight engineer announces that the four engines were in idle.

At 22:12:56, the LXR 513 requested to the tower clearance to roll.

At 22:13:00, the tower clears LXR 513 to roll into runway 33, via taxiway Alfa and to enter the runway for back track.

At 22:13:04, the radio operator announces TG16 (APU) OFF and pedal test, confirmed by the Captain.

At 22:13:09, the radio operator requests instrument check and autobrake on automatic, obtaining confirmation from the Captain.

At 22:13:13, the radio operator asks the navigator about his switches, having been answered "*...all ON*".

At 22:13:17, the radio operator asks the flight engineer to check the instruments vibration system, fuel selection system, hydraulic system and fuel quantity.

At 22:13:22, the flight engineer informs: "*...normal, automatic, nine tons and a bit more".*

At 22:13:24, the radio operator requests the status of doors and hatches and the flight engineer informed that they were closed and locked.

At 22:13:26, the radio operator asks for the nose wheel steering check, the Captain having confirmed "working".

At 22:13:30, the radio operator asks for the TG16 (APU) status, and obtains no answer.

At 22:13:33, the Captain announced to a crew element "*... try now the pumps downwards, while ...*" (having not finished the sentence).

At 22:13:36, the radio operator informed that the cargo weight was 1750 Kg.

At 22:13:37, the Captain continues the sentence interrupted by the radio operator intervention , saying: "*...while going down should ...*" (having not finished the sentence).

At 22:13:40, the Captain asks if they have clearance for the runway, the radio operator having confirmed the clearance.

At 22:13:50, the Captain ordered "*...turn them forward just as ...*" the flight engineer having informed that all pumps were ON.

At 22:13:55, the Captain exclaimed: "*... and nothing is ...*".

At 22:13:58, the flight engineer confirmed the non existence of fuel commenting: "*No, we will see in the climb, it seems to me that the rear one will be..*" (having not finished the sentence).

At 22:14:01, the Captain commented: "*... once if it would not go turn it off. Then, in the climb it will be back ... how do you see that?*"

At 22:14:09, the radio operator asked confirmation of: altimeter zero, QNH 1020 and 15º flaps, the flight engineer having confirmed - "SET UP".

At 22:14:14, the radio operator announced doors and cockpit windows, the Captain having confirmed "CLOSED".

At 22:14:17, the radio operator announced the departure procedure - SID 2.

At 22:14:23, the tower asked notification when ready for departure, having been confirmed by the radio operator.

At 22:14:28, the navigator said: "*... straight ahead and right turn, heading 110º* ", reading afterwards the take-off parameters: "*... V1 180 and critical 230/240 ...*".

At 22:14:40, the radio operator asked: "*propellers?*", having asked the navigator if they were ready.

At 22:14:42, the Captain announced: aircraft brakes released, ready.

At 22:15:46, the radio operator informed the tower they were ready to take-off.

At 22:15:50 the tower transmitted the information: " ...LIMA X-RAY ROMEO, FIVE ONE TREE WIND ZERO FOUR ZERO AT SIX, CLEARED FOR TAKE-OFF, RUNWAY THREE THREE, USE CAUTION DAMP RUNWAY...".

At 22:15:54, the radio operator informed the tower: "*rolling now*".

At 22:15:56, the radio operator said: "*... hold on a little ... well, never mind...*".

At 22:16:02, the flight engineer reported normal parameters.

At 22:16:10, the navigator reported 110, 4 seconds later 150, 4 seconds later V1/CRITICAL, 5 seconds later 230, 2 seconds later 240 and 3 seconds later 250.

Through the analysis of the CVR records, at 22:16:31, it is perceptive the failure of one engine.

At 22:16:33 the flight engineer announced that engine #3 had automatically feathered.

At 22:16:35, the Captain ordered the copilot: " *... Dancho, press the left one*"."

At 22:16:39, and also through the analysis of the CVR records, it is perceptive the failure of another engine.

At 22:16:41, the flight engineer announced that engine #4 had automatically feathered.

At 22:16:46, the Captain commented: " *...we could have landed!*".

At 22:16:48, the navigator alerted: " *... a bit to the left, ...TO THE LEFT ... TO THE LEFT IN THE DIRECTION OF THE RUNWAY!*"

At 22:16:56, the radio operator informed the tower that they were returning.

This was the last communication of the aircraft with the tower.

At 22:16:59, the tower confirmed the message and asked if they had any problems, but obtained no answer.

At 22:17:01, the navigator exclaimed: " *... to the LEFT, TO THE LEFT, ... TO THE LEFT!*".

At 22:17:02, the tower alerted the aircraft to the existence of a mountain on the right side.

At 22:17:04, the navigator shouted: " *...GO TO THE LEFT, TO THE LEFT, ... TO THE LEFT, TO THE LEFT!*".

At 22:17:08, the navigator shouted: "TO THE *LEFT!*".

At 22:17:10, the air traffic controller calls the aircraft again, interrupting the communication, exclaiming: "*Oh God, they are going to fall!*".

At approximately 22:17:13 the aircraft hit the ground and caught fire.

This was the last communication extracted from the CVR records.

The aircraft hit the ground against an elevation on the right side of runway 33, at the altitude of 67,20 meters, 665 meters from the runway centerline in the coordinates 37°45'35"N 27°05'25"W.

1.2 INJURIES TO PERSONS

INJURIES	Crew	Passengers	Others
Fatal	**5**	**---**	**2**
Serious	**---**	**---**	**---**
Minor /None	**---**	**---**	**---**

1.3 DAMAGE TO AIRCRAFT

The aircraft was completely destroyed due to the impact with the ground and in the fire that followed.

1.4 OTHER DAMAGE

Contamination of soils and destruction of the walls of the agricultural field where the aircraft crashed.

1.5 PERSONNEL INFORMATION

1.5.1 Captain

Age	47 years
Sex:	Male
License:	Airline Pilot's License, issued by SAI-Bulgaria and valid.
Medical Certificate:	16 DEC 97
Flying Experience:	
Total:	11.731 Hours
On type:	3.104 "
On post:	2.273 "
Last 30 days:	57 "
Last 24 hours:	3 "

Copilot

Age:	50 years
Sex:	Male
License:	Airline Pilot's License, issued by SAI-Bulgaria and valid.
Medical Certificate:	16 DEC 97
Flying Experience:	
Total:	5.080 Hours
On type:	1.772 "
On post:	5.028 "
Last 30 days:	57 "
Last 24 hours:	3 "

Navigator:

Age	50 years
Sex:	Male
License:	Navigator's License, issued by SAI-Bulgaria and valid.
Medical Certificate:	05 AUG 97
Flying Experience:	
Total:	7.625 Hours
On type:	2.467 "
On post:	7.625 "
Last 30 days:	57 "
Last 24 hours:	3 "

Flight Engineer

Age	47 years
Sex:	Male
License:	Flight Engineer's License , issued by SAI-Bulgaria and valid.
Medical Certificate:	24 APR 97
Flying Experience:	
Total:	5,764 Hours
On type:	740 "
On post:	5,764 "
Last 30 days:	57 "
Last 24 hours:	3 "

Radio Operator

Age	58 years
Sex:	Male
License:	Radio Operator's License, issued by SAI-Bulgaria and valid.
Medical Certificate:	01 SEP 97
Flying Experience:	
Total:	2,589 Hours
On type:	2,589 "
On post:	2,589 "
Last 30 days:	57 "
Last 24 hours:	3 "

On board the aircraft there were also two Load Masters, licensed technicians.

1.5.2 Air Traffic Controllers

On the day of the accident the designated shift was composed of three air traffic controllers supervisors on Aerodrome and Radar Approach Control, four air traffic controllers supervisors on Aerodrome and Radar Approach Control, one air traffic controller on Aerodrome and Radar Approach Control and one air traffic controller on Aerodrome Control.

During the aircraft take-off from Lajes, there were two air traffic controllers, supervisors on Aerodrome Control, on duty in the tower, one in Aerodrome position and the other in Coordination.

1.5.2.1 Occupation of work stations at the moment of the accident

1.5.2.1.1 - ATC in Aerodrome position (Shift Supervisor)

Nationality	Portuguese
Sex:	Male
License:	No. 698/95, issued by FAP - Portuguese Air Force
Qualifications:	Aerodrome Control 16 JUL 96
Medical Exam:	Class 3, issued by FAP Medical Centre, on 19 NOV 97

Education and Professional Experience

Attended the Course of Military Air Traffic Control and Radar in 1995;
Initiated training in Aerodrome Control at Lajes (Air Base No. 4), and was qualified in Coordination position on 21 FEB 96;
Qualified in Aerodrome position on 16 JUL 96;
Aerodrome Control Supervisor since 20 DEZ 96.

Work time from 28 January to 4 February 1998

The Air Traffic controller in Aerodrome position was on holidays from 20 January to 3 February, starting duties at 19H30 UTC on the day of the accident.

1.5.2.1.2 ATC in Coordination position

Nationality	North American
Sex:	Female
License:	issued by USAF

1.6 AIRCRAFT INFORMATION

1.6.1 Aircraft

Manufacturer:	ANTONOV
Type:	AN-12BP
Serial Number:	1605
Year of Manufacture:	1963
Registration Certificate:	No. 937, issued on 25 JUN 92, by State Aviation Inspectorate - Bulgaria.
Airworthiness Certificate:	No. 937, issued on 25 JUN 92, by State Aviation Inspectorate - Bulgaria, valid until 03 NOV 98
Air Operator Certificate:	No. 005-1197, issued on 21 NOV 97, by State Aviation Inspectorate - Bulgaria and valid until 28 SEP 98.
Noise Certificate:	No. 70, issued on 25 APR 95, by State Aviation Inspectorate - Bulgaria.
Aircraft Radio Station Certificate:	No. PB-20, issued on 30 JUL 92
Total aircraft hours:	
Total hours:	12,492
Hours after overhaul:	204, 50
Total landings:	7,005

Last Inspection: FG2, on 05 JAN 98

Airworthiness Directives: During the last overhaul, completed on 15 OCT 97, the aircraft was under the manufacturer's control (Antonov Design Bureau), that attributed the aircraft a potential of 15,000 hours, 8,000 flights and 35 years. On the above mentioned date, all the mandatory Service Bulletins were fulfilled, according to information provided by the Bulgarian State Aviation Inspectorate.

Pending Anomalies

Due to the destruction of the flight documentation, it was not possible to check if there were pending anomalies at take-off from Lajes.

1.6.2 ENGINES

IVCHENKO AI-20M

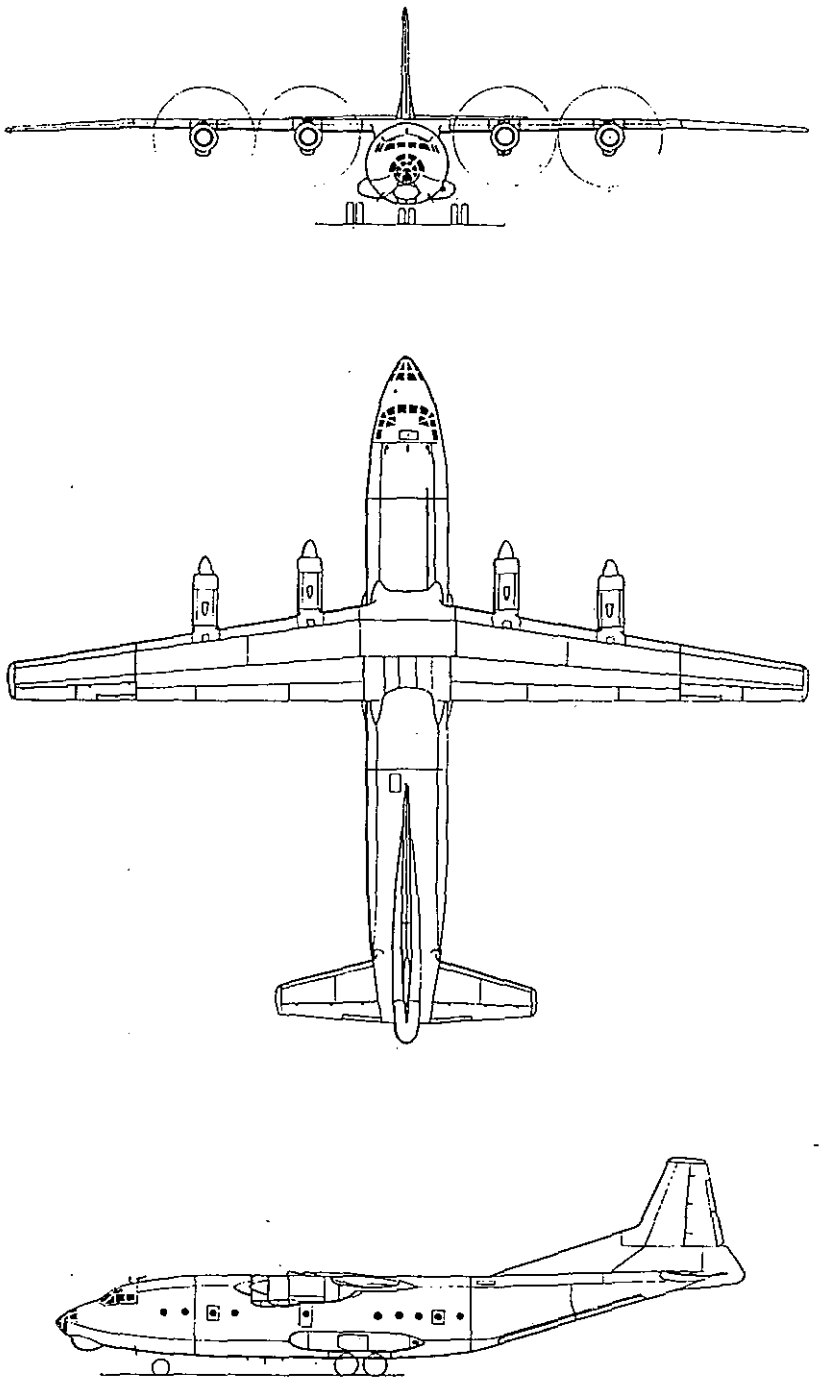
POSITION	SERIES	S/N	YEAR MANUF.	TOTAL TIME	TIME AFTER OVH	LAST INSP.
# 1	**6 A**	**H2316106**	**1973**	**9127:20**	**5193:20**	**FG2 (05JAN98)**
# 2	**6 A**	**H28036033**	**1980**	**3509:23**	**3214:00**	"
# 3	**6**	**H22261033**	**1972**	**17029:00**	**5875:50**	"
# 4	**6**	**H2016057**	**1970**	**5648:30**	**2035:30**	"

Potentials and Airworthiness Directives

The four engines were within the potential limits established by SAI.
The Mandatory Service Bulletins were fulfilled, according to information provided by SAI.

Pending Anomalies

Due to the destruction of the flight documentation, it was not possible to check if there were pending anomalies at take-off from Lajes.



GENERAL VIEW OF THE AIRCRAFT

1.6.3 PROPELLERS

AW-68i

POSITION	SERIES	S/N	YEAR OF MANUF.	TOTAL TIME	TIME AFTER OVH	LAST INSP.
# 1	04A	H105T340	1971	8640	2520	FG2 (05JAN98)
# 2	04A	H053280098	1983	3197	1834	"
# 3	04A	H105T336	1971	8947	206	"
# 4	04A	H080400100	1990	3598	---	"

Potentials and Airworthiness Directives

The four propellers were within the potential limits established by SAI. The Mandatory Service Bulletins were fulfilled, according to information provided by SAI.

Pending Anomalies

Due to the destruction of the flight documentation, it was not possible to check if there were pending anomalies at take-off from Lajes.

1.6.4 WEIGHT AND BALANCE

There were seven crew members on board the aircraft and 1693,5 kg of bulk cargo, although stored in the cargo compartment and secured by metallic bars on the front and back ends

The Investigation Commission computed the weight and balance as follows:

- Take-off weight — 46,700 kg
- Balance conditions — MAC 20%

The weight and balance, computed with the help of SAI, were within the approved limits.

1.6.5 FUEL SYSTEM

1.6.5.1 - Description of the System

The aircraft fuel system comprises seven wing tanks, numbered from zero to six, and two other Groups located under the floor of the cargo compartment. The wing tanks are fuel-cell type, except the tanks of the Group zero which are integral.

All the wing tanks have a dual flow fuel pump, two modes, (Normal and High), except Group 6 that has two dual flow fuel pumps, two modes, (Service and Normal).

In the fuselage tanks, the front Group has two pumps and the back Group one.

1.6.5.2 - OPERATION OF THE SYSTEM

The fuel system can operate in two different modes:

AUTOMATIC and MANUAL

1.6.5.2.1 - Automatic Mode Operation

In AUTOMATIC mode the consumption sequence initiates in Group 6 tanks which immediately begin to receive fuel from Group 0.
After the fuel from Group 0 is consumed, the fuel from Group 6 goes on being consumed until it reaches the approximate quantity of 2.000 liters, after which the sequential consumption from Groups 1, 2, 3 and 4 is initiated.
After Group 4 is spent, Group 5 consumption is initiated, which feeds simultaneously the engines and tanks from Group 6, until these are full.
After Group 5 is spent, Group 6 consumption is initiated.
The fuel in the fuselage tanks is consumed after transfer in MANUAL mode to Group 1.
The engines feeding is made from the tanks of Group 1 to 6 .

1.6.5.2.2 - Manual Mode Operation

In Manual mode the system feeds the engines from Groups 1 to 6 tanks, according to the selection made by the crew.

1.6.5.2.3 - System Control

Control Panel

The fuel system is controlled from a panel fitted in the upper right side of the flight engineer's panel.
The control panel of the fuel system is composed by a set of green lights that indicate which tank is being consumed in MANUAL mode, with the exception of tank 6 lights, which are always ON (both in MANUAL and AUTOMATIC).
Under these lights there is a set of blue lights that indicate which tank is being consumed in AUTOMATIC mode. The panel has a system to adjust the brightness.

A first set of switches that control respectively form left to right:

- 2 switches - Group 6 pumps;
- 1 switch with guard that controls the emergency operation of the pumps.
- 6 switches for the manual control of the pumps of the remaining wing tanks.

A second set of switches that control respectively form left to right:

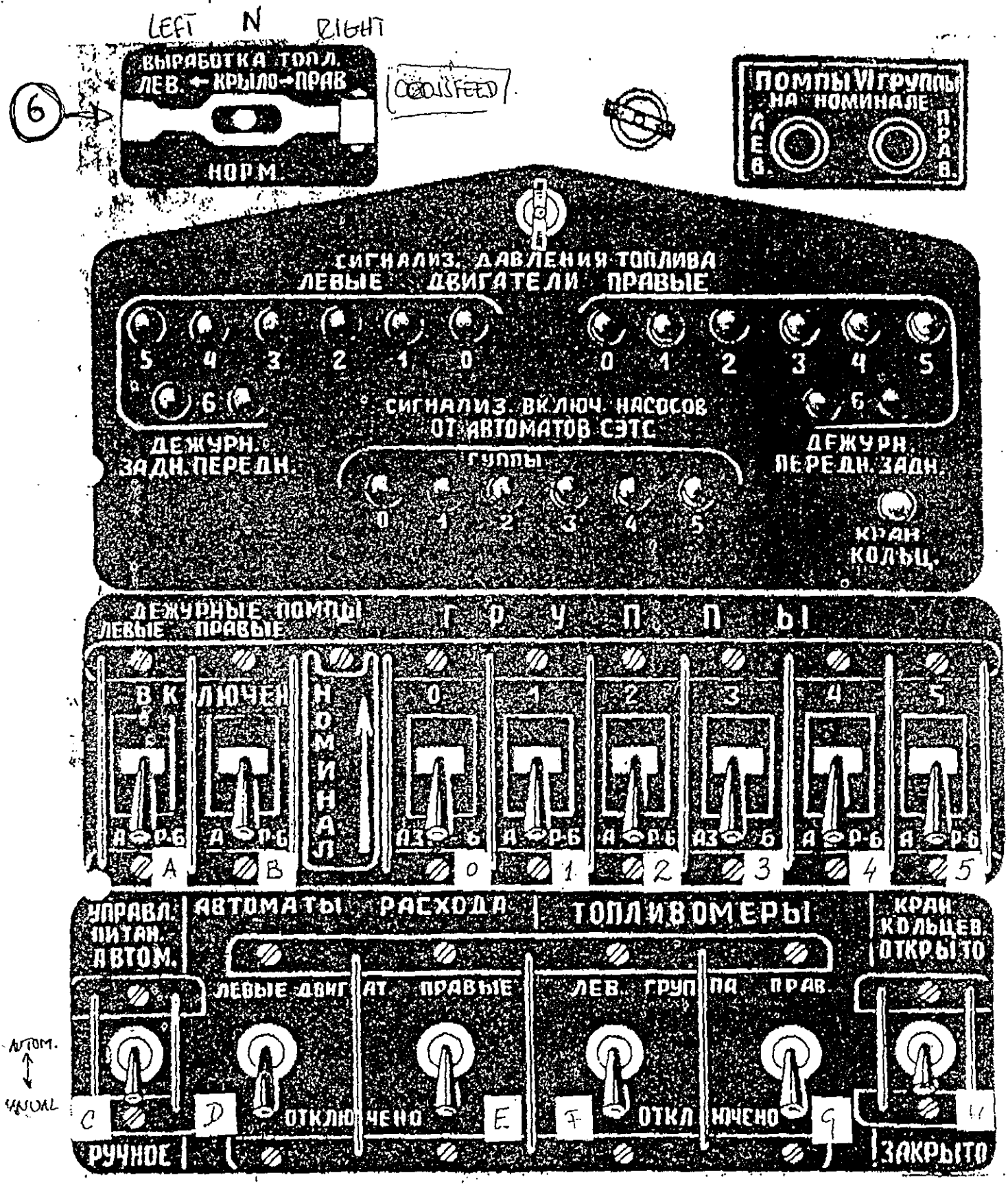
- First - Selection of the AUTOMATIC and MANUAL modes
- Second and third - Selection of the consumption in AUTOMATIC (power supply left and right units)
- Fourth and fifth - Selection of the quantity of fuel
- Sixth - Cross-feed system selection.

AUTOMATIC control

In AUTOMATIC control, the mode selection switch is selected to AUTOMATIC, Group 6 pump switches should always be ON as well as the switches of the position CONSUPTIOM.

In this situation, the green lights which indicate that Group 6 is functioning should be ON, as well as the blue light indicating the tanks that are being consumed.
In this situation of AUTOMATIC consumption, the position of the switches of the remaining tanks has no influence over the operation of the system, whether they are ON or OFF, and the green lights indicate the pressure of the fuel pumps.

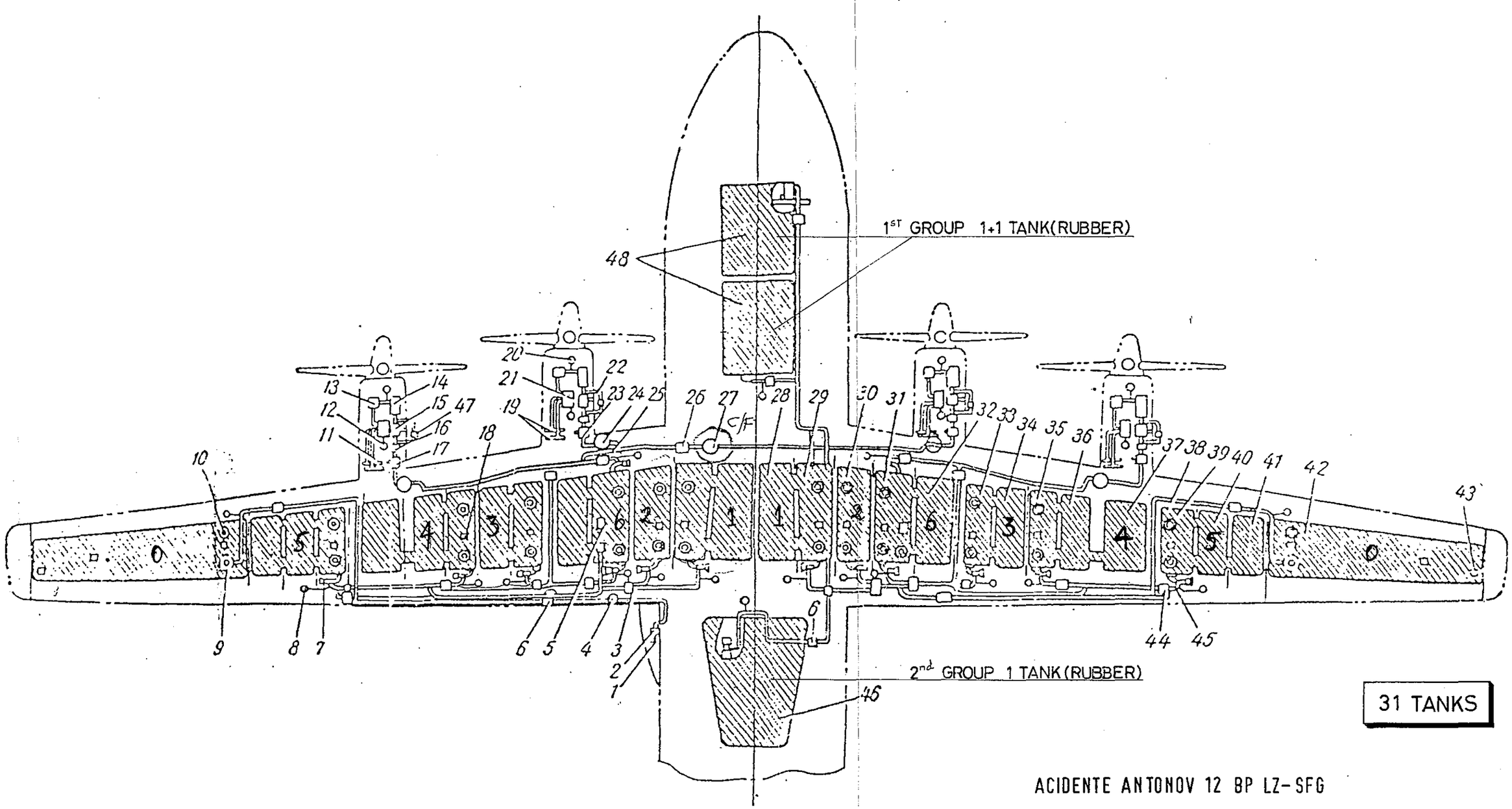
FUEL CONTROL PANEL AN 12



Фиг. 71. Щиток управления сигнализации и топливной системы.

Рис. 69. Принципиальная схема топливной системы:

1—штуцер подвода топлива к ТГ-16М; *2*—фильтр ПТФ-30; *3*—двойной обратный клапан; *4*—электромагнитный кран; *5*—поплавковый клапан; *6*—обратный клапан; *7*—подкачивающий насос (агр. 463); *8*—сигнализатор давления (СДУ-2А-0,18); *9*—подкачивающий насос (агр. ЭЦН-14А); *10*—заливная горловина; *11*—сливной кран; *12*—датчик давления ПДТ-100; *13*—насос высокого давления на двигателе; *14*—датчик расходомера (РТМС-1,2-Б1); *15*—фильтр тонкой очистки (агр. 12Т-15СН); *16*—подкачивающий насос на двигателе; *17*—фильтр грубой очистки (агр. 80296005); *18*—датчик топливомера; *19*—топливный коллектор форсунок двигателя; *20*—датчик давления ПДТ-4; *21*—командно-топливный агрегат; *22*—сливной кран; *23*—штуцер консервации двигателя; *24*—пожарный кран; *25*—обратный клапан с отверстием в тарелке; *26*—штуцер забора топлива в гидросистему; *27*—кран кольцевания; *28*—бак № 1; *29*—бак № 2; *30*—бак № 3; *31*—бак № 4; *32*—бак № 4А; *33*—бак № 5; *34*—бак № 6; *35*—бак № 7; *36*—бак № 8; *37*—бак № 8А; *38*—жиклер; *39*—бак № 9; *40*—бак № 10; *41*—бак № 11; *42*—бак-кессон; *43*—сливной клапан; *44*—обратный клапан с пружиной Т6100-107-1; *45*—обратный клапан с пружиной П6100-130-3; *46*—обратный клапан с пружиной П6100-107-2; *47*—датчик СГДФ-1Г; *48*—подпольные баки



ACIDENTE ANTONOV 12 BP LZ-SFG

LAGES-AÇORES EM 04 FEV. 1998

SISTEMA DE COMBUSTÍVEL

MANUAL control

In MANUAL control, the mode selection switch should be selected to MANUAL, Group 6 pump switches should be ON, as well as the switch of the Group of tanks that is selected to consumption.

The switches indicating the consumption should be OFF / ON.

In this situation, Group 6 green lights should be ON, as well as the green light of the Group of tanks that is being consumed.

Fuel Transfer

The use of the fuel stored in the fuselage tanks is controlled by a panel located on the upper right central part of the cockpit, which transfers in MANUAL mode the fuel to Group 1 tanks.

1.17 METEOROLOGICAL INFORMATION

1.17.1 Meteorological Information provided by ATIS

At 21:55 UTC:
Wind
Beginning of runway: 050º/08 kts
Runway center: 050º/08 kts
Visibility: > 10 km
Clouds: SCT 2600 ft; SCT 4500 ft
Temperature: 12º C
Dew point: 08º C
Pressure (QNH): 30.13 In/Hg, 1020 hPa

At 22:22 UTC:
Wind
Beginning of runway: 040º/07 kts
Runway center: 040º/08 kts
Visibility: > 10 km
Clouds: SCT 2600 ft; SCT 4500 ft
Temperature: 12º C
Dew point: 08º C
Pressure (QNH): 30.14 In/Hg, 1020 hPa

1.8 NAVIGATIONAL AIDS

1.8.1 Introduction

The aerodrome was equipped with the following radio navigational aids:

- NDB GP - FREQ. 341 KHz (384659N - 0270651W)
- VOR LM, - FREQ. 112.30 MHz (384703N - 0270620W)
- TACAN LAJ - CH4 (384248N - 0270700W)
- TACAN TRM - CH109 (384538N - 0270534W)
- ILS 15
  LLZ DK - FREQ. 109.90 MHz (384459N - 0270444W)
  GP - FREQ. 333.80 MHz
- ILS 33
  LLZ OZ - FREQ. 111.50 MHz (384641N - 0270459W)
  GP - FREQ. 332.90 MHz

1.8.2 Functioning of the Radio Aids Equipment

The functioning of the Radio Aids System was analyzed according to periodical and special check reports, in flight, by the FAA with a HS-25 aircraft type.

NBD (GP) System

The in flight periodical check report, performed on 25 SEP 97, classifies the Radio Aid NDB for "Unrestricted" use.

The Air Traffic Services maintenance occurrence report revealed no deficiencies.

VOR (LM) System

The in flight special check report, performed on 29 SEP 97, classifies the Radio Aid for "Restricted" use. The restrictions are published in the MILITARY AIP - PORTUGAL, page COM 2-5.

The Air Traffic Services maintenance occurrence report revealed no deficiencies.

TACAN (LAJ) System

The in flight periodical check report, performed on 12 DEC 96, classifies the Radio Aid for "Restricted" use. The restrictions concern alterations to the ground checkpoint of the intersection of the taxiway with the beginning of runway 35 to R047/3.0.

The Air Traffic Services maintenance occurrence report revealed no deficiencies.

TACAN (TRM) System

The in flight periodical check report, performed on 07 JAN 97, classifies the Radio Aid for "Restricted" use.
The restrictions are published in the MILITARY AIP - PORTUGAL, page COM 2-6.

The Air Traffic Services maintenance occurrence report revealed no deficiencies.

ILS 33 System

The in flight check report, performed on 02 APR 97, classifies the Radio Aid for "Unrestricted" use.

The Air Traffic Services maintenance occurrence report revealed no deficiencies.

ILS 15 System

The in flight periodical check report, performed on 25 SEP 97, classifies the Radio Aid for "Unrestricted" use.

The Air Traffic Services maintenance occurrence report revealed no deficiencies.

1.9 COMMUNICATIONS

According to the Air Traffic Services maintenance occurrence report of Air Base No. 4, it was verified that during February 1998, there were no anomalies or functioning discrepancies in the transmitters/receivers COM/VHF and COM/UHF that could have interfered with the communications with the aircraft.

The Investigation Commission performed analysis of the communications recordings and transcriptions of the frequency 122.10 MHz.

The transcriptions of the recordings are attached in Annex.

1.10 INFORMATION ON THE AERODROME

1.10.1 General Information

All the services related to the Air Traffic services, in general, are the responsibility of the Portuguese Air Force.
In MILITARY AIP - Portugal, published by Air Force Aeronautical Information Services, practices and procedures applicable in this Aerodrome are published.

1.10.2 Lajes Aerodrome

Reference Point:

Coordinates:	38°45'52" N 027°05'36" W
Altitude:	55 m (180 ft)
Magnetic Deviation:	14°32' W (1996)

Checking Points:

Altimeter:	
Rwy 15 threshold:	158 ft
Rwy 33 threshold:	180 ft
Taxiway H:	154 ft

Runways: 15/33

True Orientation:	140°44' / 320°44'
Length:	3,312 m
Width:	91 m
Landing Zone:	317 m / 284 m
Runway Resistance:	NIL
Runway Pavement:	asphalt / concrete

Taxiways:

Width:	Taxiways A,B,D,E,F,G,H,I - 30 m Taxiways C and HS - 60 m
Resistance:	90.000 lb / 200 PSI
Pavement:	asphalt / concrete

Markings:

Runway 15/33:	runway identification marks, center line, threshold, runway distance remaining, touchdown zone, lateral runway limits, stop zone.
Taxiways	Markings for center line, holding and intersection zones, vertical identification markings of the taxiways and holding areas to runway.
Obstacles:	Markings of all obstacles

Equipment:

Auxiliary emergency power:	Auxiliary electrical power is assured according to the requirements of Annex 14.

Visual Navigation Aids:

Reference Visual Aids: Aerodrome beacon

Indicators and signal devices:

For landing:	Illuminated wind sock
For communication:	There is no signal area

Lightning devices:

Runway 15 approach:	short approach lights (length 2000 ft) with sequence lights, PAPI, 3° slope, on the left side of the runway, all with variable brightness.

Runway 33 approach:	standard approach lights (USA model) with high and variable brightness (ALSF-1) with sequence lights, PAPI, 3,2° slope on the right side of the runway, all with variable brightness.
Runway 15/33:	Edge lights and threshold lights with variable brightness.
Taxiways:	Edge lights (blue).

1.10.2.1 - Operation of the lightning devices

The lightning devices of runway 15/33 were operational at the time of the accident.

1.11 FLIGHT RECORDERS

The aircraft was fitted with the following flight recorders:

- a flight data recorder (FDR), model MSRP12-96, serial number 81.061;
- a cockpit voice recorder (CVR), model MS 61-B, serial number 15/352 in operational status.

In addition, the aircraft had on board a second cockpit voice recorder, model MS 61-B, without wire tape, as spare unit.

Both flight recorders, in their spherical metallic crash protection units, were found in the aircraft wreckage, and the total external surface of the crash protection units were found to have been externally submitted to high temperatures, related to post-impact fire on aircraft.

These units were removed from the accident aircraft site and latter transported to GPS, DGAC-Portugal.

Due to the fact that there were no technical means at DGAC-Portugal to perform a readout of both flight recorders, assistance was requested for this work, in accordance with Annex 13 to Convention, Chicago 1944, to "FUS-Flugunfalluntersuchungsstelle beim Luftfahrt-Bundesamt", Braunschweig, Germany, that accepted the task.

Both flight recorders were transported, by the Investigation Commission, to "FUS", Braunschweig, Germany, and on March 5, 1998, the crash protection units were opened and photographed and the flight recorders tapes recovered for readout and analysis.

During all these operations, observers of the Bulgarian Aviation Authority and the operator AIR SOFIA were present , in accordance with Annex 13 of ICAO.

A readout was performed on both flight recorders and data consistent with the accident was located.

The reports of these operations are attached to the present report.

1.11.1 RECORDS OF CONVERSATION AND AURAL WARNINGS IN THE COCKPIT THROUGH THE CVR

The steel wire type magnetic tape removed from the MS 61-B unit, in which are recorded the voice communications and the aural environment on the flight deck of the accident aircraft, was found in good visual conditions, and with no damages, due to the external high temperatures, as well as the recorder unit itself which was found to be operational - checked "in loco".

The CVR records the last 5 hours of operation.

As the recorder unit was of ancient conception, it records only in one channel all communications - the voice communications transmitted from or received in the aircraft by radio, the aural environment on the flight deck and the voice communications of the flight crew using the aircraft's interphone system. Neither, was recorded as time reference base, superimposed to the recorded communications.

So, in order to correlate the voice communications recorded in the CVR and the voice communications recorded in the Log Radio of the ATS unit, the time found between the several aircraft voice communications was measured and compared with those found in the ATC Log Radio.

Copies of the CVR recordings were produced in normal magnetic tape and preserved in DGAC archives; one copy was sent to the Bulgarian Aviation Authority.

The transcription of the CVR communications is attached to the present report.

1.11.2 RECONSTRUCTION OF THE FLIGHT THROUGH THE PARAMETERS REGISTERED ON THE FDR AND CORRELATED WITH THE CVR RECORDS

The recorder unit used an original 250 meters standard studio tape, 50 μm thick, and operated at the speed of 3 ¾ ips to allow the recording of the last 90 minutes of flight; the tape reverse is caused by means of metal foils.

The original Russian made tape has the magnetic layer on one side and no back coating. The use of a professional tape with back coating prevented the sticking of windings under the influence of heat.

The tape exhibited damages due to the high temperatures developed during the post-impact fire and its constructive characteristics, namely the tape in the free part between reels and guide rollers and in the lower reel.

The tape in the upper reel exhibited minor damages, and despite the reduced magnetisation, the data recorded was recovered.

The readout of this data allowed the identification of parameters related to the last Lajes airport approach (24' 00") and the last Lajes airport take-off (01' 08"), except the last few seconds of the accident flight, not recovered and recorded in the free part between reels and guide rollers.

The sequence of aircraft events derived from FDR data are as follows:

- at 22:15:54 UTC, the aircraft initiated the take-off run;

- after 16 seconds, the aircraft speed was 110 km/h;

- 4 seconds later, the aircraft speed was 150 km/h;

- at 22:16:18 UTC, the aircraft speed was 180 km/h (V1);

- 5 seconds later, the aircraft speed was 230 km/h;

- at 22:16:25 UTC, the aircraft speed was 240 km/h and simultaneously a drop indication of #3 engine torque to 11kg/cm2, followed by the drop of #1 and #2 engine droop respectively to 35 kg/cm2 and 37 kg/cm2;

- immediately to these drops, the three engines recovered, including #3 engine in which its torque attained the value of 31 kg/cm2;

- 6 seconds latter, the #3 engine torque reduce to 11 kg/cm2, and does not recover, feathering 3 seconds latter, at 22:16:34 UTC;

- simultaneously, the aircraft rolls to the right, increasing, until the end of the recording;

- the medium value of the rudder deflection angle, after the #3 engine stopped, was 13,8° left;

- the medium value of the right aileron deflection angle, after the #3 engine stopped, was minus 10°;

The records of #4 engine torque were not found at FDR data, due to a probable malfunction on sensor or recorder.

The spectral sound analysis of the aural environment on the flight deck (CVR data), allowed to confirm that # 4 engine initiates its stoppage 7 seconds after the stoppage of #3 engine.

The FDR data confirms that the #4 engine feathered 8 seconds after #3 engine feathered.

1.12 IMPACT AND WRECKAGE

1.12.1 IMPACT

The aircraft hit the ground against an elevation on the right side of runway 33, at the altitude 67,20 meters, 665 meters from the runway centerline in the coordinates 37° 45' 35"N, 27° 05' 25"W.

The aircraft wreckage was spread over an area of 3075 square meters in a way that showed a high angle of impact but with a not too high speed.

Engine #1 and the left wing were found to the right of the place of first impact and in the direction 360°. Propellers #1 and #2 were found on the place of initial impact buried into the ground and covered by debris.

Ahead of the site of impact and in the direction 070°, part of the rear section of the central fuselage was found over a stone wall in a downward position with its forward part oriented to 070°.

The front and rear parts of the fuselage were completely destroyed due to the impact and fire.

The nose and the main gears were found in front of the rear part of the central fuselage and the left cargo door to the right side of the gears.

The cargo ramp was found 10 meters to the right of the fuselage and over a stone wall.

The cargo was spread over the area where the wreckage of the forward part of the central fuselage was found.

One of the CVR's was found intact near the wreckage of the central fuselage.

The second CVR, that was inoperative, was found open, with the two semi-spheres separated and the registration equipment separated too.

The FDR was found intact among the wreckage of the rear part of the central fuselage, near the area of the cargo ramp.

To the right, partly under the left side of the rear part of the central fuselage ceiling, engine #2 was found and a few meters ahead the engine cowlings and the oil cooler.

Engine # 4 was found on a road 52 meters away from the initial impact site and near the stone wall of the yard.
Over this same wall, and to the left of the engine, approximately 10 meters away the right cargo door was found.

The right outer wing section, was oriented in the direction 340° and was found to the left of the rear fuselage.

The right inner wing section was found to the left of the rear part of the central fuselage and near the right main gear fairing.

Between the inner section of the right wing and the rear part of the central fuselage, among the aircraft wreckage there was a diving air bottle which exploded due to the heat caused by the fire.

Engine #3 was found near the two sections of the right wing and oriented in the direction 220°.

Propellers #3 and #4 were found to the left of the impact point, half buried and with the blades feathered.

1.12.2 FUSELAGE

The fuselage, on the immobilization zone, was divided into three parts and completely consumed by fire.

The cockpit area was totally buried into the ground, crushed by the impact action and completely consumed by fire.

1.12.3 TAIL SURFACES / FLIGHT CONTROLS

The horizontal and the vertical stabilizers as well as the elevator and rudder controls, were spread over the impact site, broken and near the rear part of the fuselage completely destroyed and carbonized.

The right and left wing flaps were near their respective wing casings destroyed and carbonized.

The right wing aileron was separated from the wing, destroyed and partially carbonized.

The left wing aileron was attached to the wing destroyed and partially carbonized.

1.12.4 WINGS

the right wing was separated from the fuselage, broken into two sections and consumed by fire.

The outer section of the right aileron was separated from the wing.

The right wing flaps were in their casings and partially distended.

The left wing was separated from the fuselage broken in several parts and consumed by fire.

The aileron was attached to the wing.

The left wing flaps were in their casings and partially distended.

1.12.5 CABINS

Forward Cabin (Cockpit Attendant Cabin)

All the forward cabin was destroyed by the impact and the subsequent fire.

Central Cabin (Cargo Cabin)

The central cabin was partially destroyed due to the impact and the subsequent fire.

Rear Cabin (Cargo Ramp and Tail)

All the rear cabin and the tail area was destroyed by the impact and the subsequent fire, except for the doors and cargo ramp which were projected after the collision with the ground.

1.12.6 DOORS

The access door to the cockpit, located near the nose gear area, was completely destroyed by to the impact and the subsequent fire.

The door from the forward cabin into the cargo compartment, got loose from its attachment fittings due to the impact and was found near the main gear wreckage.

The rear doors to the cargo compartment got loose from their attachment fittings due to the impact and the one on the right side was projected forward and to the left of the wreckage, while the one on the left side was projected forward and to the right of the wreckage.

The ramp to the cargo compartment got loose from its attachment fittings, due to the impact and was found to the right of the rear part of the backward fuselage wreckage, over a yard stone wall, with evidence of having been slightly consumed by fire and showing a high degree of corrosion by the detachment of some parts of the structural cover.

1.12.7 ENGINES

Engine #1

The engine was found seriously damaged near the wreckage of the left wing, showing evidence of ingestion of stones and sand which indicates that it hit the ground in high power.

The engine was separated from the gear box and from the propeller.

Engine #2

The engine was found partially under the left side of the rear part of the central fuselage (in the same STA of the APU) seriously damaged, showing evidence of ingestion of stones and sand which indicates it hit the ground in high power.

The engine was separated from the gear box and from the propeller.

Engine #3

The engine was found near the wreckage of the right wing, seriously damaged. It did not show evidence of ingestion of debris, which indicates it hit the ground with power off and was partially consumed by fire.

The engine was separated from the gear box and from the propeller.

Engine #4

The engine was found seriously damaged, on a road 52 meters away from the impact site and near the stone yard wall. It did not show evidence of ingestion of debris foreign objects, which indicates it hit the ground with power off.

The engine was separated from the gear box and from the propeller.

1.12.8 PROPELLERS

Propeller #1

The propeller was found to the right of the impact area, completely buried into the ground, covered with wreckage, showing the blades 1, 2 and 3 bent in the rotation direction.

Blade no. 4 was fractured with separation near the blade root.
The damage evidenced that the propeller hit the ground in high power.
Due to the impact effect on the ground the spinner was molded to the propeller hub.

Propeller #2

The propeller was found to the right of the aircraft impact site, completely buried into the ground, covered with wreckage with all the blades bent in the rotation direction.
Blades no. 2 and 4 showed damages on the edges.
The edge of blade no. 3 was consumed by fire.
The damage evidenced that the propeller hit the ground in high power.
Due to the impact effect on the ground the spinner was molded to the propeller hub.

Propeller #3

The propeller was found to the left of the aircraft impact site, partially buried into the ground with the blades feathered and with no dragging traces on the blades surface, evidencing power off when hitting the ground.

Blade no. 1 showed minor damages on the trailing edge.

Due to the impact effect on the ground, the spinner was molded to the propeller hub.

Propeller #4

The propeller was found to the left of the aircraft impact site, partially buried into the ground with the blades feathered and with no dragging traces on the blades surface, evidencing power off when hitting the ground.

Blade no. 2 showed minor damages on the trailing edge.

Due to the impact effect on the ground, the spinner was molded to the propeller hub.

1.12.9 APU

The APU showed no damages except the ones resulting from the exposure to fire.

1.12.10 LANDING GEAR

Right Main Gear

The gear was found on the down blocked position, 28 meters ahead of the rear part of the central fuselage and to the right of the aircraft impact site.

The wheels showed evidence of having been exposed to the fire.

Left Main Gear

The gear was found on the down blocked position, 21 meters ahead of the rear part of the central fuselage and to the right of the aircraft impact site.

The wheels showed evidence of having been exposed to the fire.

Note: *Two of the main gear spare wheels were found ahead of the of the wreckage of the central fuselage, showing evidence of having been exposed to the fire.*

Nose Gear

The gear was found on the down blocked position, 20 meters ahead of the rear part of the central fuselage wreckage, to the right of the aircraft impact site and to the left of the left main gear.

1.12.11 INSTRUMENTS AND CONTROLS

The cockpit was completely destroyed due to the impact on the ground. However, it was possible to identify the following instruments and controls:

1.12.11.1 FLIGHT INSTRUMENTS

Airspeed Indicator

Indicates approximately 280 Km/H IAS (carbonized)

Turn and Bank

Carbonized.

Altimeter

Indicates 135 meters (carbonized).

VOR/ILS Selector

VOR system selected to 112.3 (carbonized).
ILS System selected to 111.5 (carbonized).

1.12.11.2 AIRCRAFT INSTRUMENTS

Hydraulic System #2 Indicator

Indicates 200 Kg/cm^2 (carbonized).

1.12.11.3 ENGINE INSTRUMENTS

Triple Indicator (Oil and Pressure Temp. and Fuel Pressure)

Engine #1, #2, #3, and #4 instruments were found carbonized.

Thrust Lever Position Indicator

Engines #1 and #2 indicator was found with the needles positioned out of scale (carbonized).

Engines #3 and #4 indicator was found carbonized.

Tachometers

Engine #1 tachometer indicated 105%.
Engine #2 tachometer indicated 36%.

> **NOTE**: *The tachometers boxes were found deformed on the upper rear part, evidencing an impact of approximately 135º (inverted flight).*

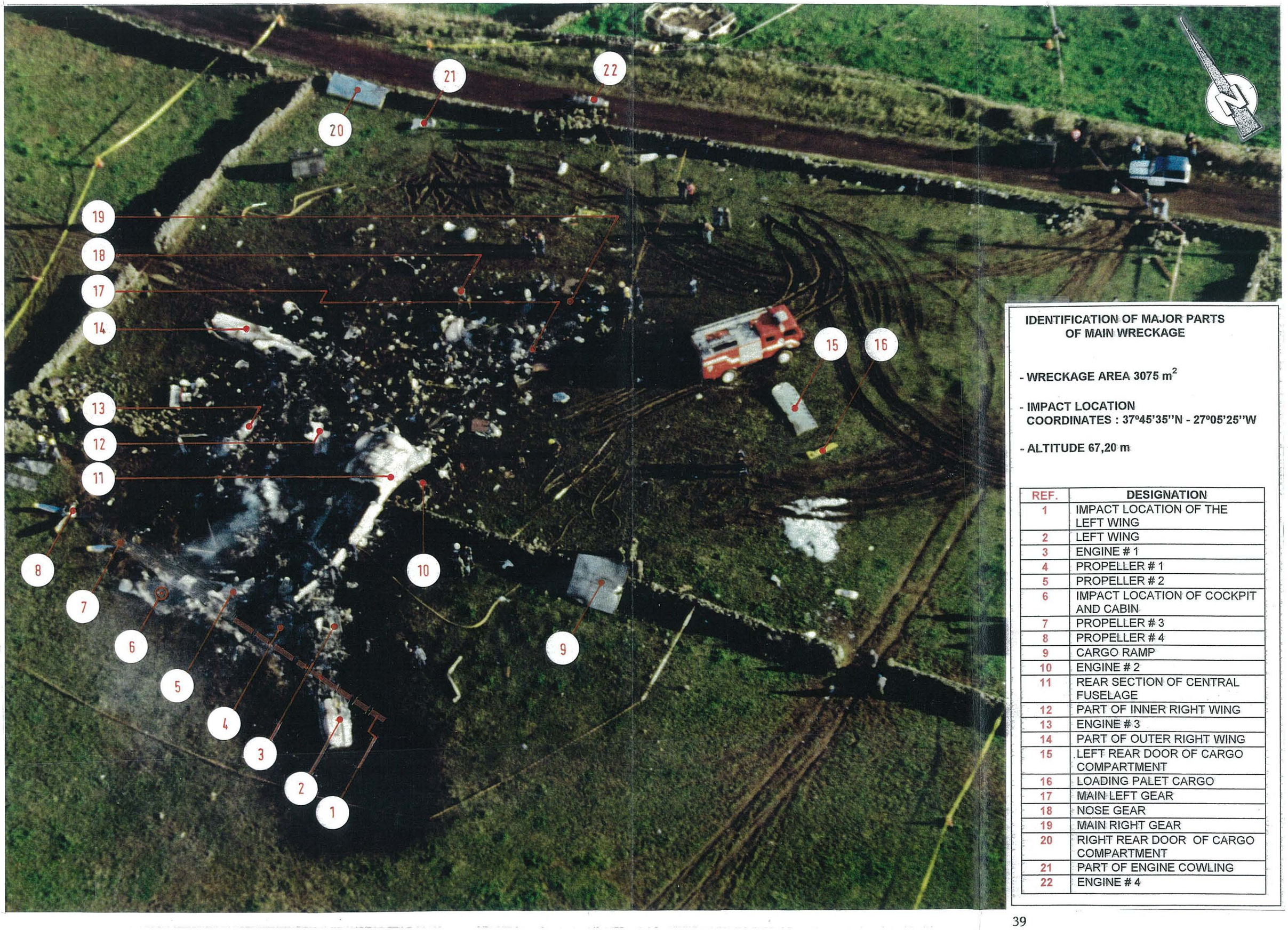
1.12.11.4 PANELS

Fuel System Control Panel

The Fuel System Control Panel was recovered from the aircraft wreckage seriously damaged, with some of its components missing and evidencing having sustained high temperatures, resulting from the fire.

It was verified that the control switches were in the following positions:

- Mode Control -ON position (Automatic).
- Group 0 Control - ON position.
- Group 1 Control - Toggle switch ON position.
- Group 2 Control - Toggle switch OFF position.



IDENTIFICATION OF MAJOR PARTS OF MAIN WRECKAGE

- WRECKAGE AREA 3075 m^2
- IMPACT LOCATION COORDINATES : 37°45'35''N - 27°05'25''W
- ALTITUDE 67,20 m

REF.	DESIGNATION
1	IMPACT LOCATION OF THE LEFT WING
2	LEFT WING
3	ENGINE # 1
4	PROPELLER # 1
5	PROPELLER # 2
6	IMPACT LOCATION OF COCKPIT AND CABIN
7	PROPELLER # 3
8	PROPELLER # 4
9	CARGO RAMP
10	ENGINE # 2
11	REAR SECTION OF CENTRAL FUSELAGE
12	PART OF INNER RIGHT WING
13	ENGINE # 3
14	PART OF OUTER RIGHT WING
15	LEFT REAR DOOR OF CARGO COMPARTMENT
16	LOADING PALET CARGO
17	MAIN LEFT GEAR
18	NOSE GEAR
19	MAIN RIGHT GEAR
20	RIGHT REAR DOOR OF CARGO COMPARTMENT
21	PART OF ENGINE COWLING
22	ENGINE # 4

- Groups 3, 4 and 5 Controls- All toggle switches were OFF position
- Group 6 Control (2 switches) - Left toggle switch OFF position.
  Right toggle switch OFF position.

Upper Fuel Panel- Flight Engineer

The crossfeed panel was found completely destroyed and carbonized.

Electrical Panel

The lower section of the panel was found completely destroyed and partially carbonized.

Fuel Quantity Selector (9 positions)

It was found selected to tanks 2 or 3, partially destroyed and carbonized.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

The death of seven crew members was due to multiple lesions, resulting from the powerful inertia forces when the aircraft crashed and also to the fire.

1.14 FIRE

The fire originated by the explosion of the fuel the tanks when the aircraft crashed.
The whole area of the fuselage was destroyed by the fire.
The wings were partially consumed by fire.

The Base fire fighting Department, alerted by the tower, responded to the emergency at 22:19, proceeding to the accident site with eight vehicles initially , arriving at 22:26 and immediately began to fight the fire and search for survivors.

The fire was fought with 118.760 liters of water and 11.571 of foam.

At 22:39, two fire fighting vehicles, from Praia da Vitória, arrived and used 4000 liters of water, of the 8.0000 liters available, to fight the fire.

At 22:41, firemen's Chief reported multiple explosions, probably due to the magnesium combustion of the aircraft structure, reporting six minutes later that the aircraft was still burning.

At 23:03 the fire was under control, and another search was initiated with 15 firemen.

At 23:48 two other explosions of small intensity occurred.

On the day after the accident, at 01:47, the fire was considered extinguished, with only small focus remaining.

The fire fighting department left the site at 03:43, but a prevention vehicle remained there.

The fire was fought by 70 firemen approximately (53 USAF + 17 local), using the following means and extinction agents:

VEHICLE	QUANT.	MOD	CREW	CAPACITY (Litres)	PRODUCT
OSHKOSH	**1**	**P-2**	**2**	**9500 L**	**8740 L Water 760 L Foam**
OSHKOSH	**1**	**P-15**	**3**	**24757 L**	**22800 L Water 1957 L Foam**
OSHKOSH	**1**	**P-19**	**2**	**4294 L**	**3800 L Water 494 L Foam**
KOVATCH	**2**	**P-22**	**4**	**5510 L**	**10260 L Water 760 L Foam**
TELEDYNE CONTINENTAL	**2**	**P-23**	**2**	**28880 L**	**50160 L Water 7600 L Foam**
INTERNATIONAL	**1**	**P-26**	**2**	**19000 L**	**19000 L Water**
MERCEDES	**2**	**---**	**2**	**8000 L**	**4000 L Water**
TOTAL:	**10**				**118.760 L Water 11.571 L Foam**

1.15 SURVIVAL ASPECTS

1.15.1 SURVIVABILITY

Due to the intensity of the impact forces and the subsequent fire, the accident was not survivable.

1.15.2 SURVIVAL EQUIPMENT

Of the survival equipment which was supposed be on board, only a life-jacket was recovered, intact, but with the inspection date expired and with signs of aging

1.15.3 RESCUE

After the arrival of two fire fighting vehicles at the site of the accident, two of the firemen with fire-proof equipment began the initial search for survivors.

The search lasted approximately 40 minutes, but without results due to the intensity of the fire that enveloped the aircraft and to the poor visibility caused by the smoke.

37 minutes later, a new search was initiated with 16 firemen, to be interrupted due to two explosions of low intensity.

A new search was initiated at 00:04, of the following day, where the bodies of three crew members were found at 00:58.

The first body was removed at 01:30, and a fourth body, presumably, was found.

The last body was removed at 01:32.

The search for the last three bodies lasted the following three days, since they were in the middle of the aircraft debris which had to be removed first.

The search and removal operations of the bodies was completed on the 9th February at 12:00.

1.15.4 LAJES AERODROMO (AIR BASE 4) EMERGENCY PLAN

The aerodrome emergency plan, under Portuguese Air Force responsibility, was approved by the Commander of Açores Air Zone and was revised in the 1st of April 1997.

The plan was tested on the 10th of December 1997 and no discrepancies were found that would justify its revision.

During the accident the emergency plan was totally performed.

1.16. TEST AND RESEARCH

1.16.1 RESEARCH - FLAPS SYSTEM

The left and right wings flaps were found near their casings, partially extended, destroyed and burnt.

In the measurements performed on the screw jacks of the left and right wings system flaps, showed there was no asymmetry and that the extension corresponded to partially extended. This condition corresponds to the configuration used at take-off.

1.16.2 RESEARCH - FUEL SYSTEM CONTROL PANEL

The fuel system control panel recovered from the aircraft wreckage was seriously damaged, with some of the components missing and showing evidence of having been subjected to high temperatures resulting from the fire.

The examination revealed that the control switches were as follows:

- Mode control — **ON** (automatic)
- Group 0 control — Electrical contacts **OFF**
Mechanism **ON** and toggle **ON**
- Group 1 control — Toggle **ON**
Mechanism **ON** and contacts **OPEN**
- Group 2 control — Electrical contacts **OFF**
Mechanism **OFF** and toggle **OFF**
- Groups 3,4 and 5 control — All toggles were **OFF,** as well as the mechanisms and electrical contacts.
- Group 6 (2) control — Left: Toggle **OFF** and electrical contacts open and **OFF**
Right: Toggle **OFF** and electrical contacts open and **OFF**

Using the same type of switch than those in the control panel, a simulation of the blocking of the mechanism block on the **OFF** position, was performed and the contacts were subjected to heat to study their behavior.

The switch enclosed in a metallic box is composed by toggle, actuation mechanism and electrical contacts.
It was observed that the heat causes the contacts to open even if the mechanism is blocked on **OFF**.

Since the panel was found buried, the switches mechanisms may have blocked due to the presence of earth, which might explain the disagreement between the position of the mechanisms and the contacts of some of the switches.

1.16.3 RESEARCH OF ENGINES #3 AND #4 FUEL CONTROL UNITS

In order to determine the engines regimen, the Commission with the technical support of SAI representatives, and according to the instructions of the Bulgarian technicians, measured screw 46 of engines #3 and #4 fuel control units.

The calculations determined that engine #4 was working between 98% and 105% and that engine #3 at 96,5%.
The fuel taken from the fuel control units during this research did not show evidence of water.

The Commission performed the same measurements later in engines #1 and #2 fuel control units, having determined the engines to be in 98,5% and 102,5% regimen, respectively.

1.6.4 FUEL ANALYSIS

After the accident the Commission took the following fuel samples:

- From the fuel control unit (FCU) filter of engine #2;
- From engine #2 high pressure pump;
- From the FCU filter of engine #4 ;
- From engine #4 high pressure pump.

The examination of the samples revealed water in the following quantities:

ENGINE #2	SAMPLE	FUEL QUANTITY (c.c)	WATER CONTENT (c.c)
	FCU FILTER	**15**	**45**
	HIGH PRESSURE PUMP	**8**	**0**
ENGINE #4	**FCU FILTER**	**55**	**65**
	HIGH PRESSURE PUMP	**17**	**water signs**
	FCU - SCREW 46	**26**	**0**

It was not possible to take samples from engines # 1 and # 3, since there was no evidence of fuel.

These samples, as well as a fuel sample taken in 5 February 1998 from the tank of the fuel supplier that refueled the aircraft on the day of the accident, were sent to the Police Laboratory to test for contaminants.

These tests did not reveal any evidence of contaminants. The comparison between a fuel sample taken from the tank that supplied the fuel trucks that refueled the aircraft and a sample of the fuel being used, on 2 September 1998, did not reveal any difference.

1.16.5 OIL ANALYSIS

After the accident The Commission took oil samples from engines #2 and #4 FCU filters. These samples were sent to the Portuguese Air Force Laboratory for a spectrometric analysis.

From the tests performed it was concluded that the plumb element (Pb) showed slight discrepancies, but the results of the analysis were considered normal for turboprop engines.

1.17 ORGANIZATION AND MANAGEMENT

1.17.1 General considerations

Air Sofia had an operator certificate issued by Bulgarian State Aeronautical Inspectorate and was authorized to operate scheduled and non scheduled transport flights in Europe, Asia, Africa, Australia and South America.
The aircraft was operating in Portugal under a Wet Lease ACMI regime to the Portuguese operator Air Luxor.

The traffic rights and the commercial responsibility belonged to Air Luxor. Air Sofia, according to the contract, was responsible for the operation.

1.17.2 OPERATIONAL PROCEDURES

The company has a Flight Operations Manual, where the operational procedures are stated, and a AN-12 Flight Manual.

The pertinent procedures for the investigation are appended to this report.

1.17.3 FUEL PLANNING

Upon arriving in Lajes the crew had doubts as to the accurate quantity of remaining fuel on the aircraft, supposedly 10.750 kg.
The captain decided not to refuel. After starting up in Lajes and during the engines test, the flight engineer verified that there was "a little over 9.000 kg".

Considering that the aircraft refueled in Lisbon with 14.070 kg and would have on board, according to the statement of Air Sofia technicians, approximately 4.000 kg, it must have taken off from Lisbon with approximately 18.000 kg.

The probable distribution of fuel on the tanks was estimated as follows:

Group 0 - 2.240 kg
Group 1 - 3.200 kg
Group 2 - 1.400 kg
Group 3 - 1.800 kg
Group 4 - 2.200 kg
Group 5 - 1.350 kg
Group 6 - 2.300 kg
Lower tanks - 3.600 kg

Which adds up to approximately 18.000 kg.

The segments Lisboa /Ponta Delgada and Ponta Delgada / Lajes, had a duration of 3.15 hours.

Considering a fuel consumption according to the Flight Manual, the theoretical remaining fuel at arriving at Lajes would be 10.000 kg, approximately.

Assuming that at take-off from Lajes there would be approximately 9.200 kg of fuel remaining and considering the automatic sequence the wing tanks fuel consumption on the two previous segments, the computed fuel distribution at take-off from Lajes would probably be as follows:

Group 0 - 0 kg
Group 1 - 850 kg
Group 2 - 1.400 kg
Group 3 - 1.800 kg
Group 4 - 2.200 kg
Group 5 - 1.350 kg
Group 6 - 1.600 kg
Lower tanks - 0 kg

It was assumed that 750 kg of fuel were transferred from the lower tanks to Group 1and it was considered that Group 1 had 100 kg of remaining fuel.

The Commission computed the necessary fuel for the segment Lajes / Lisboa at FL 270 (without wind) to be in the region of 7.425 kg plus 500 kg for the APU start-up, of the four engines and for the roll, which adds up to 7.925 kg of minimal theoretical fuel for the above mentioned segment, adding another 2.500 kg for the legal reserve (hold, descent procedure and alternate), adding up to 10.425 kg required for the Lajes / Lisboa segment.

The Commission considered that the above calculations can be somewhat subjective, due to the lack of real data for en-route winds as well as through actual in flight fuel consumption.

2. ANALYSIS

2.1 Generalities

the aircraft was properly certified in accordance with the Bulgarian regulations, and according to the information provided by the State of Registry, the airworthiness conditions were fulfilled. No mechanical failure was detected prior to take-off.

The prevailing meteorological conditions were not a causal factor to the accident.

2.2 Aircraft Performance

The aircraft took-off from Lajes at the estimated speed of 250 Km/h, with seven crew, approximately 9200 kg of fuel and 1693,5 kg of cargo on board.

The estimated take-off weight was 46.700 kg, which was under the MTOW (61.000 kg) and with enough margin of power.
The configuration used was the one recommended and the balance conditions were within the limits prescribed in the Flight Manual.

The quantity of fuel on board, at take-off and to fly the segment Lajes/Lisboa , was insufficient in case the aircraft had to divert, which may justify some rush in obviating some of the items on the checklist, as well as the crew concern in using all the fuel in the several tanks, including taking advantage of the taxi slope to make the fuel transfer from the aft lower tank to Group 1 tanks.

2.3 Crew Procedures

Upon arriving at Lajes, the crew determined, although with some reservation, that the remaining fuel in the aircraft was 10.750 kg, and thus the captain decided no to refuel.

The Commission ascertained, considering the difference of fuel price in the Continent and in Azores, that it was the company's policy to refuel only in Lisbon.

The Commission verified that both in Lisbon and Lajes airports, Air Sofia crew that refueled at those airports, normally took samples from the refueling vehicles and from the respective tanks purges after refueling. On the day of the accident and because the aircraft did not refuel in Lajes, the crew did not purge the fuel tanks.

The Commission verified that the above mentioned quantity (10.750 kg), was sufficient for the segment Lajes/Lisboa, in accordance with ICAO's Annex 6 and An-12 Flight Manual.

After start-up in Lajes and during the checklist "Procedures After Start-Up", the crew established that the quantity of fuel on board was only a little more then 9 tons. The Commission ascertained that this quantity was insufficient for the segment Lajes/Lisboa.

The "Before Start-Up" procedures on the checklist were fulfilled, except steps 2, 9 and 10, and on the "After Start-Up" procedures, steps 7 and 10 were not fulfilled.
The Commission determined that the referred checklist (step 6) is not explicit enough as to the mandatory configuration of the fuel control panel, according to AN-12 Flight Manual.

During the verification procedures "During Taxiing", steps 1 and 3 were not fulfilled.
Out of context of the referred checklist, the crew maintained conversations about fuel management and the captain had to instructed the flight engineer twice to select the fuel pumps, in order to ascertain if there was fuel on the lower tanks. Having finally verified that the result was not the expected and being certain that there was still some fuel on the rear lower tank, he instructed the flight engineer to "switch-off the pumps and to try again during climb."

The "Before Line-Up" checklist was totally fulfilled.

On the "Line-Up to Take-off" checklist, only the 5th step is mentioned. The first four steps are not mentioned.

The "After Take-Off" checklist was not fulfilled.

The Commission determined that during take-off run, the aircraft traveled approximately 1318 meters, with all engines running.

The first engine failure, engine #3, must have occurred when the aircraft had traveled 1526 m, approximately, and a second engine failure (#4) occurred about 8 seconds later, estimating that the aircraft traveled approximately 2150 m, since the beginning of taxiing.

When engine # 3 failure occurred, there were still approximately 1635 m of runway with more 275 m of over-run, and the Captain did not choose to abort take-off. Only after engine 4 failed did the Captain recognize that option.

The decision to proceed the take-off after reaching critical speed was correct. The CVR records confirm that the indication of failure of the first engine was recorded after reaching 250 km/h.

Up to the flight's final phase, the aircraft maintained take-off configuration (gear down and 15º flaps), not fulfilling one of the steps prescribed in the "Engine Failure After Take-Off" procedures, which determines the immediate retraction of the landing gear.
The landing gear retraction in those circumstances could not be rapidly performed (normal procedures), since there was no hydraulic power for the landing gear circuits, provided by engines #3 and #4 (already feathered).
The emergency retraction was also not initiated, since as it is more complex and slow, it may not have been considered a priority in solving the emergency.

According to eyewitness statements, the crew decreased the climb rate in the attempt of gaining speed.

However the almost simultaneous power failure of the two engines of the right wing, in a critical flight situation combined with the parasite drag of the landing gear and flaps, may have contributed for a significant decrease in speed, subsequent loss of lift and induction of a rapid and uncontrollable turn to the right.

The cargo distribution, in bulk, may have contributed for the aggravation of the turn and subsequent loss of stability and control of the aircraft, although the Flight Manual states that when two engines on the same wing fail and feather, the aircraft has enough power, stability and control to go on flying, and even climb or perform turns to the side of the operational engines. However, the crew efforts to turn to the left were not successful.

On the final phase of the flight, the aircraft rotated to the right on the longitudinal axis, in an inverted position and hit the ground in a pitch down attitude of approximately 135º.

2.4 Fuel Management System

During the "After Start-Up" procedures, the flight engineer confirmed that the system was on automatic.

During taxi, the captain instructed the flight engineer to try to transfer fuel from the lower tanks.

It is obvious that his intention was to take advantage of the slope of the taxiway ramp in order to transfer the fuel from the lower aft Group to Group 1.

During taxi, the captain instructs the flight engineer to switch ON the pumps (to the front) in the transfer panel , and the engineer replied that all pumps were ON, which led the captain to conclude that there was no fuel.

This situation was confirmed by the Flight Engineer, who added that during climb he would check if there was fuel on the lower rear tank. Consequently the captain instructed him to switch off the pumps.

From the fuel panel, recovered from the debris, it was verified that the system was selected to AUTOMATIC mode, with Group 6 switches off. This selection invalidates the operation of the system on AUTOMATIC mode, when the remaining fuel in Group 6 is above 2000 liters.
On the other hand, Groups 0 and 1 switches were ON and the others were OFF.

The positioning of Groups 0 and 1 switches in ON position would have no influence on the operation of the system, when the remaining fuel in Group 6 is above 2000 liters and the system is selected to AUTOMATIC mode.

This configuration of the panel might have originated when MANUAL mode was selected, in order to allow the fuel transfer from the lower tanks to the wings. As a matter of fact, the fuel transfer of the lower tanks can only be executed if the system is on MANUAL mode.

2.5 CAUSAL FACTORS FOR THE TWO ENGINES FAILURE

2.5.1 Technical Hypothesis

2.5.1.1 - From the Aircraft Manufacturer

The aircraft Manufacturer, Antonov Design Bureau, presented as hypothesis for the engines failure the presence of air in the fuel pipes, if the fuel pumps of the wing tanks were OFF, which would imply the engines feeding by gravity.
The increase of the pitch at take-off, would cause the air to enter the pipes and subsequently the failure to feed the engines.

With the decrease of power there was also a decrease in speed and pitch, which left the fuel entrances covered, preventing the air to enter the system, recuperating the engines, except engine # 3 that feathered, due to having attained 10 Kg/cm^2 of pressure.

The turn to the right caused the fuel reflow, leaving once more the entrances uncovered, allowing the air to enter the system, which caused engine # 4 to stop. In this situation, engines # 1 and # 2 power was gradually restored.

2.5.1.2 - From the Engines Manufacturer

The engines Manufacturer, Zaporojie Design Bureau, presented as hypothesis for the engines # 3 and # 4 failure, the ingestion of fuel contaminated with water or other incombustible fluids, during a short period of time.

2.5.1.3 - From the Investigation Commission

The Commission verified that the fuel selection executed by the crew was not correct, because in the Fuel System Control Panel the selection of AUTOMATIC MODE, procedure recommended for take-off, was not activated because the fuel pumps control switches of Group 6 tanks were not ON. (Necessary condition to operate the AUTOMATIC MODE of fuel consumption.)

In this situation the engines feeding was being carried out by gravity.

From the cockpit conversation transcript, it was established that the crew tried to transfer all the remaining fuel in the lower tanks, because they were worried with the quantity of fuel available for the segment Lajes /Lisboa, which would be a little more than 9 tons, checked after start-up, which according to the Commission calculations would have to be of approximately 10.425 kg, including the legal reserve. During the attempt to transfer the fuel, after fulfilling the checklist step that instructs to select the SYSTEM TO AUTOMATIC, the crew failed to select the switch of Group 6 to ON position.

The captain's decision not to refuel in Lajes, was probably due to the fact that on the last part of the segment Ponta Delgada/Lajes, the crew estimated that the residual fuel was a little more than 10 tons, sufficient for the last segment. The cost of the fuel in Lajes, more expensive than in Lisboa, may have influenced the captain's decision.

The Commission analyzed both hypothesis, having considered that engine manufacturer's one is less likely because the quantity of water found in the fuel samples, taken the day after the accident, may have infiltrated the system, which was open to the outside (broken filters, fuel lines open), during the fire fighting where large quantities of water were used and also by the rain that fell after the accident.

The aircraft had already flown 3H15, since departing from Lisboa where it was refueled and no engine malfunction was detected, and the fuel consumed from the lower tanks and Group 6 would probably be 2.900 kg and 700 kg, respectively.

It may be considered, however, that during the attempt to transfer all the remaining fuel in the lower tanks, some water infiltrated Group 1, to where the fuel of the lower tanks was transferred.

It was also verified that the fuel samples taken from the Fuel Control Units showed no evidence of water.

No contaminants were found in the fuel analysis.

The hypothesis presented by the aircraft Manufacturer is the most likely, considering the tests made to the Fuel System Control Panel that revealed that the AUTOMATIC SYSTEM was not properly selected. However, one should not exclude the possibility of there being water in the system coming from the lower tanks that were not purged in Lajes, a normal situation since the aircraft was not refueled.

Considering the Fuel Panel configuration, the engines were being fed by gravity, if the remaining fuel in Group 6 was above 2000 liters.

As Group 6 pumps were OFF, the engines were being fed by suction from Group 1 tanks, if the remaining fuel in Group 6 was below 2000 liters, which would be the normal consumption sequence in AUTOMATIC MODE. Group 1 contained only the fuel transferred from the lower tanks and the engines feeding would have to be made by selecting the System to MANUAL MODE.

3. CONCLUSIONS

3.1 FINDINGS

The aircraft was in airworthiness conditions and properly certified for the flight.

The weight and balance were within the approved limits.

The cargo, in bulk , was not properly secured

The aircraft had the correct configuration for take-off.

The aircraft was only refueled in the beginning of the first segment.

The fuel revealed no contaminants.

Water was found in the samples taken from FCU filters of engines #2 and #4.

The crew was properly qualified and certified for the flight.

The air traffic controllers were properly licensed and qualified.

The meteorological conditions at Lajes Airport were not a causal factor for the accident.

Engines #3 and #4 stopped at take-off.

The Fuel System was not properly selected.

The fuel on board the aircraft was insufficient for the flight.

The Flight Data Recorder did not register the parameter "engine #4 torque.

The checklist procedures were not totally fulfilled.

The firemen action was swift and efficient.

The accident was not survivable.

3.2 CAUSES

The Commission identified the following probable causes:

Engines # 3 and #4 stoppage at take-off, due to incorrect selection of the Fuel System;

Interruption of the checklist sequence in the attempt to transfer fuel from the lower tanks to the wings, which may have contributed to the incorrect selection of the Fuel System.

The Commission considered the following contributing factors:

The fact that the cargo was not secured may have contributed to the deterioration of the stability and controllability of the aircraft;

The impossibility to retract the landing gear, in time, which contributed to the decrease of the aircraft performance.

4. SAFETY RECOMMENDATIONS

The following safety recommendations are made:

Air Sofia should ensure that the approved checklist procedures are fulfilled and that cockpit management is improved.
[Safety Recommendation 45-99]

Air Sofia should establish a fuel management policy that contributes to the increase of flight safety.
[Safety Recommendation 46-99]

Air Sofia should revise the cargo accommodation policy.
[Safety Recommendation 47-99]

The Portuguese Civil Aviation Authority should publish adequate regulation to assure that the foreign operators who operate in the country, under ACMI contract, follow safety patterns identical to those in the country and that the documentation necessary to control operations and the state of airworthiness is presented in Portuguese or any other language accepted by the Authority.
[Safety Recommendation 48-99]

Lisboa, 29 September 1999