PART I

REPORT OF THE BOARD OF INQUIRY INTO THE ACCIDENT TO TUPOLEV 134A-3 AIRCRAFT C9-CAA ON 19TH OCTOBER 1986

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G.P.S.

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REPORT OF THE BOARD OF INQUIRY INTO THE ACCIDENT TO TUPOLEV 134A-3 AIRCRAFT C9-CAA ON 19TH OCTOBER 1986 AT MBUZINI, IN THE DISTRICT OF KOMATIPOORT, IN THE REPUBLIC OF SOUTH AFRICA, IN WHICH PRESIDENT SAMORA MACHEL OF THE PEOPLE'S REPUBLIC OF MOZAMBIQUE AND 33 OTHERS LOST THEIR LIVES

To the Honourable the Minister of Transport Affairs:

Sir,

In terms of the provisions of section 12(1) of the Aviation Act, No 74 of 1962, as amended, and of Annex 13 to the Chicago Convention, we have the honour to submit herewith our Report on the cause of and responsibility for the above named accident.

Our Report is unanimous.

Dated at Pretoria this 2nd day of July 1987.

C S MARGO CHAIRMAN

Dated at London, UK. this 2nd day of July 1987.

E W EVELEIGH

Dated at Las Cruces,NM. this 2nd day of July 1987.

FRANK BORMAN

Dated at Winchester,UK. this 2nd day of July 1987.

G C WILKINSON

Dated at Pretoria this 2nd day of July 1987.

J J S GERMISHUYS

Dated at Jan Smuts Airport this 2nd day of July 1987.

P VAN HOVEN

INTRODUCTION

The members of the Board were the Hon Mr Justice C S Margo, DSO, DFC, FRAeS, of the Supreme Court of South Africa, the Rt Hon Sir Edward Walter Eveleigh, PC, former Lord Justice of Appeal, of the UK, Col Frank Borman, Congressional Space Medal of Honour, former chief test pilot, astronaut, aeronautical engineer and President and Chief Executive of Eastern Airlines, of the USA, Mr Geoffrey Crichton Wilkinson, CBE, AFC, FRAeS, former test pilot, aeronautical engineer, and Chief Inspector of the Accidents Investigation Branch, Ministry of Transport, of the UK, Mr J J S Germishuys, former Commissioner for Civil Aviation, of the RSA, and Mr P van Hoven, Chairman of the Airlines Association of SA, of the RSA.

The Board appointed its own attorney, Mr N van Rensburg, of the firm of Rooth & Wessels, Pretoria, and counsel, Mr C E Puckrin, SC, to lead the evidence. They were assisted by Mr Peter Martin, of the firm of Frere Cholmeley, solicitors, of London. Mr J H Coetzee, SC, with him Mr P Z Ebersohn, instructed by Messrs J P Krause and J N J Koegelenberg of the State Attorney's office, Pretoria, appeared at the hearings to represent the Departments of Foreign Affairs, Transport and Defence.

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On 6 November 1986, 3 members of the Board inspected the crash site and the surrounding area and also the wreckage of the aircraft.

On 15 January 1987, a further inspection of the crash site, the surrounding area and the wreckage was carried out by the full Board.

Public hearings of the Board took place at the Supreme Court, Johannesburg from 20 to 26 January 1987, when the Board adjourned to consider its findings and conclusions. Representatives of the USSR and Mozambique did not formally participate in the hearings, but were helpful in submitting further information and documents.

The Board is indebted to the respective accident investigation teams of the RSA, the USSR and Mozambique for the thoroughness and competence with which the field investigations were carried out, and for the jointly compiled and agreed factual statement (which, though not binding on the Board, was of great assistance to it).

As the field investigation progressed the representatives of each State drew up and signed what were termed protocols, in which they recorded agreement on various arrangements and on various findings. The Board records its appreciation of the

co-operation achieved by the parties and of the valuable results thereof.

THE APPOINTMENT OF THE BOARD AND ITS TERMS OF REFERENCE

The USSR delegation signed the 'Aircraft Accident Factual Report' subject to an attached statement which reads as follows:

> "The Soviet Delegation, acting in terms of Chicago Convention of 1944 and in accordance with Standards and Recommended Practices of Annex 13 to the Chicago Convention, considers that analysis and conclusions should be developed and added to the aircraft accident factual report by the same investigation commission.
>
> According to Annex 13 paragraph 6.11 the analysis and conclusions must be elaborated and agreed to on trilateral basis by the States participating in the investigation.
>
> Any other procedure of elaboration of report contradicts international rules and cannot be accepted by the Soviet side."

This statement amounts to a denial of the right of the Board to conduct the present inquiry and argues that the RSA accident investigation team, and the similar teams (or delegations) of the USSR and Mozambique, who have co-operated in assembling the factual evidence, are collectively an 'investigation commission' and the body to report finally upon the accident under the terms of the Chicago Convention. It is to be noted that no 'investigation commission' has been appointed other than this Board.

The claim rests upon a misunderstanding of the role of the 'accredited representatives' who constitute the delegations. The Standards and Recommended Practices in Annex 13 do not prescribe that the analysis and conclusions of an accident report must be developed only by the person(s) who carried out the investigation. In terms of various paragraphs of Annex 13, an interested State is entitled to appoint accredited representatives "to participate in the investigation". The State of Manufacture and the State of Registry were entitled to appoint such representatives (see Annex 13 paras 5.19 and 5.22). However, it is important to determine the locus standi of such a representative. This is set out in paragraph 5.26 under the heading "Participation", viz:

> "5.26 Recommendation - Participation in the investigation should confer entitlement to:

(a) visit the scene of the accident;

(b) examine the wreckage;

(c) question witnesses;

(d) have full access to all relevant evidence;

(e) receive copies of all pertinent documents; and

(f) make submissions in respect of the various elements of the investigation."

The entitlement stops short of the right to deliberate and adjudicate with the 'Investigator-in-Charge'. This person is the "person charged, on the basis of his qualifications, with the responsibility for the organisation, conduct and control of an investigation" (Annex 13 Chapter 1 - Definitions). However, it is specifically provided in a Note to the definition that "Nothing in the above definition is intended to preclude the functions of an Investigator-in-Charge being assigned to a commission or other body". The Board is such a body.

The overriding provision in the Convention for an Inquiry such as the present is Article 26, viz:

"Investigation of accident.

In the event of an accident to an aircraft of a contracting State occurring in the territory of another contracting State, and involving death or

serious injury, or indicating serious technical defect in the aircraft or air navigation facilities, the State in which the accident occurs will institute an inquiry into the circumstances of the accident, in accordance, so far as its laws permit, with the procedure which may be recommended by the International Civil Aviation Organisation. The State in which the aircraft is registered shall be given the opportunity to appoint observers to be present at the inquiry and the State holding the inquiry shall communicate the report and findings in the matter to that State."

Annex 13, in the Foreword, explains the "Relationship between Annex 13 and Article 26 of the Convention". In that explanation the following is said:

"It being understood:

19 that ... pursuant to this Article (i.e. Article 26) 'the State in which the accident occurs will institute an inquiry', 'the State in which the aircraft is registered shall be given the opportunity to appoint observers to be present at the inquiry' and 'the State holding the inquiry shall communicate the

report and findings in the matter to that State' ..."

Then it is stated: "The accredited representative and the advisers referred to in the Annex together comprise the observers that are given the right to be present at an inquiry under Article 26" (underlining added).

Decision making is thus clearly for the State holding the inquiry. Accordingly Article 26 and the provisions of Annex 13 quoted above give an accredited representative the right to be present as an observer at the "Inquiry", (at least where he is appointed by the State of Registry) and to participate in the "Investigation" to the extent laid down in Annex 13 para 5.26 (see above).

The RSA has gone further than the Convention requires to accommodate the other States by inviting their attendance to participate in the inquiry and offering them the "right to be represented at the hearing, to cross-examine witnesses and to call their own evidence".

To enable effect to be given to the Chicago Convention the Aviation Act, No 74 of 1962, as amended, of the Republic of South Africa was enacted. Section 12(1) reads as follows:

"Investigation of accidents.

(1) In the event of any accident arising out of or in the course of air navigation and occurring in or over the Republic or the territorial waters thereof, or, in the case of South African aircraft, wheresoever they may be, the Minister may appoint one or more persons as a board of inquiry, known as an accident inquiry board, to make an investigation into the cause of and responsibility for the accident and report to him thereon."

The duty of the Board, having been appointed under section 12(1), therefore includes the conduct of the Inquiry postulated by the Chicago Convention.

Chapter 5 of Annex 13 deals with the "Responsibility for Instituting and Conducting the Investigation". Paragraph 5.4 reads:

"The Accident Investigation Authority shall have independence in the conduct of the investigation and have unrestricted authority over its conduct. The investigation shall include the gathering, recording and analysis of all available relevant information, if possible the determination of the cause(s), and the completion of the Final Report

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> followed, if appropriate, by Safety Recommendations. When possible the scene of the accident shall be visited, the wreckage examined and statements taken from witnesses."

The completion of the Final Report is therefore a matter for the RSA, which has appointed the Board to conduct an inquiry for, inter alia, the purpose of Article 26 of the Convention.

The contrast between the control of the conduct of an investigation (which is the responsibility of the State of Occurrence) and the right of other States to participation through their representatives is discernable in paragraph 5.27 of Annex 13, where the entitlement to participate is limited to the matters therein set out. It is the duty of the State of Occurrence to "inquire" by virtue of Article 26 and it is enjoined to report in the various circumstances laid down in Annex 13.

Thus we find in paragraph 6.11 under the heading "Responsibility of the State Conducting the Investigation" and the sub-heading "Consultation" the following:

> "6.11 Recommendation.
>
> The State conducting the investigation should send a copy of the draft Final Report to the State which instituted the investigation and to all States that participated in

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> the investigation, inviting their significant and substantiated comments on the report as soon as possible. If the State conducting the investigation receives comments within sixty days of the date of the transmittal letter it should either amend the draft Final Report to include the substance of the comments received, or append the comments to the Final Report. If the State conducting the investigation receives no comments within sixty days, it should issue the Final Report in accordance with 6.12, unless an extension of that period has been agreed by the States concerned."

The position in the present case therefore is that while the States other than the State of Occurrence have the right to participate in the investigation and the State of Registry has also the right to be present at the inquiry and they both have been offered a substantial role in the conduct of the inquiry, nothing in the Convention or Annex 13 gives them the right to adjudicate or make the final decision. Insofar as it claims this right the statement of the USSR delegation is erroneous, but there exists, of course, the right to comment on the draft Final Report and to have the comments, if any, dealt with in accordance with paragraph 6.11.

AIRCRAFT ACCIDENT REPORT

OPERATOR AND OWNER	:	People's Republic of Mozambique (Mozambique)
AIRCRAFT TYPE AND MODEL	:	Tupolev TU-134A-3
AIRCRAFT NATIONALITY AND REGISTRATION MARKS	:	The aircraft was registered in Mozambique as C9-CAA
DATE AND TIME OF ACCIDENT:	:	1986-10-19 at 19.21:39

Note: 1. Save where otherwise stated Universal Co-ordinated Time (UTC) is used throughout this Report. Local time is UTC plus 2 hours.

2. Flight level (FL), altitude and elevation are expressed in feet, or metres with the equivalent in feet. Linear measurement is expressed in metres. Distance is expressed in kilometres or nautical miles, as the case may be.

PLACE OF ACCIDENT	:	Mbuzini, District Komatipoort, Republic of South Africa (RSA), latitude 25° 54' 41" S, longitude 31° 57' 26" E.

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SYNOPSIS

On 1986-10-19, at 19.21:39, the aircraft crashed in hilly country while descending in darkness and cloudy conditions. The crew were under the erroneous impression that the aircraft was in the vicinity of Maputo Airport, Mozambique.

A map indicating the approximate position of the relevant points is annexed as Appendix III.

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The aircraft, which was being used to transport a group of senior Mozambique Government officials led by President Samora Machel, was en route from Mbala in northern Zambia to Maputo with an estimated arrival time of 19.25.

The Chief of Accident Investigations of the State of Occurrence (the Republic of South Africa) received telephonic notification of the accident at 05.30 on 1986-10-20. The State of Registry and of the Operator, Mozambique, was notified by means of the Aeronautical Fixed Telecommunications Network at 06.50 on 1986-10-20, and the State of Manufacture, the Union of Soviet Socialist Republics (USSR), at 06.00 on 1986-10-22.

The investigator-in-charge of the State of Occurrence arrived at the scene of the accident at 12.00 on 1986-10-20 and commenced the investigation, followed by further investigators on 1986-10-21.

The State of Occurrence approached both the USA National Transportation Safety Board (NTSB) and the British Accidents Investigation Branch (AIB) for assistance with the investigation but both were reluctant to get involved on an individual basis. ICAO was then requested to approach contracting States for investigators and for assistance to ensure an impartial investigation. ICAO replied that, as the investigation was in the hands of the State of Occurrence, and that the State of

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Registry and the State of Manufacture were represented, there was no need for a further communication from ICAO. The RSA then requested Mozambique also to approach ICAO to arrange that an impartial expert participate in the read-out of recorders and analysis of information, after which three advisers were made available to the State of Registry. In the absence of the assistance requested by the State of Occurrence, it obtained the services of three independent advisers.

Representatives of the State of Registry and of the State of Manufacture were invited to join the investigation team of the State of Occurrence, and these three parties jointly undertook the field investigation. This tripartite investigation team jointly produced an agreed Aircraft Accident Factual Report which was signed on behalf of all three parties on 1987-01-16.

The State of Occurrence appointed an Accident Inquiry Board, the members of which were from the RSA, USA and the UK, to make an investigation into the cause of and responsibility for the accident. The Board has carried out the functions of Investigator-in-Charge in terms of Annex 13 to the Chicago Convention. The State of Occurrence, and also the Board, invited the State of Registry and the State of Manufacture, and all other interested parties to participate in the Inquiry by attending the proceedings directly or through representatives, with the right to cross-examine witnesses, to call their own

witnesses and produce any other evidence, and to make representations to the Board. In addition due notice of the date of the proceedings of the Board was given in writing to the representatives of the USSR and of Mozambique.

On the invitation of the USSR, representatives of Mozambique and the RSA visited Moscow from 1986-11-20 to 1986-11-23 and were given information on the flight recorders, crew procedures and the aircraft equipment. The CVR was transcribed in Zürich, Switzerland, from 1986-11-24 to 1986-11-26 in the presence of representatives of the three participating States. The USSR provided the read-out equipment and technicians and the Government of Switzerland provided the facilities. Back in Moscow from 1986-11-27 to 1986-12-02 the digital flight data recorder was decoded and read out, the data were analysed and the flight path and the ground track were reconstructed in the presence of representatives of the three participating States.

The aircraft, on its last flight, departed from Mbala at 16.38 and was routed to Maputo via Kasama, Lusaka and Kurla. At 18.47 the crew contacted Maputo Information and reported overhead Kurla flight level (FL) 350, estimated position abeam Limpopo at 19.05 and Maputo at 19.25. The crew reported 48 persons on board and an endurance of 04.00 hours.

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At 18.49 the aircraft acknowledged the Maputo AFIS controller's information that no delay was expected for an ILS approach to runway 23 and confirmed that the flight would continue at FL 350 to VMA (VOR Maputo).

At 19.02 the aircraft reported top of descent and was instructed by the controller to report runway lights in sight or reaching 3 000 feet. The Metar report for Maputo airport was given.

During the descent the aircraft executed a turn through 37° to the right. Had such turn been executed 8 minutes later, it would have resulted in the interception of radial 045 (VMA) for an ILS landing on runway 23 at Maputo airport.

At 19.18 the aircraft reported at 3 000 feet and was cleared for an ILS approach to runway 23. Later, when the aircraft radio operator reported (erroneously) that the ILS was unserviceable, the controller cleared the aircraft for a visual approach to runway 05.

The aircraft continued to descend in darkness at an average rate of 2.5 metres (8 feet) per second, or 480 feet per minute, in an attempt to establish visual contact with the Maputo runway lights. In fact it was then out of range of most of the Maputo navigational aids and the crew were unsure of their position.

The radio operator continued communications with the Maputo controller until 19.21, after which time there was no response to calls from the controller.

The wreckage of the aircraft was found approximately 35 nautical miles west of Maputo airport, in the RSA. The crash site was in hilly terrain at an elevation of 666 metres (2 185 feet), approximately 150 metres inside the RSA - Mozambique border.

Those fatally injured totalled 34. They included the President of Mozambique. The flight engineer and 9 passengers were injured. One of the injured passengers subsequently died of his injuries.

Immediately prior to impact the aircraft and all relevant equipment were fully serviceable and airworthy. There was no evidence of sabotage or outside interference.

As appears from its Conclusions in section 3 of the Report, the Board has unanimously determined that the cause of the accident was that the flight crew failed to follow procedural requirements for an instrument let-down approach, but continued to descend under visual flight rules in darkness and some cloud, i.e. without having visual contact with the ground, below minimum safe altitude and minimum assigned altitude, and in addition ignored the GPWS alarm.

In terms of section 12(1) of the Aviation Act, No. 74 of 1962, as amended, the Board is also required to determine responsibility for the accident. The Board's findings on this aspect appear from the Analysis and Conclusions set out later in this Report.

1. FACTUAL INFORMATION

1.1 History of the Flight

The history of the flight has been reliably established by reference to the information obtained from the Digital Flight Data recorder (DFDR MSRP-64-2), the Cockpit Voice Recorder (CVR MARS-BM), the Air Traffic Control tape, a radar plot by the South African Air Force, inspections of the accident site and wreckage, and testimony, viva voce and written, of witnesses.

The Tupolev TU 134A-3 aircraft C9-CAA was being operated by Mozambique on a Presidental flight from Maputo via Lusaka to Mbala in Zambia, and then on a return flight to Maputo in the evening.

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The aircraft was refuelled for the flight on 1986-10-18 at 13.35, and 14 765 litres of fuel were uplifted. Take-off from Maputo for Lusaka was at 05.12 on 1986-10-19, and the aircraft was routed to Lusaka via Kurla-Masvingo-Fylde-Gadba.

After arrival at Lusaka at 07.05 the aircraft was parked at bay 5 from 07.10 to 07.40. It was refuelled during the period 07.18 to 07.38, and 7 620 litres of fuel were uplifted.

The flight plan filed at 07.25 for the flight from Lusaka to Mbala gave the aircraft's endurance as 5 hours and Estimated Elapsed Time (EET) of flight as 1 hour 15 minutes. C9-CAA departed from Lusaka at 07.46 and was routed via Ndola and Kasama to arrive at Mbala at 09.00. The aircraft was not refuelled at Mbala.

C9-CAA departed from Mbala that evening at 16.38 with a computed fuel mass of 10 384 kg, a crew of 9 and 35 passengers. According to the navigator's plot and DFDR data the aircraft was routed to Maputo via Kasama-Nidot-Udlo-Ndola-Lusaka-Gadba-Fylde-Masingo-Kurla at FL 350. No flight plan was filed for this flight. Estimated Time of Arrival (ETA) at Maputo was 19.25. The en route weather forecast was favourable

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for the flight. At 17.44 the aircraft reported overhead Lusaka and was cleared to FL 370. On reaching the FIR boundary at 17.53 C9-CAA was handed over to Harare FIR. No information is available on the flight over Zimbabwe.

At 18.46:19 C9-CAA made contact with Maputo Information and reported its position as Kurla at FL 350. The time abeam Limpopo was given as 19.05, endurance as 4 hours and the number of persons on board as 48. In fact the aircraft's endurance was 3 hours 45 minutes and the number on board was 44. Maputo Advisory Flight Information Service (AFIS) advised the aircraft that there was no reported traffic at FL 350 and no delay expected for an ILS approach to runway 23. The aircraft acknowledged and reported maintaining FL 350 to Maputo VOR (VMA). The 18.00 weather information passed to C9-CAA indicated 090/10 surface wind, visibility more than 10km, 3 octas of cloud at 1 800 feet and 4 octas at an undetermined height with a QNH of 1016.

At 18.49 the aircraft acknowledged this information and at 19.02 reported top of descent. It was instructed by AFIS to report at 3 000 feet or runway lights in sight. The aircraft thereupon initiated its descent. While

descending, between 19.02 and 19.10, the heading of the aircraft changed from an average of 189° to 184° with variations left and right. The entire flight was made with automatic pilot engaged, save that prior to the commencement of the descent the pitch channel was disengaged. The roll and yaw channels remained engaged until impact.

The DFDR analysis shows that, until a turn of 37° was made to the right, as hereinafter described, C9-CAA maintained its required track with minor lateral deviations (4-6 km). At 19.09:12 the captain observed that the reserve fuel warning light did not light up during the descent, but in fact, 3 minutes later, at 19.12:26, that light came on for 25 seconds. At 19.09:16 the navigator advised that the distance remaining was 120km. At 19.10:41 a turn to the right, from 184°M to 221°M, was commenced. At 19.10:48 the navigator reported the distance as 100km. The captain reduced power on the right engine at 19.11:11. The turn was executed at an angle of bank of 10-15°. The altitude at commencement of the turn was 19 167 feet and, on roll-out, 17 217 feet. The turn was completed at 19.11:39 and was commented upon by the captain. The navigator replied that the "VOR indicates that way". This change of heading is confirmed by the

S A Air Force radar plot, but in a radar plot by the Mozambican Military the turn is not shown. The descent continued, and at 19.12:26, as already noted, the reserve fuel warning light (2 400kg of fuel remaining) illuminated for 25 seconds. At 19.14:57 the navigator reported the distance as 60km.

At 19.16:58, at a height of 1 514m (4 967 feet), the captain made a comment to the flight engineer about the radio altimeter, saying: "It is necessary to find out and tell them about RV". At 19.17:21, and again 6 seconds later, the captain said: "There is no Maputo". On the latter occasion he added: "Electrical power is off, chaps!". The navigator said: "ILS switched off and DME", and the captain said: "Everything switched off", to which the navigator added: "And NDBs do not work!". No direct reference was made to unserviceability of the VOR.

C9-CAA reached 3 000 feet at 19.18:24 and informed the Maputo controller that it was maintaining that altitude. In fact, as the DFDR shows, it continued to descend. At 19.18:46 the aircraft was cleared for an ILS approach to runway 23, informed that transition level was 40, given a QNH of 1017 and instructed to report established on the 045° radial. The radio operator

acknowledged and stated that the ILS was out of service. The Maputo controller replied: "Affirmative", and cleared the aircraft for a visual approach to runway 05. The navigator reported the distance to go as 25 - 30km, and the captain remarked that something was wrong. The radio operator reminded him of the cloud of three octas at 1 800 feet, of which they had been advised earlier. The captain referred to lights that were visible to the right and the co-pilot responded that the runway was not lit. Meanwhile the aircraft continued to descend.

At 19.19:50 the controller was asked by the radio operator to "Check your runway lights". The controller acknowledged and re-cleared the aircraft for a visual approach to runway 05, adding: "Join .... left down-wind". The radio operator responded with a request "to join right down-wind", which was approved. The captain queried this request by the radio operator, indicating that he intended doing a straight in approach. At 19.19:58 the reserve fuel warning light (2 400kg remaining) illuminated again and remained on until impact 1 minute 41 seconds later. At 19.20:54 the navigator reported some 18 - 20km to go, whereupon the radio operator requested the controller to "Check again runway lights". At 19.21:02 and at a height of

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796m (2 611 feet) above ground, the alarm of the ground proximity warning system (GPWS) sounded and remained on for 32 seconds. The captain cursed, but the descent was continued. The rate of descent was then 2,5m (8,00 feet) per second (480 feet per minute). At 19.21:05, the controller, in answer to the request to "Check again runway lights", replied, "Roger" and once again cleared the aircraft for a visual approach to runway 05.

At 19.21:17 the radio operator asked the controller if the runway lights were out of service. At the same time, while the aircraft continued to descend, the captain emphasized that it was "cloudy, cloudy, cloudy". The controller requested the aircraft to confirm that the runway lights were out of service and C9-CAA replied in the affirmative, stating that the lights were not in sight. At 19.21:27 the controller replied: "Affirmative" and instructed the aircraft to join right down-wind. At 19.21:36 the navigator said: "No, no, there's nowhere to go, no NDBs, there's nothing!". The captain added his plaint: "Neither NDBs, nor ILS!", and those were the last words recorded by the Cockpit Voice Recorder (CVR). The impact occurred at 19.21:39, in darkness. The geographical position of the site was determined as latitude

25° 54' 41" S, and longitude 31° 57' 26" E. This position is approximately 35 nautical miles west of Maputo. The elevation of the impact point was 666,75m (2 187 feet).

Prior to the impact the aircraft had followed a heading of 221°M. The No 2 VOR setting was found set at 112,7MHz. No 1 VOR/ILS was found selected to 110,3MHz, which was the Maputo ILS frequency. The crew had throughout maintained VHF radio communication with Maputo right up until the time of impact.

The crew were required (but in material respects failed) to operate the aircraft in accordance with the applicable Mozambique Regulations and the officially approved Flight Manual produced by the manufacturer.

The survivors remember being told at approximately 19.00 to fasten their seat-belts for landing. All confirm that the aircraft appeared to be operating normally up to impact. One survivor referred to an "explosion" in the "forward section of the plane", upon which the lights went out. The noise of the engines then stopped. Others heard no explosion. Two of the survivors who attempted to follow lights on the ground

were confused as nothing on the ground appeared familiar to them.

1.2 Injuries to Persons:

Injuries	Crew	Passengers	Total
Fatal	8	26	34
Serious	1	8	9
Minor	None	1	1

One seriously injured passenger died of his injuries on 1987-01-05. For statistical uniformity he remains classified as a seriously injured person and his subsequent death is not classified as a fatality.

1.2.1 Flight Deck Crew:

The captain, co-pilot, navigator and radio operator were fatally injured. The flight engineer received serious injuries. All members of the flight deck crew were USSR Nationals.

1.2.2 Cabin Crew:

All four cabin crew members were fatally injured. Their nationality was Mozambican.

1.2.3 Passengers:

Of the 35 passengers 26 were fatally injured. Of the surviving passengers 8 received serious injuries and 1 passenger received minor injuries. Of the passengers 31 were from Mozambique. All 4 passengers of foreign nationality were fatally injured: 2 were from Cuba, 1 from Zaire and 1 from Zambia.

1.3 Damage to Aircraft.

The aircraft was destroyed by the ground impact.

1.4 Other Damage.

There was some fuel contamination of the farmland at the accident site, but no other damage.

1.5 Personnel Information.

1.5.1 Flight Crew:

The information supplied by the USSR chief ("Flying Group Commander") at Maputo was as follows:

The pilot-in-command (the captain), aged 48 years, held a valid and appropriately rated USSR Airline Transport Pilot's Licence (ATPL), first class, No 002982, with instructor rating. His total flying

experience was 13 056 hours. His experience on TU-134 aircraft was 7 523 hours, of which 6 462 hours were as pilot-in-command and 2 044 hours were at night.

The co-pilot, aged 29 years, held a valid and appropriately rated USSR ATPL, No. 009633. His total flying experience was 3 790 hours. His experience on TU-134 aircraft was 2 380 hours of which 1 116 were at night.

The flight engineer, aged 37 years, held a valid and appropriately rated USSR Flight Engineer's Licence, first class, No 005956, with instructor rating. His total flying experience was 6 203 hours, all flown on TU-134 aircraft.

The navigator, aged 48 years, held a valid and appropriately rated USSR Navigator's Licence, first class, No 001863, with navigator instructor rating on TU-134A aircraft. His total flying experience was 12 942 hours, of which 6 074 hours were on TU-134 aircraft.

The radio operator, aged 48 years, reportedly held a valid USSR Radio Operator's Licence, first class (the

number of which was not furnished to the Board). His total flying experience was 14 370 hours, of which 1 450 hours were on TU-134 aircraft.

The crew members flying C9-CAA at the time of the accident had been examined and tested for licence renewal as a crew on two separate occasions.

On 1986-05-06 the licences of the co-pilot, navigator and flight engineer were validated for a further year. On 1986-07-01 that of the captain was also validated for a further year.

All the flight crew members had been declared medically fit without restrictions.

They were well experienced in day and night flying in Mozambican airspace and in landings at Maputo.

The flying time of each of the flight crew members during the preceding 90 days was 58 hours. Their flying time was 6 hours 10 minutes on the date of the accident. Their duty time started at 03.42, i.e. 1 hour 30 minutes before commencement of flight, and the accident occurred at 19.21:39. A rest period of 7 hours 25 minutes was had at Mbala. The

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laid down duty time is 8 hours, and was therefore not exceeded.

The crew were USSR State employees operating the aircraft for the Mozambique Government. It is reported that their USSR licences were validated by the Mozambique Civil Aviation Authorities.

1.5.2 Cabin Crew:

The cabin crew of 4 were all women. The performance of their duties was unrelated to the crash, and details of their qualifications and service experience are therefore not pertinent to this Report.

1.5.3 Air Traffic Controller:

The controller was a graduate of the fourth ATC course conducted by the Mozambique National School of Aviation. His theoretical results were the best in his class. He fared less well in his practical subjects but still graduated top of the course. The course ended on 1985-11-14. He had been controlling without supervision for 3 months prior to the accident.

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The above-mentioned ATC course included 294 hours of instruction in the English language. After the 90 hours which comprised the first part of the language course, he scored 69%, second from the bottom of the class. At the end of the course in English he scored 56%, once again second last in his class. The consolidated course report states that 60% is regarded as satisfactory in every subject of the course. The controller was fulfilling a dual function, i.e. that of Advisory Flight Information Service (AFIS) and that of aerodrome control. This was permissible in view of the low density of the traffic at the time.

1.6 Aircraft Information.

1.6.1 The aircraft:

C9-CAA, with serial number 63457, was constructed according to specifications for Mozambique. It was completed on 1980-09-19 and was first flown on 1980-10-14. A certificate of quality was issued on 1980-10-18.

A Check D or major inspection was carried out in the USSR in August 1984. Since completion of the inspection the aircraft had flown 461 hours.

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According to the last log-book entry on 1986-10-19, the aircraft had completed a total of 1 105 flying hours since new.

The two D-30 III series engines with serial numbers CO3413009 (left) and CO3413006 (right) were installed during the last Check D inspection on 1984-06-06. Both engines were in service for a total of 475 hours.

Service records are reported to have shown that the aircraft was properly maintained prior to the last flight. According to the DFDR information the aircraft and all its systems operated normally up to impact.

1.6.2 Fuel:

Fuel load from Lusaka to Mbala and Maputo was calculated by the investigation team of the State of Occurrence and found to have been as follows:

On 1986-10-19 the aircraft uplifted 7 620 litres of turbine fuel at Lusaka.

Total fuel prior to take-off from Lusaka	14 094 kg
Start and taxi	220 kg
Net Total	13 874 kg
Flight to Mbala	3 490 kg
Total remaining	10 384 kg

Flight from Mbala to Maputo

Auxilliary Power Unit (APU) fuel for one hour)	165 kg
Start and taxi	220 kg
Flying time, with wind correction of 280° at 75km/h, fuel burnt	7 600 kg
(Note: The accident investigation teams of the USSR and of Mozambique calculated this figure as 7 320 kg)	
Total	7 985 kg

(Note: The corresponding figure calculated by the USSR and Mozambique teams was 7 705 kg)

Hence	10 384 kg
Less total fuel used	7 985 kg
	(or 7 705 kg on the USSR and Mozambique Calculation)
Fuel remaining at impact	2 399 kg
	(or 2 679 kg)

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As already noted the reserve fuel warning light (2 400 kg remaining) was activated at 19.12 for 25 seconds and again at 19.19:58 for the rest of the flight, i.e. for 1 minute 41 seconds. Pitch and roll attitudes might have affected the accuracy of the indication. Nevertheless, the fuel contents gauge inspected at the crash site showed a total of 2 400 kg.

The alternate airport, as indicated in the navigator's navigation log, was Beira, for which the remaining fuel was inadequate. To divert to Beira, 4 730 kg would have been required.

1.6.3 Mass and Balance:

The aircraft's mass and balance for the flight from Mbala to Maputo were calculated as follows:

	MASS	CENTRE OF GRAVITY MOVEMENT ALONG MEAN AERODYNAMIC CHORD
Aircraft empty mass	29 859 kg	39,08%
5 Crew	400 kg	
4 Cabin Crew 75 kg each	300 kg	
35 Passengers 75 kg each	2 625 kg	

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Catering	360 kg	
Total Mass	33 544 kg	31,7%
Plus take off fuel from Mbala	10 384 kg	
	43 928 kg	
Taxi fuel	220 kg	
	43 708 kg	
APU fuel (one hour)	165 kg	
	43 543 kg	27,8%
Take-off mass at Mbala	43 543 kg	
Less fuel from Mbala to Maputo	7 600 kg	
Aircraft mass on impact	35 943 kg	29,3%

(On the USSR and Mozambican figures the mass on impact would have been 36 223 kg). On these figures the aircraft mass was well within permissible limits. The limits for the movement of the centre of gravity of the aircraft were 21% forward and 38% rearwards of the MAC. The loading balance was thus also well within limits.

1.6.4 Cockpit layout of navigation equipment:

The aircraft was equipped with the following USSR manufactured radio and navigation equipment: 2 x ADF, 2 x VOR/ILS, 2 x DME, one transponder with mode A and C, one HF, 2 x VHF, one Doppler

system, radar, 2 x radio altimeters and automatic flight control system with Cat II capability.

It was agreed between the accident investigation teams of the RSA, the USSR and Mozambique in their joint factual report that the navigation equipment installed in the aircraft enabled the crew to conduct flights in "adverse" meteorological conditions, and provided jointly to the automatic pilot system:

- automatic piloting along the required heading;
- automatic piloting of the aircraft along the lateral direction by the VOR aids;
- automatic stabilization along the required route by signals of the on-board automatic navigational unit;
- automatic stabilization of angles and height of the flight;
- automatic and directional approach down to altitude of 30m, ICAO category II.

All navigation equipment, which determined the position of the aircraft in respect of the ground, angles of bank and inclination, speed, height, heading, azimuth and distance by VOR/DME, heading angles by radio aids etc., had dual systems in order

to provide the proper information. All such equipment was mounted on the instrument panels of the pilot, co-pilot and navigator. Indicators of the absolute height indicated by two independent radio altimeters were mounted on both the captain's and the co-pilot's panels. The navigation equipment included a Doppler navigation system, and the navigator obtained information regarding the distance flown, speed, drift angle, linear track and deviation.

At the central part of the instrument panel there were "monitors of navigation and landing systems", namely VOR, DME No 1, ILS and VHF No 1 radio communication unit; VHF No 2 radio communication unit and DME No 2 were situated on the overhead panel. All the panels mentioned were accessible to both the captain and co-pilot. Two ADFs, HF radio communication unit, "heading system" and Doppler navigation system were mounted on the navigation panel.

The layout of the flight deck, with the navigator seated behind the co-pilot, would have made it difficult, especially at night, for the navigator to see the VOR selections on the central panel in front of the two pilots.

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1.7 Meteorological Information.

(a) The 16.00 met report for Mbala was as follows:

Surface Wind	:	Calm
Visibility	:	30km
Cloud	:	3/8 Cumulus at 5 000 ft
		6/8 Cirrus at 30 000 ft
Temperature	:	24°C
Dew Point	:	13°C
QNH	:	1 020.6 hPa

Shortly after C9-CAA made contact with AFIS at Maputo the operator passed the 18.00 weather to the aircraft as follows:

Surface Wind	:	090/10
Visibility	:	10km
Cloud	:	3/8 Cumulus at 1 800 ft
		6/8 Cirrus, height not determined
Temperature	:	23°C
Dew Point	:	20°C
QNH	:	1 016

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This weather information coincided with the met report and remained unchanged for the 19.00 update except for the QNH, which increased to 1 017. This update was passed to C9-CAA by the operator at 19.18:54. The pilot of a Boeing 737 which landed at Maputo at 16.00 reported that the weather at that time was fine. From his radar he was able to confirm that there was no cumulonimbus within 150 nm of Maputo. He added that to the south-west the weather was becoming dark, but it was far away. The pilot of a HS-125 which landed at 16.30 confirmed that the weather was fine but reported some mist. The flight engineer, who survived the accident, said that there was "a little mist" at 700 - 800 meters (2 296 - 2 625 ft) which obscured their view. The CVR indicates that shortly after leaving 3 000 ft the aircraft encountered cloudy conditions.

The inhabitants of the village of Mbuzini, who were later interviewed, differed in their observation of the actual weather at the scene of the accident. One said that it was clear. Another said that although it was not raining there had been drizzle shortly before the impact was heard. The third said that it had been raining a little. None heard thunder nor observed lightning. The pilot of flight TM-103, a Boeing 737

en route from Beira to Maputo at FL 310, reported 7/8 stratocumulus above Maputo at 20.00.

The accident took place at night, a few minutes before moonrise. There was no real period of twilight and it was very dark.

1.8 Aids to Navigation.

Once C9-CAA passed Masvingo there were no further aids to navigation on its track before Maputo. Kurla, the reporting point on the Mozambique border, had no facility. According to other pilots, use was made of the Phalaborwa VOR and Hoedspruit DME to obtain a fix at Kurla. After passing Kurla pilots would route direct to Maputo, as Limpopo (Lima Papa) NDB had been unserviceable for years. As the NDBs at Maputo (Mike Alpha and Mike Oscar) were known to be weak, and as Mike Alpha in any event had not been coding for about two years, maximum use was made of the VOR/DME at Maputo, i.e. Victor Mike Alpha (112.7MHz), which usually functioned well. Pilots would also commonly use the Maputo broadcasting station. The NDB facility at Namaacha, the reporting point between Carolina and Maputo, had also been unserviceable for years. Matsapa, in Swaziland, had a new VOR/DME, Victor

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Mike Sierra (112.3MHz), which was on test, as well as a NDB, Mike Sierra (262.5KHz). The Nelspruit NDB, November Sierra, is very weak and according to pilots, can be received only within about 15 nm of the facility. Jan Smuts (Juliet Sierra on 220KHz) is a very powerful NDB and can be received on the ground at Komatipoort airfield - a distance of 407 km.

1.9 Communications.

Transmission and reception of VHF communications between C9-CAA and Maputo AFIS were normal throughout and were conducted on 127.3MHz. There was only one controller on duty that night and the aircraft remained on this frequency for Maputo tower. This was in accordance with a Notam issued on 9 August 1985. The radio operator of C9-CAA conducted all the radio communications with Maputo recorded on the Maputo ATC tape. The language used was English. The captain of C9-CAA was proficient in English and capable of conducting his own communications in that language. The AFIS controller had been tutored in English during his ATC training, as mentioned above.

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As the joint factual report of the three accident investigation teams observes: "While the physical radio communications were normal, there were certain perceptual difficulties experienced in getting the correct message across".

At 19.01:58 C9-CAA reported top of descent and was requested to report runway lights in sight or reaching 3 000 ft. When C9-CAA reported "maintaining 3 000 ft" at 19.18:24, the controller responded that Transition Level was 40, although the aircraft had already reported at 3 000 ft. At 19.18:59 the radio operator stated "ILS out of service" to which the controller replied "Affirmative". This was done although the monitor in the tower, according to him, had earlier indicated that there was nothing wrong with the ILS.

The crew of C9-CAA having been unable to see runway lights, the radio operator at 19.19:50 asked the controller to 'check' his runway lights. The controller responded with a clearance for a visual approach and increased the intensity of the runway lights. The request to 'check' the runway lights was repeated at 19.20:57 and once again the controller responded with a clearance for a visual approach on runway 05. When C9-CAA asked, at 19.21:17, whether the runway lights

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were out of service, the controller had the question confirmed and then replied in the affirmative. At no stage did the controller actually inform C9-CAA that the runway lights were operating normally. With due regard to the interpretation of the word 'check', as reflected in Annex 10 to the Chicago Convention, para. 5.2.1.4.8, the controller appears to have been under the bona fide and reasonable impression that the word, as used by the radio operator, meant that he had seen the runway lights.

1.10 Aerodrome Information.

Maputo airport has two hard surface runways - runway 05/23, 3 660 m long, and runway 10/28, 1 700 m in length. The airport elevation is 145 ft. Initial approach altitude for Maputo is 3 000 ft and the circuit is flown at 1 700 ft.

As per NOTAM CO14 dated 1985-08-09, CTA APP SVC (Terminal approach control services) are available to TMA/MA from 05.00 to 18.00. After that hour only Aerodrome Control Service and AFIS are available.

Runway 23 is equipped with an ILS. The VOR (Victor Mike Alpha) and the DME at Maputo were found service-

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able by two other pilots who landed approximately 2 hours before C9-CAA's ETA. The fact that the NDB Mike Alpha has not coded for about 2 years was well known to all pilots using the airport.

According to the controller all facilities were serviceable at the time of the crash. The pilot of Flight TM-173, a Boeing 737, which landed at 16.00, said that neither NDB Mike Alpha nor Mike Oscar was working. However, the pilot of the next aircraft to land at Maputo, a HS-125, which landed at 16.30, and the pilot of an AN-26 which landed at 16.54, reported that both facilities were working. The HS-125 pilot picked up Mike Oscar at 25 - 30 nm and Mike Alpha at 40 - 50 nm. Both reported the VOR and the DME to be serviceable. The runway lights at Maputo were also working. The pilot of TM173 stated that at 20 000 ft they are normally visible at 60 nm.

He landed on runway 23 and the lights "were definitely working". He monitored his approach by means of ILS and confirmed its serviceability. He mentioned that pilots have found that the 045 radial for runway 23 is not as good an approach as the 047 radial. The HS-125 pilot landed on runway 05. He saw the runway lights at 10 nm at 3 000 ft. He confirmed that both the

runway and the Precision Approach Path Indicator (PAPI) lights (sic) were serviceable. There is no radar or VHF Direction Finder (VDF) equipment at Maputo airport. Maputo airport is in fact not equipped with a PAPI system but has a 3 bar Visual Approach Slope Indicator (VASI) system on runways 05 and 23.

1.11 Flight Recorders.

1.11.1 Description:

C9-CAA was equipped with a total of four recorders as follows:

Flight Data Recorder (FDR) K-3-63;
Cockpit Voice Recorder (CVR) MARS-BM;
Digital Flight Data Recorder (DFDR) MSRP-64-2;
Quick Access DFDR (QAR) MSRP-64-2.

1.11.2 Location:

The FDR was mounted in the fuselage of the aircraft in line with the trailing edge of the wings. The DFDR was mounted in the rear of the aircraft at the base of the vertical stabilizer. The CVR and QAR were mounted in the equipment bay immediately behind the cockpit.

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1.11.3 Condition:

The recorders showed evidence of surface damage caused by the impact, which is to be expected under the circumstances. Other than this the recorders were in good condition. All necessary information was recovered without difficulty.

1.11.4 Pertinent Data:

1.11.4.1 Flight Data Recorder K-3-63:

This recorder records altitude, vertical acceleration, airspeed and time. This data was not analysed for the purpose of this investigation as all necessary information was obtained from the DFDR.

1.11.4.2 Cockpit Voice Recorder:

The aircraft was fitted with a Soviet made CVR, MARS-BM. The recording tracks of this type of CVR are as follows:

captain audio;

co-pilot audio;

cockpit area microphones;

time signal.

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All the cockpit conversation was in Russian and was translated by means of a group effort by the three participating countries. In the CVR transcript of the recording the identity of the person speaking has been indicated wherever that is possible. The CVR transcript has also been integrated with the ATC tape for greater clarity (see Appendix III). The time channel was inoperative as far as the digital time signal was concerned. Unfortunately, the DFDR discrete which gave the time of transmissions from the aircraft was also inoperative and this meant that there was no common signal by which the tapes could be synchronised. To solve this problem the time of the proximity alarm was used as a base time. This time was established as 19.21:02 according to the ATC and CVR tapes. This event took place 37 seconds before impact which gave the corrected time for the crash of 19.21:39. The DFDR time was thus reduced by 9 seconds to achieve synchronisation. The elapsed time of 2h 44 min 22 secs obtained from the DFDR gave a corrected take-off time of 16.37:17 which was used for all further calculations.

1.11.4.3 Digital Flight Data Recorder:

The MSRP-64-2 DFDR was found to have functioned perfectly except for only one parameter which was unserviceable, i.e. microphone keying. The following information was obtained from the analysis:

Take-off : 16.37:17

The elapsed time of the last flight (from the beginning of the take-off roll on the aerodrome until the first impact on the ground) was 2h 44 min 22 secs.

Discrete:(remaining fuel 2 400 kgs) came on after 2h 35 min 9 secs, i.e. at 19.12:26, and stayed on for 25 secs, i.e. till 19.12:51. It came on again after 2h 42 min 41 secs, i.e. at 19.19:58, and stayed on for 1 minute and 41 seconds till impact. Fuel remaining in the tanks at the time of impact, even as calculated by the RSA accident investigation team, was enough for the flight to Maputo. The automatic pilot was operating normally. The roll and yaw channels were engaged 2 min 44 secs after take-off and remained engaged for the whole flight. The pitch channel was engaged 23 min

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03 secs after take-off and disengaged prior to the descent at 19.01:06, i.e. 2h 24 min 49 secs after take-off.

The aircraft electrical system functioned normally until the time of impact.

The barometric pressure was set to 760mm 2 min 48 secs after take-off and remained unchanged for the whole of the flight. Altimeter QFE setting of 759 on reaching transition level was not read out by the MSRP-64-2 as this figure is within the laid down limits of 760 $\pm$ 1.

While the aircraft was descending, between 19.02 and 19.10, the heading changed from an average of 189° to 184° with variations left and right. Between 19.10:41 and 19.11:39 the heading changed at 10 - 15° angle of bank from 184°M to 221°M and remained on or near to this course until the moment of impact. At 19.11:07 the power on the right engine was reduced by pulling the thrust lever back to 16,4°. It remained at this setting until 19.20:49. Thrust lever travel is 0° to 60°. The radio altimeter registered automatically at 19.18:54 at a pressure altitude of

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1 092 m (3 583 ft) and an absolute height of 760 m (2 493 ft). The Ground Proximity Warning System (GPWS) was activated at 19.21:02 and remained on for 32 secs. This system is activated between absolute heights of 50 to 400 m if the flight is conducted over hilly or mountainous terrain and when the rate of descent is between 6 to 27 m per second. While descending the GPWS is activated between absolute heights of 600 to 50 m when the rate of closure is between 8 to 15 m per second.

Impact with the ground took place at 19.21:39 with flaps and landing gear retracted, speed 411,4 km/h, right roll 0,22°, pitch + 2,2°, heading 223,5°M, pressure altitude 618 m (2 027 ft), an actual elevation of 666 m (2 187 ft).

According to the DFDR there were no aircraft system failures or malfunctions during the flight. A probable flight path was calculated and plotted by the USSR specialists using information obtained from the DFDR.

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1.11.4.4 Quick Access DFDR Recorder:

This recorder recorded the same parameters as the DFDR and was used for flight and crew information purposes. It did not have the same protection as the DFDR, and as the results of the DFDR readout were intrinsically and extricably entirely consistent and satisfactory, it was not decoded for the purposes of this investigation.

1.12 Wreckage and Impact Information.

1.12.1 General:

The first object which was struck by the outboard section of the left wing, was a tree on the side of a hill which slopes from left to right when facing in the direction of flight. The tree impact occurred at an elevation of 668,56 m (2 193 ft) and 145 m from the RSA - Mozambique border. The velocity at impact as well as the undulating terrain caused the aircraft structure to break up over a distance of 280 m from the initial impact point, before it tumbled down the hill. The wreckage was distributed over a distance of 846 m and in a direction of 223° M.

From the first tree impact and over a distance of 77,2 m several small thorn tree tops were severed by the left wing before the tip struck the ground at an elevation of 666,75 m (2 187 ft), indicating that the aircraft was descending at an angle of 1° 20' 36" while the wings were level. Several pieces of navigation light lens and red glass pieces were found near this ground mark.

The left wheel-bay fairing, which is situated below the wing, then struck the ground 19 m from the wing tip mark at an elevation of 665,88 m (2 185 ft), followed by the right wheel-bay fairing, which caused a ground mark 12 m forward of the latter.

The first fuselage ground mark was at a distance of 4 m from the right wheel nacelle mark. Another 4 m on, the right wing tip contacted the ground, as evidenced by the navigation light lens and green glass pieces.

After the fuselage had caused a 51 m long ground scar, the aircraft left the ground for a distance of 42 m, presumably without the left outboard wing panel and the landing-gear nacelles, which

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broke off due to impact forces. The bottom nose section of the aircraft, right rear structure and outboard wing panel then struck the ground. An upward deflection of the nose section after impact caused the tail to whip down and strike the ground 9 m further on.

The right outboard wing panel, both engines and the tail section then separated from the rest of the aircraft. The main wreckage, consisting of the fuselage and both inboard wing panels, had sufficient momentum to continue for a further distance of 263 m in a direction of 215°M before it struck the ground at an elevation of 646 m (2 119 ft). The impact was severe enough to break the fuselage into two pieces and cause the left wing to separate from the centre section, while the right wing remained attached to the centre fuselage section. A strong smell of turbine fuel was noticeable in this area for several days after the accident.

The tail section and both engines maintained the initial impact direction and came to rest to the right of the main wreckage.

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The left engine broke into three pieces, while the right engine remained intact after ground impact. Deformation of the left engine outer casing suggested reduced power on ground impact, while the right engine suffered less torque deformation because it sustained less impact damage after separation.

The CVR unit, with markings TIP 70A-10M on the top and N259024 on the bottom, broke out of the aircraft and was located near the main wreckage.

The DFDR, marked MPP-15-5 on the top and N10410 on the bottom, and the QAR, marked MLP-14-6 on top and N10414 on the bottom, were found further forward and closer to the main wreck.

The scratch foil type FDR, K3-63, was found in the centre fuselage section 3 days after the accident. All the deformation and fractures of the components were consistent with high impact forces. The aircraft struck the ground in the flight configuration, with landing gear and flaps retracted and the stabilizer in the cruise position.

The above observations confirmed the DFDR analysis with regard to the direction, rate of descent and the velocity of 411,4 km/hr at impact.

1.12.2 Panel Indications:

The USSR investigating team arrived several days after the cockpit readings and settings had been recorded by the teams of the RSA and Mozambique. The observations of the three teams differ in some respects as indicated below. The Board has approached the data revealed in the post-impact state of the instruments with the customary caution. The actual settings immediately before impact could have been disturbed by impact forces, or by the removal of the bodies of the two pilots, or otherwise unwittingly by persons on the scene. However, scientific investigation has established the actual settings in most cases, and the weight of evidence has provided the answers in other cases (e.g. the navigator's one DME showed 35 nm which represents the actual distance between Maputo airport and the crash site).

1.12.2.1 Pilot's Instrument Panel:

INSTRUMENTS	RSA	MOZAM-BIQUE	USSR
Radio Altimeter	115 m	113 m	110 m
MDA BUG	Zero	Zero	Zero
Angle of Attack	1,7°	1,7°	1,7°
Vertical Acceleration	+1,4	+1,4	+1,4
RMI: Magnetic Heading	218°	218°	218°
No 1 Needle	284°M	283°M	283°M
Selected to:	ADF	ADF	ADF
No 2 Needle	156°M	156°M	158°M
Selected to:	ADF	Undeter-mined	Undeter-mined
HSI: Magnetic heading	218°	218°	218°
Selected Course	210°	210°	210°
ADF No 1	298°	298°	298°
Altimeter	2 530 ft	2 530 ft	2550 ft
Sub scale	1 013,2	1 013	1 013
Altimeter	870 m	870 m	830 m
Sub scale	789,5mm Hg	790mm Hg	789mm Hg
Bug set	450 m	450 m	Not seen
DME No 1	874,7 km	874,7 km	874,7 km
DME No 2	793,1 nm	793,1 nm	793,0 nm

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1.12.2.2 Centre Panel:

Remaining fuel L/H	1 200 kg	1 200 kg	Not seen
R/H	1 200 kg	1 200 kg	Not seen
ILS/VOR No 1	110,60 MHz	110,06 MHz	110,6 MHz
Course selector	164°	164°	164°
Whether "TO" or "FROM"	HA (TO)	HA (TO)	HA (TO)
ILS/VOR No 2	116,75 MHz	117,75 MHz	116,75 MHz
Course selector	207°	207°	207°
Whether "TO" or "FROM"	HA (TO)	HA (TO)	HA (TO)
DME No 1	133,7 MHz	133,7 MHz	133,7 MHz
VHF No 1	126,075	126,075	126,075
Flap selector	UP	UP	UP
Landing gear selector	Neutral (Retracted)	Neutral (Retracted)	Neutral (Retracted)

1.12.2.3 Co-Pilot's Instrument Panel:

Clock	9.23	9.23	9.21
Flying Time	2:36	2:36	2:35
Radio Altimeter	300 m	300 m	340 m
Bug	Zero	Zero	Zero
Altimeter	14 780 ft	14 780 ft	14 780 ft
Sub scale	1 012	1 012	1 013
Altimeter	590 m	590 m	600 m

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Sub scale	760mm Hg	760mm Hg	760mm Hg
RMI Heading	223°M	223°M	221°M
Needle No 1	228°	228°	283°
Selector	ADF	ADF	ADF
Needle No 2	140°	140°	135°
Selector	ADF	Undetermined	Undetermined
HSI Heading	220°M	220°M	220°M
Selected course	212°	212°	212°
ADF No 1	300°	300°	300°
DME No 1	73,9 km	73,9 km	73,9 km
Fuel contents gauge selected on zone 3 L/H	1 000 kg	600 kg	Not seen
R/H	1 400 kg	1 400 kg	Not seen

1.12.2.4 Navigator's Panel:

Altimeter	400 m	370 m	400 m
Sub scale	743mm Hg	743mm Hg	746mm Hg
Bug setting	950 m	950 m	Not seen
Altimeter	47 905 ft	5 940 ft	5 693 ft
Sub scale	1 004	1 004	1 006,0
DME No 1	74,9 km	74,9 km	74 km
DME No 2	35 nm	35 nm	35 nm
ADF No 1 Channel 1	221,8 KHz	220 KHz	221,8 KHz
Selected to Channel 2	278,5 KHz	278,5 KHz	278,5 KHz

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Compass selector to	Compass	Compass	Compass
ADF No 2 Channel 1	394,0 KHz	394,0 KHz	394 KHz
Selected to Channel 2	290,5 KHz	290,5 KHz	290,5 KHz
Compass selector to	Compass	Compass	Compass
RMI: Magnetic heading	212°	212°	211,5°
No 1 Needle	276°	276°	235°
Selected to	ADF	ADF	ADF
No 2 needle	107°	112°	117°
Selected to	ADF	ADF	ADF
HF Radio Frequency	12171,0 KHz	02172,0 KHz	02172,0 KHz
Mode	AM	AM	AM
Compass reference indicator	221°M	221°M	221°M
CDI selected course	220°	Not seen	Not seen
Doppler Panel Wind Selector:			
Aircraft Heading	346°	350°	150°
Wind Direction	046°	Not seen	Not seen
Wind Speed	18 km/hr	20 km/hr	0
"B" Cross track error	0	0	0
"C" Distance to go	20 km	20 km	0
Ground Speed	425 km/hr	450 km/hr	450 km/hr
Drift	0	0	0
Radar:			
Range Setting	250 km	250 km	250 km
Mode Selector	Drift	Drift	Drift

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Tilt	4° Down	4° Down	4° Down
DFDR Setting	19:10:6	19:10:6	19:10:6
	8:0:1:6	8:0:1:6	8:0:1:6

1.12.2.5 Side and Overhead Panels:

DME No 2	112,65 MHz	112,65 MHz	112,65 MHz
VHF No 2	127,30 MHz	127,30 MHz	127,30 MHz
Transponder	1771	1771	Not seen

The following trip switches were found in the 'off' position:

Automatic pilot modes
Nose wheel steering
Landing gear control
Stand-by horizon
Emergency descent warning
No 1 hydraulic pump
No 2 hydraulic system warning
Left side landing gear selector: Neutral (retracted).

Note: The instruments and switches on the side and overhead panels showed impact damage.

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1.13 Medical and Pathological Information.

The post-mortem examination of the bodies of the 4 flight crew members who perished and of the bodies of 3 passengers were conducted by a State Pathologist of the State of Occurrence. There was medical evidence that each of the flight crew members was in a good state of health and well able to cope with all normal functions during the particular flight. The findings of the post-mortem examinations conducted by the South African pathologist are summarised as follows:

1.13.1 Captain:

Chief findings: Chest and abdominal injuries.

Cause of death: Chest injuries.

No abnormalities were noted which could have caused incapacitation during the flight. Vitreous humor and blood specimens were free of alcohol. No carboxy-haemoglobin was detected in the blood.

1.13.2 Co-pilot:

Chief findings: Head injuries with fracture of the skull and subdural haemorrhage, rib fractures, signs of aspiration of stomach contents in the airways and limb fractures.

Cause of death: Multiple injuries and aspiration of stomach contents.

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No abnormalities were noted which could have caused incapacitation during flight. Blood and vitreous humor specimens were free of alcohol. No carboxy-haemoglobin was detected in the blood.

1.13.3 Navigator:

Chief findings: Fractures of the skull, spine and ribs.

Cause of death: Multiple injuries.

Abnormalities noted in the decomposing heart were that one branch of the coronary artery was completely occluded and there was interstitial fibrosis. There were, however, no centrilobular changes indicative of heart failure. The concentration of alcohol in the blood specimen was 0,01 gram per 100 mℓ but was free of carboxyhaemoglobin.

A specimen of vitreous humor was, however, free of alcohol. The alcohol concentration might have been the result of endogenous ethanol formation caused by decomposition changes.

1.13.4 Radio Operator:

Chief findings: Multiple chest injuries, fracture of

the skull, rupture of the liver and fracture of the pelvis.

Cause of death: Multiple injuries. The heart showed a marked stage of decomposition. The coronary vessels appeared narrowed due to subintimal thickening and the right side of the heart had fat infiltration. The blood specimen was free of carboxyhaemoglobin but the alcohol concentration was 0,02 gram per 100 mℓ. The specimen of vitreous humor was, however, free of alcohol. The alcohol concentration might have been the result of endogenous ethanol formation caused by decomposition changes.

1.13.5 The cause of death in the case of each of the 3 passengers was multiple injuries. The nature of the injuries sustained reflected the severity of the accident.

1.14 Fire or Sabotage.

There were no signs of fire in the wreckage. As earlier noted, the aircraft and all relevant equipment were fully serviceable and airworthy immediately prior to impact, and there is no evidence of sabotage.

1.15 Survival Aspects.

1.15.1 Survivability:

This was a partially survivable accident where 10 of the 44 occupants survived, although one died of his injuries some 2½ months later. All the passenger seats separated from the railage on the floor. Chair attachment points remained intact, but the mounting rails were bent and broken in numerous places. It appears that, on impact, the chairs moved forward (decelerating) and to the right (causing scratch marks on floor boards), indicating that the aircraft was in a yaw to the left when the chairs and attachments tore away from the rest of the railing. From the interviews with the survivors it appears that nine of the ten who escaped death were seated in the back right hand section of the aircraft, while the tenth (the flight engineer) was in the cockpit section. When the District Surgeon arrived at the scene he found all of the survivors within an area of approximately 10 meters in radius. Of the survivors, 4 were found by the District Surgeon inside the front section of the aircraft wreckage while 3 others were found next to this section. Apparently the survivors, other than the flight engineer, lived through the sequence of impact

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forces because they were pinned to the right-hand rear side of the cabin, which sheltered them. The seat belts of some of the survivors were still fastened while all the seats were found to be broken. The flight engineer's seat belt had not been fastened. The passengers were not aware nor were they informed by the crew of any emergency.

1.15.2 Search and Rescue:

The last radio transmission from the aircraft was at 19.21:34. When the aircraft did not respond to further radio calls by the controller, he alerted the 'dispatch' at 19.27 hours. Thereafter military units were alerted for search and rescue. The ATC recording of the radio communication between the aircraft and the controller was listened to and it was confirmed that the aircraft was in radio contact four minutes before its estimated time of arrival. Hence it was reasonable to assume that the aircraft was near Maputo, and the initial search area was defined accordingly. A search helicopter departed from Maputo at 22.55 and returned at 00.21. Another helicopter departed on a search and rescue mission at 02.44 and returned at 03.22. The first helicopter was airborne again between 02.44 and 04.51. This

was followed by 4 other aircraft. A marine search in the Maputo Bay was also carried out.

The site of the accident was a remote corner of South Africa, to which access is not easy. On the South African side, a police warrant officer was the first person outside Mbuzini to be advised of the accident. A telephone report was made to him by a villager. This was at approximately 23.00. He in turn advised Komatipoort Police Station. The first member of the Komatipoort Police Station arrived at the scene of the accident at 23.40. Other members of the South African Police arrived at intervals after this. As they feared that the survivors could be further injured if they were moved, they gave what comfort they could and protected them from the elements. The District Surgeon based at Komatipoort was the first medical person on the scene, having been advised at about 00.15 and arriving at 01.00. The treatment given by him was that of comfort and pain-killing injections as he did not have all the necessary equipment with him to give further aid. The local clinic could also not be of further assistance. More sophisticated medical assistance became possible when the military team arrived. A helicopter and medical crew at the South African Air

Force Base at Hoedspruit was alerted at 01.55 and the medical staff departed by helicopter at 02.55 with the necessary equipment on board. The crew arrived at Komatipoort at 03.45 whereupon they were briefed on all the available information. They reached the scene of the accident shortly after 04.00 and within 20 minutes had the survivors (save one) placed on board a helicopter and flown to Nelspruit Hospital. One survivor refused to be taken by helicopter and was sent to Nelspruit by ambulance.

Personnel based at the Mozambique Defence Force Camp, about 1 km from the scene of the accident, and directly beneath the flight path of the aircraft, made no report of the accident.

The DETRESFA signal sent to FAJS (the Johannesburg FIC at Jan Smuts Airport) by the Mozambique authorities was dispatched at 04.04 on 1986-10-20. At 04.06 this was followed by a signal advising that Maputo airport was closed.

1.16 Test and Research.

1.16.1 The VOR/ILS marker selector, VOR course selectors, VOR frequency selectors, DME selectors

and ADF selectors were examined by the South African bureau of Standards (SABS) to determine selections at the time of impact, and if indicator lights were illuminated at the time of the impact. The examination report contains the following information:

1.16.1.1 VOR/ILS marker selector:

The top left switch was selected to ILS. The light marked K1 on the selector was probably illuminated. The top right switch (marker) was selected to the right. Light K2 was on.

The bottom centre switch was set on 1, but it was moved after the accident.

Light globe marked r2 on the selector was probably on, indicating a setting to the left.

1.16.1.2 VOR course selectors:

No 1 was undisturbed on 164°M. No 2 indicated a reading of 164°M on impact. The switches on both selectors were set to HA (i.e. TO) with the top light globes illuminated.

1.16.1.3 VOR frequency selectors:

No 1 had a reading of 110,6 and showed no marks due to the accident.

Selector No 2 showed a mark on the side of the dial corresponding with a reading of ,70. A dirt mark on the dial and on the face of the selector corresponded with a reading of 112. The most probable selection at impact was therefore 112,70 (Maputo VOR).

1.16.1.4 DME selectors:

No 2 DME was found to have read 112,70 MHz (Maputo). A mark of a spring on one gear corresponded with this reading. The switch was selected to "PEZEPB" (a Russian inscription apparently indicating a 'hot stand-by' position), and the left-hand light was illuminated.

No 1 DME had damage marks on the gears and on the dial corresponding to a reading of 110,60 MHz. The switch was selected to DME.

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- Regarding the mechanical damage, it should be noted that, as the accident involved a succession of impacts, the readings registered at the initial impact might have changed and the mechanical damage might have captured the reading at a subsequent impact.

1.16.2 The joint factual report of the tripartite teams records that:

"In accordance with the 3-side decision of the Commission (sic), the blocks of (both) KURS-MP-2 instruments system (i.e. the collective VHF navigation systems, of which there were 2 sets) were sent to Moscow in order to investigate block system serviceability, the course receivers KRP-200P setting and the indication of azimuth on the UN-2P blocks.

RESULTS OF INVESTIGATION

The blocks KURS-MP2, KRP-200P No's 117814, 187801, UN-2p No's 188783, 188789, 5SH No's 418987, 488976, GRP-20PM No's 530678, 530671, MRP-3PM No's 340689, 340697 are serviceable and their technical parameters correspond with the

norms determined by technical exploration documentation.

FREQUENCY SET ON THE KRP-200P COURSE RADIO RECEIVERS

On the KRP-200P No 117814 (the 1st half-set) receiver, the frequency of the landing system ILS was set as 110,3 MHz, on the glide path receiver GRP. 20PM N 530678 was set 335,0 MHz as corresponded to above. The receiver KRP-200P N 187801 (the 2nd half-set) had the VOR frequency 112,7 MHz set.

AZIMUTH INDICATIONS ON UN-2p BLOCKS

On the dial of the checking system of Un-2P N 188783 block (the 1st half-set) the azimuth 44,5° functioned. The speed of functioning of azimuth dial was 26° per second. On the dial of the checking system of UN-2P N 188789 (the 2nd half-set) the azimuth 107,5° functioned. The speed of functioning of azimuth dial was 17° per second."

Stated shortly, these findings, as agreed between the 3 parties, are consistent with those enumerated earlier in this Report.

1.16.3 Simulator Flight:

An exercise was carried out in a Boeing 737

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simulator in accordance with the plot of C9-CAA's flight path which was drawn up in the USSR on the basis of the DFDR and all other available data. The simulator flight served to confirm that the 37° turn coincided with the 045 Radial from the Matsapa VOR.

1.16.4 A report dated 1986-12-31 by Mr B Caiger, a flight recorder specialist assisting the Mozambique government, was made available to the Board. The report, entitled "GROUND PATH RECONSTRUCTIONS FOR FLIGHTS F C9-BAA AND C9-CAA AIRCRAFT ON 19TH OCTOBER 1986" was apparently compiled in Montreal and Ottowa, and reconstructs the respective tracks of C9-CAA and of a Boeing 737, C9-BAA. The latter aircraft was on a flight from Beira to Maputo on 1986-10-19 until it was turned back at 19.57, presumably because of Maputo's concern with the Tupolev aircraft, with which radio contact had been lost. C9-BAA took off from Beira at 19.07, so that it was heading towards Maputo during the last 14 minutes of C9-CAA's flight, and for 36 minutes thereafter.

During the investigation it was suggested that the track of C9-BAA on its flight towards Maputo deviated to the right of its intended track, and that

that indicated that it had been induced to fly more to the west by a spurious VOR beacon on the Maputo frequency. The theory of a spurious beacon is disposed of in an appendix to this Report, but what the Caiger report demonstrates is that C9-BAA did not in fact deviate from its correct track. In this context it is noteworthy that, according to the statement of the captain of C9-BAA, his aircraft flew on the usual Maputo navaids, all of which were working normally.

A further inference from the Caiger report is that neither the track of C9-CAA nor that of C9-BAA was curvilinear, as they would have been if a spurious VOR signal had been operative on the same frequency as Maputo's VOR.

1.17 Additional Information:

1.17.1 Navigation Publications:

The Aerad Africa Supplement found on board the aircraft was dated 1984-06-04. There were two Jeppesen Airway Manuals found in the wreckage. One, an Africa Vol 2, was out of date and contained landing plates dating from 1979, with the newest

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being April 1982. The second Jeppesen was bound in an Aeroflot Airway Manual Africa 72 folder and was amended up to 1986-01-20.

1.17.2 Camp Site:

During the on-site investigation an abandoned camp site was found on the RSA side of the border approximately 150 m south-east of the place where the aircraft initially contacted the ground.

Witnesses on Mozambique's side of the border said that a tent on the site had been removed on the day after the accident. The SA Police Security Branch at Komatipoort were requested to investigate the matter of the camp site, and when and by whom the alleged large tent was erected on the site.

The investigating officer found an employee of the Department of Veterinary Services who was patrolling the particular section of the border fence during September and October 1986. He frequently saw members of the S A Defence Force camping at the place. Their tents were, however, small. The soldiers sometimes played with a yellow ball. He once saw the ball lying on the site shown to him by the Security Branch Commander. The Company

Commander of the army unit in the Komatipoort area, denied the existence of any camps with large tents in the particular area.

2. ANALYSIS

NOTE:

In its investigations and deliberations the Board has had recourse to the following sources of data and expertise, inter alia:

(a) the 'Aircraft Accident Factual Report', being an agreed report jointly drawn up by the respective accident investigation teams of the RSA, the USSR, and Mozambique;

(b) the various protocols signed on behalf of the RSA and the accredited representatives of the other two States;

(c) the Board's own inspections of the site of the crash, the surrounding area and the wreckage;

(d) the viva voce and written evidence of witnesses on the facts;

(e) the evidence of the expert witnesses;

(f) the report and reconstruction of flight paths compiled by Mr Caiger, the expert assisting Mozambique;

(g) the research exercises and tests including the SABS investigation of instrument settings, the USSR investigation of instruments in Moscow, the USSR flight path reconstructions, the simulator exercise to test C9-CAA's flight path, and information on the practical operation of the Matsapa VOR beacon;

(h) the information on the aircraft, crew, instruments and regulations provided by the USSR;

(i) the medical evidence;

(j) the numerous documentary and real exhibits;

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(k) the re-assembled actual instrument panels on the flight deck;

(l) the SAAF radar plot (Mr Caiger's report explains that the Mozambique radar plot is unreliable);

(m) the DFDR analysis in Moscow;

(n) the ATC tape;

(o) the CVR transcript (which, as is normal, yielded a record of the last 30 minutes, although it is possible that more relevant data - e.g. on the reasons for the inadequacy of the fuel reserves - would have emerged from a recording of the last hour of the flight);

(p) the expert knowledge of the Board members.

2.1 The Turn to the Right.

On the day of the accident the aircraft had flown the route Maputo, Lusaka, and Mbala without incident. The return flight initially proceeded uneventfully with no

major excursions from the planned route. Contact was established with Maputo AFIS at 18.48, and at 19.02 the radio operator advised Maputo that the aircraft was leaving Flight Level (FL) 350. At 19.10:41, while passing FL 190, the aircraft turned to the right from a heading of 184° M to 221° M. This turn was a diversion from the expected flight path, and was clearly the result of a crew-initiated automatic pilot command. There is no doubt that the turn was executed by the navigator, who could only have used the Doppler system heading selector for that purpose, and was without reference to the captain, who commented: "Making some turns ... couldn't it be straight?". The navigator responded to the pilot's comment saying: "VOR indicates that way!".

On the information originally before the Board, the navigator's Combined Omni Bearing Selector/Course Direction Indicator (OBS/CDI) was directly coupled to the No 2 VOR receiver, but it has since been ascertained that the OBS/CDI could have been coupled to either the No 1 or the No 2 VOR receiver, and that the normal procedure was to couple it to the No 1 VOR receiver. That accords with the fact that the VOR control switch was found in the No 1 position.

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The navigator's OBS was found set on 220°, while both the pilots' course selectors were set on 164°. This was the course found on the navigator's log for the leg from Lusaka to the Harare FIR boundary, and the settings were not changed thereafter. The navigator's OBS setting of 220° was very close to the required inbound heading of 225° to maintain the 045° radial, and it can be accepted that 225° was set on the navigator's OBS before the turn was initiated. The 045° radial would have positioned the aircraft on the extended centre line of runway 23 and on the ILS localiser.

With the aircraft on a heading of 184°, the navigator received indications on his CDI that the aircraft was intercepting the 045° radial and he accordingly turned the aircraft. The turn, according to the agreed most probable flight path and simulator reconstruction of the flight path, coincided approximately with the 045° radial from the Matsapa VOR, and, because of the inherent errors in the VOR system, probably coincided with the indicated 045° radial from the Matsapa VOR.

After the navigator's comment: "VOR indicates that way!", there was no further response from the captain. The turn, although too early, was in fact onto the heading the captain was expecting for a straight in

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approach to runway 23, and this would explain his acceptance of it.

The indications are clear that the turn was made on a VOR signal. On the overwhelming probabilities no VOR facility other than that at Matsapa could have indicated the change of heading to 221° (the theory of a false beacon is disposed of in Appendix I to this Report). The only reasonable explanation for the turn is therefore that either the No 1 or the No 2 VOR had at that stage been selected to the Matsapa VOR frequency of 112,3 MHz, instead of the Maputo VOR frequency of 112,7 MHz.

How then could the Matsapa VOR frequency have been selected?

There are two possibilities. The first is that the Matsapa VOR frequency was selected on the No 1 VOR temporarily as a cross-check by the co-pilot, who later returned the VOR selector to the Maputo frequency. Laboratory tests of the equipment in the USSR determined that the No 2 VOR selector was on the Maputo VOR frequency at the time of impact, but No 1 navigation system selector was on the Maputo ILS and not on the VOR.

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The other possibility, which is now regarded as the more likely, is that during the descent the Maputo VOR was selected on the No 2 VOR receiver, i.e. on the frequency of 112,7 MHz. Whoever (the captain or the co-pilot) selected the frequency on the No 1 VOR receiver intended to select the Maputo frequency, but inadvertently selected the Matsapa frequency. Circumstances conducive to such an error were the poor design of the selectors, the absence of back lighting on the selector, the surprising closeness of the frequencies (which differed by only 0,4 MHz) and the resemblance between the figures '3' and '7' on the Soviet instrumentation (each has a horizontal bar at the top with a curved appendage descending from the right side). This could have occurred the more readily with a crew whose performance standards on this flight were far from diligent. In this regard, the flight deck design was such that it would have been extremely difficult for the navigator, seated behind the co-pilot, to see and check the frequencies selected on the VOR selectors, which were on the front panels. The navigator himself had no access to the selection of the frequencies. The prescribed procedures called for a spoken call-out check of the frequencies selected. The CVR, however, reveals a complete absence of any form of cross-checking of frequencies between crew members, and of

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any proper identification of navigational aid coding by the crew. This omission was contrary to the operating procedures prescribed in the Flight Manual, and was also an inexcusable departure from ordinary operating standards. In the catalogue of accidents and incidents ascribable to human factors in the cockpit, the selection of an incorrect frequency, even where the correct one has been regularly used previously, is not unknown. That indeed is why cross-checking and identification are required. It is also to be noted at this point that the correct course, i.e. 225°, was not set on the pilots' course selectors; although the navigator had set 225° on his OBS/CDI, this selection would not have influenced the operation of the authopilot had it been selected in the VOR mode.

Further on this aspect of the probabilities, the VOR was found selected to the No 1 VOR system, which was the normal method of operation. The navigator's OBS/CDI was thus coupled to the No 1 system. With the aircraft descending on a southerly heading, the navigator would have seen on his CDI the interception of the indicated 045° radial which he would have assumed was from the Maputo VOR. The distance from Maputo just before the commencement of the turn was given by the navigator as 100 km. This would have

suggested to him that he was to the left of track and was intercepting the radial further out than was expected. He then turned the aircraft manually through the Doppler/autopilot by means of the Doppler heading control, onto the heading of 221°. No attempt was made to place the autopilot in the VOR mode or to fly the aircraft on the intercepted radial.

It is quite likely that, when the captain perceived the turn towards the heading that he required for a straight in approach to runway 23, he then selected the ILS frequency that was found on the No 1 VOR receiver. In that process the VOR radial servo unit would automatically have been disengaged, and the last indicated radial would have been retained, as found by the USSR.

Although the ILS frequency was probably selected early in the turn, the captain did not attempt to use the ILS at that stage. There was still plenty of time, and the CVR indicates that he was pre-occupied with finding a pen and the distribution of beers and "cokes" before noticing that the ILS signal was not being received.

When the ILS frequency was selected on the No 1 VOR system, the navigator would have lost the VOR indica-

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tions on his CDI and would have had to select his RMI to the No 2 position to obtain radial information. Both RMI selectors were, however, found in the ADF position.

The evidence of the CVR indicates that in the final stages the crew were not following any VOR signal, even though at the distance of only 35 nm from Maputo, the Maputo VOR was most certainly being received. Confirmation of this is the fact, inter alia, that the 287,5° indicated radial was found in the No 2 VOR radial servo system; the crash site lies on the 284° radial from Maputo VOR. In the confusion on the flight deck the Maputo VOR was being ignored. The aircraft continued to fly under the influence of the Doppler/ autopilot system, with heading changes being made to compensate for the wind and not in an attempt to maintain any radial.

2.2 The Descent.

On receiving the top of descent call from the aircraft at 19.02, the AFIS controller responded by saying: "No reported traffic for a descent, report runway lights in sight or reaching 3 000 feet QNH 1 017". The QNH figure would have been the same in millibars or in hPa.

It would have been normal practice at this time for the AFIS controller to have advised the aircraft of the transition level when the altimeter setting should have been changed to the QNH of 1 017 from the standard setting of 1 013,2. The radio operator acknowledged the controller's response and the aircraft continued its descent.

During the descent the crew were subjected to a variety of distractions. The CVR shows that the co-pilot was listening on the HF radio to a Russian language radio broadcast of music and news (the news programme having commenced on the hour) right up to impact. The captain was engrossed in a discussion regarding previous flights when the fuel had been low, and regarding an allocation of beer and 'cokes' to the members of the crew.

At 19.09:12 the captain commented on the fuel low level warning light not illuminating during the descent. The inference from the conversation is that the pilot expected this light to illuminate earlier because of the nose-down attitude of the aircraft and the limited fuel state. During the descent the navigator regularly read out the approximate distance from Maputo in kilometres. It is almost certain that he took these readings from the

Doppler, which was in kilometres, and which, because of the distance gradation on the instrument face, could not be read with the same accuracy as the DME. At 19.19:32 the navigator gave the distance as 25 - 30 kilometres, and at 19.20:54 as 18 - 20 kilometres. The DME readings on the other hand would have been accurate. One of the DMEs was in any event in nautical miles.

At 19.12:51 the captain commented on the warning lights being illuminated on the VOR control panel, which was between the pilots' instrument panels (the centre panel). These lights should have indicated whether VOR or ILS signals were being received correctly, but there was some anomaly which had not been encountered before in the illumination of these lights. This was yet another distraction affecting the crew and drawing them away from the vital task of monitoring the flight path.

Until 19.17:21 the crew were unaware that anything was wrong. The captain suddenly cursed and said: "There's no Maputo" and "Electrical power is off chaps!". This appeared to be the first appreciation of an abnormal situation. The captain immediately but erroneously diagnosed the failure to be in the ground installations.

He failed to appreciate that the position of the aircraft was such that Maputo ILS signals could not be received.

Although ATC clearance had been given specifically to 3 000 feet and no lower unless the runway lights were in sight, and although neither the runway lights nor those of Maputo city were in sight, the descent was continued below 3 000 feet. The automatic pilot had been engaged in the yaw and roll modes for the entire descent with the aircraft attitude and rate of descent being controlled by the engines and the elevator trim.

This descent was in darkness, with no visual contact. The crew were aware that there was some cloud reported by Maputo airport at 1 800 feet and the captain elected to attempt to descend below the cloud in order to determine the aircraft's position. The captain actually observed that it was "cloudy, cloudy, cloudy". The aircraft flew into the ground at a rate of descent of some 500 feet per minute, with the crew totally ignoring the 32 second warning sounded by the GPWS alarm system.

It is evident that the crew were convinced that the aircraft was to the east of Maputo whereas the crash

site was some 35 nm west of the airport and at an elevation of 2 187 feet above mean sea level.

At 19.20:06 the radio operator requested permission to join runway 05 right-hand down-wind, which meant that he thought that the aircraft was over the sea. That was 1 minute 33 seconds before impact.

2.3 Ground Proximity Warning System.

At 19.21 the GPWS audio warning sounded and operated for 32 seconds terminating some 7 seconds before impact. The only response from the crew was the captain's ejaculation "Damn it" (in Russian) associated with a very slight nose-up pitch of the aircraft.

The TU 134A-3 Flight Manual contains the following information:

> "If the GPWS warning sounds with the aircraft in level or descending flight over hilly or mountainous terrain then the following actions are required by the crew:
>
> Pull the aircraft out to climb with a decisive moment of 1,25 - 1,7 acceleration and maintain the aeroplane in climb for 20 - 30 seconds with the engines operating at take-off power.

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WARNING: If the nature of the flown-over terrain is not known, the crew members shall proceed in accordance with the recommendations given for flight over hilly or mountainous terrain."

Compliance with these instructions, even seconds before impact, would have prevented the aircraft from flying into the ground. The whole situation could have been resolved if the aircraft had been climbed to a safe altitude (the minimum safe altitude for the Maputo area is 3 600 feet), and a rational assessment made of the navigational information available and displayed.

The evidence that the radio altimeter (an essential component in the GPWS) had been activated earlier in the flight is not supported by the DFDR. Be that as it may, the crew had no justification for assuming that the alarm was spurious, especially since they were uncertain of their position. The crew were no doubt under some degree of pressure because of the low fuel state and because of the belief, however unreasonable, that there had been an electrical power failure at Maputo. Little reflection was required to appreciate that the VHF radio at Maputo was working normally, and that in any event all airport navaid facilities are equipped with stand-by power in the form of automatic

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emergency generators. The crew, however, yielded to despair. The navigator said: "There's nowhere to go, no NDBs, nothing", and the captain added: "Neither NDB, nor ILS". The descent was continued into the ground.

2.4 Fuel.

When the aircraft left Lusaka the stated endurance was 5 flying hours. After a flight of 1 hour 15 minutes to Mbala, there remained 10 384 kg of fuel, giving a notional endurance of 3 hours 45 minutes for the next sector, which was Mbala to Maputo, with an estimated flight time of 2 hours 45 minutes. It is estimated that the landing weight at Mbala would have been slightly above the normal maximum landing weight of 43 000 kg. This should not have made much difference to the aircraft's performance. The omission to refuel at Mbala was unexplained.

Although no flight plan was filed the navigator's navigation log reflected that Beira was the alternate airport. In any event the normal alternate airport was Beira. The required fuel for diversion from Maputo to Beira, including reserves, was 4 730 kg. Both the calculated fuel remaining at Maputo and the evidence of the low fuel level warning indicator showed that only

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2 400 kg of fuel remained (2 679 kg on the USSR and Mozambique calculation) at the time of the accident. This was a shortfall of about 2 200 kg of fuel on the minimum diversion fuel necessary for this leg. The aircraft could not have reached Beira, a distance of 387 nm. Durban, 258 nm away, would have been a possibility. Even then the amount of fuel remaining would have been marginal. Hoedspruit, a SAAF base, would have been closer. It would have been available if an emergency had been declared.

2.5 Flight Deck Procedures.

The transcript of the cockpit voice recorder (CVR) was notable in that it featured not a single cockpit check-list item or navigational aid identification. Bearing in mind the large flight deck crew (by Western standards), the Board believes that it was essential that the crew members should have operated as a well integrated team. Demonstrably they did not.

The USSR Flight Manual for this type of aircraft, under the provisions of which C9-CAA was supposed to be operating, was quite specific in the allocation of duties to the various flight crew members, and also contained the normal detailed challenge and response check-lists which are a feature of airline operations worldwide.

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The failure by the crew to adhere to the specified procedures must reflect unfavourably on the ability of the captain to maintain an adequate standard of cockpit discipline. In turn, some of the responsibility for the poor crew performance must be borne by the operational control organisation at Maputo. The system of competency checks of crew performance was clearly inadequate.

2.6 Flight Deck Layout.

By accepted world standards the layout of the flight deck of C9-CAA was poor. In particular, the positioning of the VHF communications equipment, the VOR/ILS navigational receivers and the DME control heads was haphazard and not concentrated, as is conventional, in one location. The No 2 VHF and DME selectors in particular were awkwardly placed, outboard of the co-pilot's position. The VOR frequency selectors were lit by floodlights alone. This would have made it difficult to see the settings on the instruments from the navigator's seat. In addition, the VOR and DME frequency selectors had to be operated separately, instead of being paired, as is normal.

The selection of the ADF receivers was solely under the control of the navigator, who had the selectors

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positioned adjacent to his station. This made it all the more important that the pilots were informed of exactly what NDBs were displayed on their radio magnetic indicators (RMI). There is no record on the CVR of any such information having been passed to either pilot. This would have made the captain's task even more difficult in the final stage of the flight when he was in a confused state of mind.

2.7 Communications and ATC.

There is clear proof that the VHF system operated normally throughout and that communications were in no way impeded.

However, in the exchanges between the radio operator and the air traffic controller, there were certain departures from established RTF terminology and procedures which led to confusion. In particular, the radio operator and the controller were at cross purposes on the serviceability of the ILS and on the state of the runway lights.

At 19.18:46 the controller cleared the aircraft for an ILS approach to runway 23. At 19.18:59 the radio operator said: "Continue approach and ILS out of

service". It is not clear whether or not this was a question. The controller's response was: "Affirmative and ... cleared ... for visual approach runway 05". In his statement the controller said that he understood that the radio operator was referring to the airport ILS. However, the controller did not monitor the ILS, although he could readily have done so. The exchanges between the air traffic controller and the radio operator on the runway lights have been noted earlier in this Report (see 1.9).

2.8 Geographical Disorientation.

From the evidence of the CVR there is no doubt that the crew thought that they were over the sea to the east of Maputo or on the extended centre line of runway 23. All their attention, therefore, was directed to their right. Evidence from a witness in a light aircraft flying from Maputo to the west on a dark night, some time after the accident, was significant. He said that, from the air, there was a marked contrast between the lack of lights on the Mozambique side of the border with the RSA, and the relatively large number of lights in the RSA. There was a distinct illusion that the border was, in fact, a coast-line. This effect could well have been the reason for the

radio operator's acting on his own initiative in requesting "right-hand down-wind" for runway 05. On the other hand, the captain and the navigator were convinced that the aircraft was positioned correctly for a straight in approach to runway 23 at Maputo. In the final minutes of the flight the crew became completely disorientated and bewildered when the visual and instrument cues presented to them failed to match up to their expectations. This would have provided a major distraction which could have influenced their failure to respond to the GPWS warning and to climb to a safe altitude to assess the situation. Reference to the DMEs would by itself have shown immediately that the aircraft was some 35 nm (64,8 km) from Maputo and that the crew's idea of the aircraft's position was dangerously wrong.

2.9 Navigational Aids.

There was no evidence that, at the time of the accident, the radio navigational aids at Maputo were anything but serviceable and radiating normally, with the exception of the well-known lack of identification coding on the 'MA' non-directional beacon. The evidence of the crew of the Boeing 737 C9-BAA which was en route from Beira to Maputo at the time that

C9-CAA crashed was conclusive that the Maputo VOR was serviceable. The evidence of the navaids engineer on duty at Maputo was equally positive that the VOR functioned continuously at all relevant times.

The crew of C9-CAA were unable to identify their position by means of the ILS and two NDB signals from Maputo because of the distance from Maputo and the low altitude at which the aircraft was flying. It is significant that the No 2 DME was reading 35 nm at impact which compares closely with the distance of the crash site from Maputo.

2.10 Search and Rescue.

The Maputo controller alerted the operations room of the aircraft operator 6 minutes after the aircraft had crashed. The information available to the controller at Maputo indicated that the aircraft had been in the vicinity of the airfield when communications were lost. A primary search effort was, therefore, quite logically mounted in the first instance in the area adjacent to the airport. There was, however, an appreciable delay of some 3½ hours before a helicopter search could be organised at Maputo. In the event the search proved fruitless and the helicopters returned to base.

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In view of the remoteness of the accident site the first attendance of the South African Police at 23.40 was commendable, being only 40 minutes after the accident had been reported to them. The attendance of the Komatipoort district surgeon at 01.00 is also worthy of favourable comment. There was no evidence available that the delay in locating the crash site resulted in further fatal casualties. In fact, the survival of any of the occupants was purely fortuitous in view of the nature of the accident.

The delay of some 8 hours before the DETRESFA signal was transmitted did not materially affect the search and rescue operations as by the time the signal had been transmitted, the South African Air Force helicopter was already in attendance at the crash site.

2.11 Crew Disability.

The evidence of the post-mortem examinations of the crew and the CVR transcript indicate clearly that there was no crew disability up to the moment of impact. It is quite possible that members of the crew were tired, having had a long day. Although they enjoyed a seven hour rest period while the aircraft was on the ground at Mbala, the statement of the Flying Group Commander

at Maputo indicates that because the crew had had no rest facilities at Mbala they had stayed on board the aircraft. Rest under those conditions could have been of a poor quality, and could have led to fatigue.

2.12 Weather.

The weather report given to the crew of C9-CAA was quite suitable for either an ILS approach to runway 23 at Maputo, or for a visual circuit if the runway lights were visible. If the aircraft had flown the correct track then the 3 octas cloud reported at 1 800 feet would not have presented any problems to this experienced crew. The weather at Maputo, therefore, is not considered to have been a factor in this accident.

2.13 Adequacy of Professional Standards.

Mention has already been made of various aspects of crew performance which indicate casualness and a certain lack of flight deck discipline. To summarise these deficiencies the Board refers to the following items:

2.13.1 No flight plan was filed or given over the air.

2.13.2 In the information transmitted to Maputo AFIS, the

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number of persons on board was wrongly given as 48, and the endurance of the aircraft was wrongly calculated as being 4 hours instead of 3 hours 45 minutes.

2.13.3 The fuel on board on the last flight was some 2 000 kgs short of what was required for Beira, the alternate airport, other than for a timeous en route diversion. That was in the teeth of the relevant regulations. The inability to reach Beira could well have had a decisive effect on the captain's decision to continue the descent despite his belief that there was an electrical blackout at Maputo.

2.13.4 Members of the crew acted in important respects without reference to the captain. For example, the navigator fed the 37° turn into the automatic pilot, and the radio operator acted on his own initiative in asking the controller for a right-hand turn down-wind.

2.13.5 There were no cross-checks by the crew of navigational aid identification or of frequency selections.

2.13.6 The CVR transcript reveals the complete absence of the standard system of checks by the challenge and response method.

2.13.7 The selections on the radio altimeter remained at 0, and were not changed to minimum descent altitude.

2.13.8 The 2 VOR course selectors remained set at 164°M, which, according to the navigator's log, had been the course for the leg from Lusaka to the FIR boundary.

2.13.9 Although assigned to FL 370 at one stage of the flight, the aircraft, according to the DFDR, remained substantially below that FL.

2.13.10 On the probabilities, the Matsapa VOR frequency was selected, either inadvertently (which now seems more likely) or as a cross-check by the co-pilot, with his attention distracted by listening to the HF broadcast programme, and without appreciating that it was his selection of the Matsapa VOR frequency at that time that had misled the navigator into initiating the 37° turn to starboard.

2.13.11 The captain neglected to monitor the flight, and in particular to check the correctness of the change of heading.

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2.13.12 The captain, the co-pilot and the navigator failed to adjust their respective altimeters to the QNH given by the controller (1 017 millibars or its equivalent in hPa or mmHg). The crew reported at a flight altitude of 3 000 feet although the sub-scale settings on their respective altimeters were still on the standard of 1 013,2. The difference of 4 millibars (or hPa) represented approximately 120 feet.

2.13.13 The captain, the co-pilot and the radio operator failed to determine positively that the airport facilities were in fact in proper working order. The erroneous assumptions to the contrary were not justified. In particular the assumption of an electrical blackout at Maputo was made without regard to the VHF transmissions (indicating electrical power in operation) or to the fact that stand-by generators are standard equipment for essential airport navaids.

2.13.14 The captain allowed the descent to continue below 3 000 ft without having the runway lights in sight, and although the aircraft was flying in darkness and in some cloud.

2.13.15 The captain ignored the GPWS alarm and, although he could still have saved the situation by following the procedures prescribed, he failed to do so.

2.13.16 Although no ground references were visible, and although it was believed that all Maputo navaids were out of action, the captain continued to descend and failed to climb at least to the MSA (3 600 ft on the Jeppesen plate of Maputo airport) and then check his position by reference to the other aids at his disposal, such as the Maputo broadcast station, and his radar, which would have shown up the particularly characteristic coast-line and the city.

3. CONCLUSIONS

(a) Findings:

(i) The operating crew were qualified and properly licensed to operate the Tupolev TU-134A-3 aircraft, and had had experience of operating into Maputo at night.

(ii) The aircraft had been properly maintained and its documentation was in order. It was airworthy, and properly loaded, and there

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was no technical failure or malfunction in flight prior to impact.

(iii) The status of the radio navigational aids on the ground and in the aircraft was adequate for let down and ILS approach.

(iv) The weather at the destination airport was not a factor.

(v) The runway lights were operating normally.

(vi) The DFDR operated properly and provided essential data to assist in the investigation.

(vii) The CVR operated properly and provided essential information to assist in the investigation.

(viii) There was no evidence of crew disability prior to impact.

(ix) The crew did not file a flight plan as required by Mozambique Regulations.

(x) The crew was unaware of the correct number of passengers on board.

(xi) The crew miscalculated the endurance of the aircraft in the initial communication with Maputo AFIS.

(xii) The aircraft did not have sufficient fuel on board to proceed to the selected alternate airport.

(xiii) The cockpit layout and crew positioning prevented the navigator from visually checking the VOR frequency selection and prevented the pilots from visually checking the ADF frequency selection on the Doppler control panel. This made cross-checking by the challenge and answer system essential, but no such checking took place.

(xiv) The aircraft was prematurely (by about 8 min) turned 37° to starboard during descent. This turn was initiated by the navigator via the Doppler system and the automatic pilot.

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(xv) The aircraft would have intercepted the radial 045 for runway 23 of the Maputo VOR if the aforementioned turn had been made at the proper time.

(xvi) The navigator introduced the turn because the VOR indicated it.

(xvii) The only VOR signal that could have indicated this was that of Matsapa. The probabilities are, first (and this seems the more likely), that the Matsapa VOR frequency was selected inadvertently on the No 1 VOR selector, the navigator's OBS/CDI being coupled to the No 1 VOR receiver, and that the No 1 VOR selector was later turned to the Maputo ILS frequency; or secondly, that the Matsapa VOR frequency had been selected temporarily by the co-pilot as a cross-check, without informing the rest of the crew, and that the VOR selection had then been returned to Maputo, and that it was during that time that the navigator followed the Matsapa beacon.

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(xviii) The required procedures and callouts during the final let-down and approach were not followed. There was a breakdown in crew discipline and co-ordination.

(xix) The co-pilot was listening to music and a news broadcast on the HF radio during the critical stage of the descent.

(xx) The crew did not use the secondary navigational aids available (i.e., the broadcast station at Maputo and the on-board radar).

(xxi) The crew encountered cloudy conditions during the descent.

(xxii) The captain continued to let down below the prescribed altitude of 3 000 ft without the runway lights being in sight and without any other visual reference to the ground.

(xxiii) The crew ignored the alarm warning of the ground proximity warning system (GPWS).

(xxiv) Communications with the Maputo tower were at times ambiguous and misunderstood by both parties.

(xxv) There is no substance in the theory that the aircraft was lured off course by means of a false VOR beacon or any other device.

(xxvi) After discovery of the crash, medical and rescue assistance was provided in a timely manner considering the remoteness of the site.

(b) Cause:

The cause of the accident was that the flight crew failed to follow procedural requirements for an instrument let-down approach, but continued to descend under visual flight rules in darkness and some cloud, i.e. without having visual contact with the ground, below minimum safe altitude and minimum assigned altitude, and in addition ignored the GPWS alarm.

(c) In terms of the provisions of section 12(1) of the Aviation Act, No. 74 of 1962, as amended, the Board is also required to determine responsibility for the accident. The Board's findings on this

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aspect are adequately indicated in the Analysis and Conclusions (supra).

4.0 RECOMMENDATIONS

4.1 Aviation Authorities should draw the attention of operating crews and air traffic control personnel to the need for compliance with and the correct use of the RTF terminology interpretation, as provided in Annex 10, Chapter 5.

4.2 Attention should further be given to recurrent training in the use of correct air traffic control terminology, particularly in cases where a language foreign to that of the flight personnel or air traffic controller is used.

4.3 The monitoring of crew compliance with prescribed operating procedures should be reviewed.

4.4 The period over which CVR installations should keep a running record should be increased from 30 minutes to at least 1 hour.

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4.5 Attention is drawn to the importance of maintaining navigational aids in accordance with the standards of integrity laid down by ICAO.

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APPENDIX I

THE RUMOUR OF A FALSE BEACON

Although no charges of foul play were laid before the Board, it became aware of various rumours, some of which found expression in newspaper reports, to the effect that the RSA had deliberately caused the destruction of President Machel's aircraft. For example, in one such report it was alleged that the surviving member of the flight crew had stated that the aircraft had been shot down. In fact, the official statement taken from this person, which statement was before the Board, is devoid of any such suggestion. Moreover, as appears from the joint factual report of the accident agreed by the teams of the RSA, the USSR and Mozambique, and also from the other evidence of the integrity and normal functioning of the aircraft immediately before the impact, the rumour that it was shot down has no basis in fact.

Save as stated below, the Board deems it unnecessary to deal in the Report with the other rumours of wilful interference. The agreed factual report and the other evidence refutes them all. However, one of these rumours merits particular mention, and it is examined in this Appendix. It is the rumour that the aircraft was lured to its destruction by a false beacon.

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No direct allegation of a false beacon was put before the Board by the accredited representatives of the USSR or Mozambique, either in the agreed factual report or otherwise. However, the agreed factual report refers to a camp-site "150 m south-east of the place where the aircraft initially contacted the ground", upon which members of the S A Defence Force had frequently camped; and in photographs and witnesses' statements helpfully submitted to the Board by the representatives of Mozambique, the camp-site is described and it is suggested that a large tent was there the day before the accident and was removed immediately after it. By implication this evidence is related to the rumour that a false beacon was erected.

The existence of a false beacon would not have been directly related to the cause of the accident (see the Analysis in Section 2 of the Report and the Conclusions in Section 3 thereof). Nevertheless, for obvious reasons, the Board has thoroughly investigated and considered the possibility of such a beacon.

The Board is completely satisfied that there was no false beacon as alleged or at all. The principal reasons for this finding are as follows:

1. We are here concerned with the possibility of a VOR beacon - more accurately a VOR transmitter, for, in explaining to the captain the 37° turn to starboard, the

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navigator said "VOR indicates that way". The sole function of a VOR beacon is to indicate azimuth, i.e. direction in the horizontal plane. It is not a guide to descent and it would not cause an aircraft to descend. Only an ILS could offer such guidance, but there is not the slightest suggestion of a false ILS, and besides, on technical grounds any such suggestion would be untenable in the circumstances of this case. In any event, as clearly indicated in the CVR transcript, no ILS signal was being received. That was because the aircraft was out of range of the Maputo ILS.

2. An erroneous VOR signal would inevitably be shown up in the standard system of cross-checking by reference to the other navigational aids on board.

3. Consequently, as confirmed by the unanimous opinion of the expert witnesses, reinforced by that of those members of the Board who have expertise in this field, the deployment of a false VOR beacon would be futile as a device to lead an aircraft to destruction as alleged in this case.

4. It is clear that the Maputo VOR was serviceable and operating on 1986-10-19, for the captured radial in the No 2 VOR system of C9-CAA indicates that. In

addition other aircraft were receiving the signal. One landed at Maputo at 16.00 having captured the DME and VOR at 200 nm. In particular, C9-BAA received the signal during its flight, at a distance of some 180 nm and from a time shortly after C9-CAA had crashed. If there were a false VOR beacon in operation on the same frequency at the relevant time, the path of the aircraft would have been curvilinear, as explained by the independent and highly qualified British expert, Mr Young. However, the reconstruction in Moscow of the flight path of C9-CAA shows that it was straight, and this is confirmed by the plot compiled by Mr Caiger, the expert assisting the Mozambican team. This plot of the flight path of C9-BAA shows that it was also straight.

There was some suggestion by the pilot of C9-BAA that on his outbound-leg, he thought that he was to the west of the standard track. This he ascribed to "... the circumstances. The reduction of the speed, and because we were more worried with communications than with the navigation". However, conclusive proof that C9-BAA was in fact on the standard track, and not to the west thereof, is provided by Mr Caiger's evidence and plot of the aircraft's actual flight path. The only

inference is that C9-BAA was at no time influenced by any VOR signal other than that of Maputo.

5. None of these other aircraft was affected by any strange VOR signal, which, to have influenced C9-CAA to make the very substantial turn of 37°, would have had to be much stronger than the Maputo VOR. Yet C9-BAA, which was in flight at the same time, received only the Maputo VOR and its flight path accorded entirely with it. C9-BAA came within range of the Maputo VOR a few minutes after C9-CAA had crashed.

6. The expert views, to which Mozambique has referred in its comments on the draft Report, are, inter alia, that, for a decoy VOR beacon "to produce undisturbed radials of a desired value would require a positive dominance of power output which would be most easily guaranteed by switching off the Maputo DVOR". The Maputo VOR was not switched off. The navaids engineer who was on duty throughout the relevant period stated that it functioned normally all the time. Moreover, the other aircraft using the Maputo VOR experienced no interference. That makes it highly probable that C9-CAA's 37° turn to the right occurred because of the selection of the Matsapa VOR beacon (see the Analysis in Section 2 of this Report).

7. It is a clear inference from the CVR transcript that the aircraft was not following any VOR signal at all for several minutes while it continued its descent into the ground, and this despite the fact that at that time the VOR selector was on the Maputo frequency and the signal must have been received.

8. On the evidence the S A Air Force had no prior knowledge of the flight to Maputo, or of the time thereof, or of the identity of the aircraft when it appeared on the radar screen, or of President Machel's presence on board. No flight plan had been filed. That evidence is not consistent with the deployment of another VOR signal in respect of the President's aircraft (incidentally, without interfering with other aircraft), which would have required the bringing in of the necessary equipment and setting it up on the camp-site during Saturday 1986-10-18 and/or the following day.

9. None of the witnesses who refer to a tent or tents on the camp-site makes any mention of the presence of the 15 ft high antenna or the other essential equipment related to the setting up of a VOR beacon on that site, which would have been necessary according to the evidence of Mr Young. The evidence and the inspec-

tions showed that the camp-site was visible from the Mozambique side and that it would have been difficult to place a VOR beacon there without being detected.

10. It is not in dispute that members of the S A Defence Force camped on the camp-site from time to time and that the men erected small bivouac tents. The site was used as an observation post. The evidence of the witnesses does not establish the presence on 1986-10-19, or at any other time, of a big tent of about 11 m x 5 m in size. The S A Defence Force platoon commander in charge of the area from September to November 1986 was emphatic in his evidence that no S A Defence Force personnel were at the site from 17.00 on Sunday 1986-10-19 until the next day, when he and his men were summoned to assist at the scene of the crash. Inferential evidence of the presence of a large tent was based on an inspection of the camp-site some time after the accident and the discovery there of a large flattened area and also of a large amount of empty military ration tins, beer cans and the like. However, this evidence is inconclusive, even if one overlooks the fact that there were numerous S A Defence Force personnel on the site after the crash. Even if the fullest weight be given to the evidence of the Mozambican witnesses on the camp-site

activities, it still does not establish that a false beacon was erected there. Indeed, in all the circumstances, it does not even generate a suspicion of such a beacon.

11. To judge from the Soviet delegation's remarks on the draft Report, it would position the alleged decoy beacon in Mozambique, perhaps as far as 7 kms from the RSA border. This proposition generates further improbabilities, which are irreconcilable with the evidence on the CVR.

12. The experts who testified before the Board rejected the possibility of a false beacon. Aside from conjecture and speculation in Mozambique's comments and the Soviet delegation's remarks on the draft Report, there is not a shred of acceptable expert evidence to the contrary.

Accordingly, the Board's conclusion is that the rumour of a false beacon is without substance.

APPENDIX II

APPENDIX : CVR AND ATC TRANSCRIPT

Explanation of Terms :

CAPT	: Pilot C9-CAA
NAV	: Navigator C9-CAA
COPILOT	: Co-pilot C9-CAA
R/OP	: Radio Operator C9-CAA
ENG	: Flight Engineer C9-CAA
AFIS	: Aerodrome Flight Information Service
MOC 103	: Mocambique TM103, the Boeing 737 from Beira to Maputo.
COMMENT	: Explanation by team to explain terminology or situation to the reader.
INTERJECTION	: Where a member of the aircrew speaks at the same time as somebody else, this is indicated as an interjection.
----	: Where only the carrier wave is received it is indicated by a series of dots or dashes.
STRONG EXPRESSION	: The use of foul language is indicated by the term "strong expression".
VOVA, VOLODYA	: First names of the flight engineer.
TOLIK	: First name of the radio operator.
ATC	: Maputo ATC tapes.
CVR	: Cockpit voice recorder.
?	: Question mark inserted where identity of person or word spoken is uncertain.

NOTE: The original of this transcript has been signed and each page thereof has been initialled on behalf of the RSA and by the accredited representatives of the USSR and Mozambique.

TIME	SOURCE : CVR	TRANSCRIPTION	TIME	SOURCE : ATC TAPES	TRANSCRIPTION
			1846:19	R/OP	GOOD EVENING MAPUTO, CHARLIE NINE ALFA ALFA
				AFIS	-----
			1847:55	R/OP	MAPUTO CHARLIE NINE CHARLIE ALFA ALFA, GOOD AFTERNOON.
			1848:03	AFIS	CHARLIE NINE CHARLIE ALFA ALFA, GOOD EVENING, GO AHEAD.
			1848:06	R/OP	CHARLIE NINE CHARLIE ALFA ALFA, JUST PASSED POINT KURLA LEVEL THREE FIVE ZERO ESTIMATED ABEAM LIMPOPO AT ZERO FIVE NEXT HOUR, ECHO TANGO ALFA MAPUTO ONE NINE TWO FIVE, TOTAL ON BOARD FOUR EIGHT, ENDURANCE AT DEPARTURE ZERO FOUR ZERO ZERO.
			1848:33	AFIS	ROGER IN CHARLIE NINE CHARLIE ALFA ALFA CONFIRM POSITION LIMPOPO AT ONE NINE, ONE NINE ZERO FIVE.
			1848:41	R/OP	LIMPOPO AT ONE NINE ZERO FIVE.
			1848:46	AFIS	CHARLIE NINE CHARLIE ALFA ALFA NO REPORTED TRAFFIC FLIGHT LEVEL THREE FIVE ZERO, NO DELAY EXPECTED FOR ILS APPROACH RUNWAY TWO THREE.
			1848:58	R/OP	ROGER IN CHARLIE ALFA ALFA MAINTAINING THREE FIVE ZERO TO VICTOR MIKE ALFA, NO DELAY EXPECTED RUNWAY ILS CORRECTION RUNWAY TWO THREE.
			1849:08	AFIS	AFFIRMATIVE AND COPY THE WEATHER, MAPUTO METEO REPORT ONE EIGHT ZERO ZERO, SURFACE WIND ZERO NINE ZERO, ONE ZERO KNOTS, VISIBILITY MORE THAN TEN KILOMETERS, THREE OCTAS AT ONE, ... ONE EIGHT ZERO ZERO FEET, FOUR OCTAS NOT DETERMINATED HEIGHT, TEMPERATURE TWO THREE, DEW POINT TWO ZERO, QNH ONE ZERO ONE SIX.
			1849:42	R/OP	THAT COPIED OK CHARLIE ALFA ALFA QNH ONE ZERO ONE SIX, THANK YOU.
			1849:47	AFIS	AFFIRMATIVE AND REPORT POSITION LIMPOPO OR LEAVING FLIGHT LEVEL THREE FIVE ZERO.
			1849:53	R/OP	YES CHARLIE ALFA ALFA, NEXT REPORT LEAVING THREE FIVE ZERO, PLEASE RELAY, NUMBER ONE ON BOARD.
			1849:59	AFIS	ROGER.
1849:40		.....			
1849:55		.....			
1850:00	R/OP	BEIRA INFORMATION CONTINUE WITH MAPUTO.			

	R/OP	BEIRA C9-CAA AFFIRMATIVE.
1850:20		ASK OLEG
1851:12		.....
		.....
		YES
1851:32	NAV	758.5, 759, 1016, +23, 90° 5-10 KNOTS.
	CAPT	AH?
	NAV	10 KNOTS, LANDING RWY 23. IN 10 MINUTES, 758,5 LANDING AT 20 MINUTES? AT 20 MINUTES? THAT'LL BE OK?
1856:25	ENG	CHECK TIME.....
		HERE YOU ARE ....?
1856:37		IT WILL BE SUITABLE?
1858:02		(REMARK ABOUT AIRHOSTESS)
1859:32	NAV	((DME) IT WILL NOT BE THERE)
	CAPT	WHY?
	NAV	ITS STILL EARLY, ITS STILL 8 MORE MINUTES.
	NAV	121 (7?)
		WHAT'S THIS
1900:39		AH?
1900:51	CAPT	RECENTLY I SPOKE TO THE "ANGOLIANS" (COMMENT: SOVIET CREW WORKING IN ANGOLA), ON THE 12TH OUR PEOPLE FLEW TO LENINGRAD AND THEN, HE SAYS, TO MINSK. I SAY "45 DAYS?" "NO", HE SAYS "TWO MONTHS", THAT IS CORRECT - TWO MONTHS.

1852:42	AFIS	CHARLIE NINER CHARLIE ALFA ALFA, MAPUTO INFORMATION.
1852:46	R/OP	GO.
	AFIS	------
1852:51	R/OP	GO AHEAD MAPUTO.
1852:53	AFIS	AH CONFIRM YOUR POINT OF DEPARTURE IS LUSAKA.
1852:57	R/OP	NEGATIVE. POINT OF DEPARTURE IS MBALA. MIKE BRAVO ALFA LIMA ALFA.
1853:11	AFIS	------

	CAPT	ON THE 12TH.
1901:07	AFIS	CHARLIE NINE CHARLIE ALFA ALFA, MAPUTO.
1901:09	R/OP	GO AHEAD
1901:12	AFIS	------
1901:15	R/OP	GO AHEAD MAPUTO.
1901:17	AFIS	AH CONFIRM AH CAN YOU SPELL THIS NAME OF AH AIRPORT OF DEPARTURE MBALA AND ICAO INDICATOR.
1901:29	R/OP	POINT OF DEPARTURE MBALA. DEPARTURE IS ONE SIX THREE SEVEN.
1901:38	AFIS	AFFIRMATIVE AND AH YOUR ICAO INDICATOR, ICAO INDICATOR IS FOXTROT LIMA SOMETHING.
1901:49	CAPT?	GO ON.
1901:50	R/OP	FOXTROT LIMA BRAVO ALFA
1901:54	AFIS	ROGER THANK YOU.
1901:58	R/OP	CHARLIE NINE CHARLIE ALFA ALFA, NOW TOP OF DESCENT.
1902:02	AFIS	CHARLIE NINE CHARLIE ALFA ALFA NO REPORTED TRAFFIC FOR DESCENT, REPORT RUNWAY LIGHTS IN SIGHT OR .... OR REACHING THREE THOUSAND FEET QNH ONE ZERO ONE SEVEN.
1902:16	R/OP	ROGER CHARLIE NINE CHARLIE ALFA ALFA NOW LEAVING THREE FIVE ZERO FOR THREE THOUSAND FEET, NEXT REPORT RUNWAY LIGHTS IN SIGHT. LEAVING THREE FIVE ZERO NOW.
1902:28	AFIS	ROGER
1903:12	NAV	FLIGHT LEVEL ONE HUNDRED.
1903:17		YES
1903:32	COPILOT	CUT HERE THE BANDAGE.
1905:02	ENG	NO. NO. ILL NOT FORGET. ILL PUT ... AND TAKE STRAIGHT AGAIN.
1905:26	CAPT	YOU UNDERSTAND, AND COULD FLY, BUT IT WOULD BE MUCH COMPLAINING DURING THE FLIGHT, EXACTLY (STRONG EXPRESSION) AND THERE WOULD BE COMPLAINING AFTERWARDS AND HE WOULD REPORT TO (STRONG EXPRESSION), TO MODESTOV (STRONG EXPRESSION), THEN YOU REMEMBER WHEN WE FLEW TO

		LUSAKA FOR THE FIRST TIME, WE DID NOT REFUEL AND HE .....
1905:27	COPILOT	AND NOW SIGN IT PLEASE. ITS NOT YOURS?
1906:08	CAPT	BUT THAT SALNIKOV OF OURS WAS SO THAT IT WAS DIFFICULT (STRONG EXPRESSION) TO FLY ABROAD WITH HIM, WE FLY FROM MILAN WITH NOCKOLAI EFIMOVICH, DETACHMENT COMMANDER, 76 PASSENGERS 11 FUEL, "WHAT ARE YOU DOING?!!!!" NICKOLAI EFIMOVICH KEEPS QUIET (STRONG EXPRESSION). ON THE FOLLOWING DAY NICKOLAI EFIMOVICH COMES UP TO ME IN ADP (COMMENT: AERODROME DISPATCH POINT), I WENT THERE FOR THE DEPARTURE, KAZBEK REFUSED TO SIGN OUR DOCUMENTS, "I", SAYS HE, "AM NOT A CRIMINAL", "I", SAYS HE, "WILL NOT GO TO PRISON BECAUSE OF YOU", WE ARRIVED WITH THE REMAINING SOME 2700, 2600. HE SAYS, "HE IS NOW IN THE FLIGHT PLANNING ROOM, GO THERE, ONLY", SAYS HE "DON'T SHOUT AT HIM". I'M COMING AND I SAY : "KAZBEK! WHAT IS THE MATTER.... WHAT IS THE MATTER !!" HE BEGINS, BUT CALMLY, HE KNOWS THAT I (STRONG EXPRESSION) IF HE GOES FOR ME I WOULD ALSO STRAIGHT AWAY, HE IS CALM AND I SAY "KAZBEK! STOP TALKING RUBBISH, HE IS A DETACHMENT COMMANDER, ISN'T HE, AREN'T YOU ASHAMED?" "NO, NO, NO, NO, NO! AND LET ORESNIYI SIGN IT FOR YOU". I SAY "OK! NO PROBLEM". I AM COMING TO SERGEEVICH AND SAY: "WHAT! (STRONG EXPRESSION)! A FOOL!" (STRONG EXPRESSION)! I HAD TO TAKE THE FLIGHT FOLDER MYSELF IN THE FLIGHT PLANNING ROOM AND SIGN IT AT ZNA (COMMENT: DEPUTY CHIEF OF THE DEPARTMENT).
1907:28	CAPT	HE THINKS THAT IT IS NOT ENOUGH?
1907:36	CAPT	AND HE SAT ALL THE TIME WORRYING "AND SO .... WE SHALL SEE OVER WARSAW! IF THE REMAINING IS LESS THAN SEVEN! IT WILL BE NECESSARY TO LAND IN WARSAW". WE ARE APPROACHING WARSAW! SOME 6400, INDEED IT IS NECESSARY TO LAND. HE IS WORRYING AGAIN. I SAY: "SO KAZBEK! CALM DOWN, STOP IT, STILL ONE HOUR TWENTY OF FLYING, AND HERE WE HAVE NOW MORE, ONE HOUR FORTY FIVE EVEN". BUT THAT MODESTOV ALSO (STRONG EXPRESSION), WHEN, DO YOU REMBER, WHEN IN PEMBA, (STRONG EXPRESSION), IN THAT (STRONG EXPRESSION), AND THE SITUATION IS SO.... YOU FLY FOR SURE, (STRONG EXPRESSION), WEATHER, YOU KNOW, IS BECOMING, (STRONG EXPRESSION) HERE, OR WE CRIMINALS OR WHAT? OR ARE WE WHISKEY (STRONG EXPRESSION) BOOSERS?!
1909:12	CAPT	LOOK! IT DOES NOT LIGHT UP FOR THE DESCENT (COMMENT: REFERENCE TO LOW FUEL WARNING LIGHT BEING INACCURATE DURING THE DESCENT) (STRONG EXPRESSION), WHAT?
1909:16	NAV	DISTANCE 120.

1909:38		THIS (?) CAN BE SOLD, TRANSMITTED TOO, (STRONG EXPRESSION).
1910:48	NAV	100KM.
	ENG	... (EXCLAMATION)
1911:03	CAPT	I WILL REDUCE THE RIGHT ONE (REFERENCE TO THE RIGHT ENGINE).
1911:28	CAPT	(STRONG EXPRESSION)(STRONG EXPRESSION) MAKING SOME TURNS (COMMENT: REFERENCE TO THE AIRCRAFT TURNING) COULDN'T IT BE STRAIGHT?
1911:32	NAV	....VOR INDICATES THAT WAY.
1911:48	CAPT	HAVE YOU TAKEN AWAY THE PEN, TOLIK?
	R/OP	HAVE YOU TAKEN AWAY?
1912:08	CAPT	VOVA, HAVE YOU GOT A PEN HANDY? I HAVE TAKEN AWAY EVERYTHING.
1912:23	CAPT	THANK YOU (IN PORTUGUESE)
1912:25	ENG	OK

NOTE: A SENTENCE WAS PROBABLY LOST HERE DURING REWINDING OF THE TAPE.

	NAV	UP TO THE APPROACH THEY SHOULD BE WORKING
		THE PERSON ON THE RIGHT IS DRIVING.
1912:48	ENG	THREE BEERS AND ONE COKE, HERE
	CAPT	THREE BEER YES, VOVA?
	ENG	YES AND ONE COKE EACH
	CAPT	ALL RIGHT
1912:51	COPILOT	AND WHY THOSE TWO ARE LIT AND THESE TWO ARE NOT (COMMENT: REFERENCE TO THE VOR LIGHTS ON CENTRE PANEL).
1912:58	NAV	DISTANCE IS 80.
	COPILOT	THEY SHOULD BE LIT, IS THAT NOT SO?
1913:05	CAPT	DO WE ALWAYS HAVE IT LIKE THAT?
		.... THE REASON .... (?)
1914:08	CAPT	WILL YOU TAKE IT OR NOT?
1914:16		BASICALLY ON THE FEET.
1914:57	NAV	60 KM

1915:01	CAPT	WHAT? WON'T WE LAND AT 20?
		MAYBE (?)
1915:05	CAPT	Y-E-E-S!!
1915:10	ENG	EARLIER WE WERE SORT OF ONE MINUTE AHEAD(?)
1915:12	CAPT	YES, NOW IS 1443.
1915:21	NAV	MINE IS 14 NOW .... (?)
1915:24	CAPT	1445, WELL, 15 MINUTES, LET IT BE ... (?)
	CAPT	HOW MANY IS IT LEFT?
1915:30	NAV	60 KM
	CAPT	5 MINUTES
	CAPT	WILL YOU TAKE IT, NO VOVA, LATER?
	ENG	TWO FOR EACH, OR WHAT?
	CAPT	NO, THREE BEERS AND ONE COKE EACH, THEY BROUGHT EQUALLY FOR EACH (?)
1916:37	ENG	THREE BEERS AND ONE COKE EACH.
1916:43	CAPT	WELL
1916:58	CAPT	VOLODYA, IT IS NECESSARY TO TELL THEM ABOUT RV (COMMENT: REFERENCE TO RADIO ALTIMETER UNSERVICEABILITY)
1917:02	R/OP	SAY IT, SAY, IT IS NOT FOR THE FIRST TIME
	CAPT	BECAUSE THEY WRITE, (STRONG EXPRESSION), ANY (STRONG EXPRESSION), (STRONG EXPRESSION).
1917:21	CAPT	(STRONG EXPRESSION), THERE IS NO MAPUTO?
	COPILOT	WHAT?
1917:27	CAPT	THERE IS NO MAPUTO
1917:31	CAPT	ELECTRICAL POWER IS OFF, CHAPS!
1917:36	COPILOT	THERE TO THE RIGHT, IT IS LIT (?)
1917:42	NAV	THERE IS SOMETHING I DON'T UNDERSTAND AHH ...
1917:45	CAPT	NO THERE IS SOMETHING .... (?)
1917:49	NAV	ILS SWITCHED OFF AND DME!
1917:51	CAPT	EVERYTHING SWITCHED OFF, LOOK, CHAPS!
1917:57	NAV	AND NDBs DO NOT WORK!

	CAPT	CHAPS!
1918:04	NAV	YES, YES, EVERYTHING SWITCHED OFF - ILS, DME
1918:09	COPILOT	AND THEY DO NOT HAVE ELECTRICAL POWER
	NAV	NDBs?
	COPILOT	AND THERE TO THE LEFT .... WHAT KIND OF LIGHT IS THERE.
	CAPT	THIS IS CORRECT .... SOMETHING STRANGE?
	CAPT	WELL, MAKE CONTACT.
1918:11	COPILOT	3000 FEET.
	CAPT	TOLYA, 3000 FEET!
	R/OP	WHAT?
	CAPT	3000 FEET
	CAPT	(STRONG EXPRESSION)
	CAPT	...(INTERJECTION BY CAPTAIN) (STRONG EXPRESSION), KEEP QUIET, CHAPS.
1918:36	CAPT	NO!
1918:44	CAPT	(INTERJECTS) NEGATIVE!
1918:46	CAPT	(INTERJECTS) ILS NEGATIVE!
1918:54	CAPT	(INTERJECTS) NOT WORKING.

1918:24	R/OP	MAPUTO CHARLIE NINE CHARLIE ALFA ALFA
	R/OP	...MAINTAINING THREE THOUSAND FEET
1918:31	AFIS	CHARLIE NINER CHARLIE ALFA ALFA ROGER AND CONFIRM YOU HAVE AH FIELD IN SIGHT?
1918:37	R/OP	NOT YET
1918:39	AFIS	AND.... RUNWAY LIGHTS NEGATIVE YET?
1918:43	R/OP	NOT, NEGATIVE.
1918:46	AFIS	ROGER... CHARLIE NINE CHARLIE ALFA ALFA CLEARED ILS APROACH RUNWAY TWO THREE....
	AFIS	.....TRANSITION LEVEL IS FOUR ZERO, QNH ONE ZERO ONE SEVEN, REPORT ESTABLISHED ON RADIAL ZERO FOUR FIVE.
1918:59	R/OP	ROGER CHARLIE NINE ALFA ALFA CONTINUE APPROACH AND ILS OUT OF SERVICE?

1919:06	CAPT	AND NDB			
			1919:07	AFIS	AFFIRMATIVE AND AH CLEARED AH ... ... FOR VISUAL APPROACH RUNWAY ZERO FIVE, SURFACE WIND ZERO NINE ZERO, ONE ZERO KNOTS, QNH ONE ZERO ONE SEVEN.
			1919:22	R/OP	ROGER CHARLIE NINE CHARLIE ALFA ALFA CONTINUE APPROACH.
			1919:26	AFIS	-----
1919:30	COPILOT	AND HOW MANY APPROXIMATELY?			
1919:32	NAV	25-30 KM			
	COPILOT	25-30?			
	CAPT	YES			
	CAPT	SOMETHING IS WRONG, CHAPS			
	R/OP	HERE THEY GAVE CLOUD BASE 1800 FEET, AND SO TAKE IT INTO CONSIDERATION			
	CAPT	IS THIS ALTITUDE, ISN'T IT?			
	NAV	EIGHT OCTAS? (10/10)			
1919:38	R/OP	NO, TWO OCTAS (3/10)			
	NAV	AND SO THIS IS ...			
	CAPT	IT SHOULD BE LIT...			
1919:40	CAPT	THERE TO THE RIGHT LIGHTS ARE SEEN			
	COPILOT	RWY IS NOT LIT ... (?)			
	CAPT	RWY IS NOT LIT?			
	CAPT	.... THERE'S A PROBLEM.... (?)			
			1919:50	R/OP	MAPUTO CHARLIE NINE CHARLIE ALFA ALFA, CHECK YOUR RUNWAY LIGHTS.
			1919:56	AFIS	CHARLIE NINE CHARLIE ALFA ALFA ROGER, CLEARED VISUAL APPROACH RUNWAY ZERO FIVE, JOIN POSITION LEFT DOWN WIND, SURFACE WIND ZERO NINE ZERO, ONE ZERO KNOTS.
1920:01	CAPT	I CAN SEE! (INTERJECTION)			
			1920:06	R/OP	ROGER CHARLIE NINE CHARLIE ALFA ALFA, AND WE REQUEST TO JOIN RIGHT DOWN WIND.
			1920:13	AFIS	CHARLIE NINE CHARLIE ALFA ALFA ROGER, RIGHT DOWN WIND IS APPROVED AND REPORT POSITION RIGHT BASE FOR RUNWAY ZERO FIVE.

1920:[illegible]	CAPT	WHAT RIGHT?, WAIT, HEADING... 24
1920:22	R/OP	ROGER. CHARLIE ALFA ALFA.
1920:22	CAPT	I UNDERSTOOD NOTHING
	R/OP	DON'T YOU SEE THE RWY YET?
1920:28	CAPT	..AND WHAT RWY, WHAT ARE YOU TALKING ABOUT?
1920:32	NAV	WE ARE GOING TO DO STRAIGHT-IN APPROACH?
1920:35	CAPT	WE ARE DOING STRAIGHT-IN APPROACH
1920:38	R/OP	NO, WELL, CAN YOU SEE THE RWY?
	COPILOT	NO, THERE'S NOTHING, THERE'S NEITHER CITY NOR RWY
	R/OP	AND SO HE SAYS THAT ...
	CAPT	.... HE SAYS ....
	COPILOT	WHAT DOES HE SAY?
	R/OP	I ASKED TO CHECK THE RWY
	CAPT	I DON'T UNDERSTAND WHAT HE'S SAYING...?
	CAPT	NOTHING CAN BE SEEN, CHAPS...
	COPILOT	TELL HIM ONCE MORE TO CHECK THE LIGHTS.
	CAPT	SO NO, SURELY IT IS INDEED CLOUDY TO DESCEND.
1920:54	NAV	SOME 18-20 KILOMETERS LEFT
1920:57	R/OP	MAPUTO CHARLIE NINE CHARLIE ALFA ALFA, CHECK AGAIN RUNWAY LIGHTS
1921:02		(COMMENT: DURING THE TRANSMITION OF THE RADIO OPERATOR'S INFORMATION AN ALARM SYSTEM SOUNDED:NAMELY THE SSOS - TERRAIN PROXIMITY WARNING SYSTEM)
1921:05	AFIS	ROGER, YOU ARE CLEARED TO VISUAL APPROACH RUNWAY ZERO FIVE JOIN RIGHT DOWN WIND AND REPORT POSITION RIGHT BASE.
1921:12	CAPT	DAMN IT!
1921:17	R/OP	CHARLIE NINE CHARLIE ALFA ALFA RUNWAY LIGHTS OUT OF SERVICE?
1921:17	CAPT	NO, IT'S CLOUDY, CLOUDY, CLOUDY
1921:18	AFIS	...FIRM, RUNWAY LIGHT OUT OF SERVICE?
1921:22	R/OP	AFFIRMATIVE, LIGHTS NOT IN SIGHT.
1921:27	AFIS	AFFIRMATIVE AND JOIN RIGHT DOWN WIND RUNWAY ZERO FIVE, SURFACE WIND ZERO NINE ZERO, ONE ZERO KNOTS.

	CAPT	(INTERJECTION) NO! NORMAL!
1921:32		ALARM STOPS
1921:34	R/OP	ROGER ROGER
1921:36	NAV	NO, NO, THERE'S NOWHERE TO GO, NO NDBs, THERE'S NOTHING
	CAPT	NEITHER NDBs NOR ILS
1921:39		IMPACT IS REGISTERED BY ONE HALF SECOND OF SILENCE.
1924:10	AFIS	CHARLIE NINE CHARLIE ALPHA ALPHA REQUEST YOUR POSITION

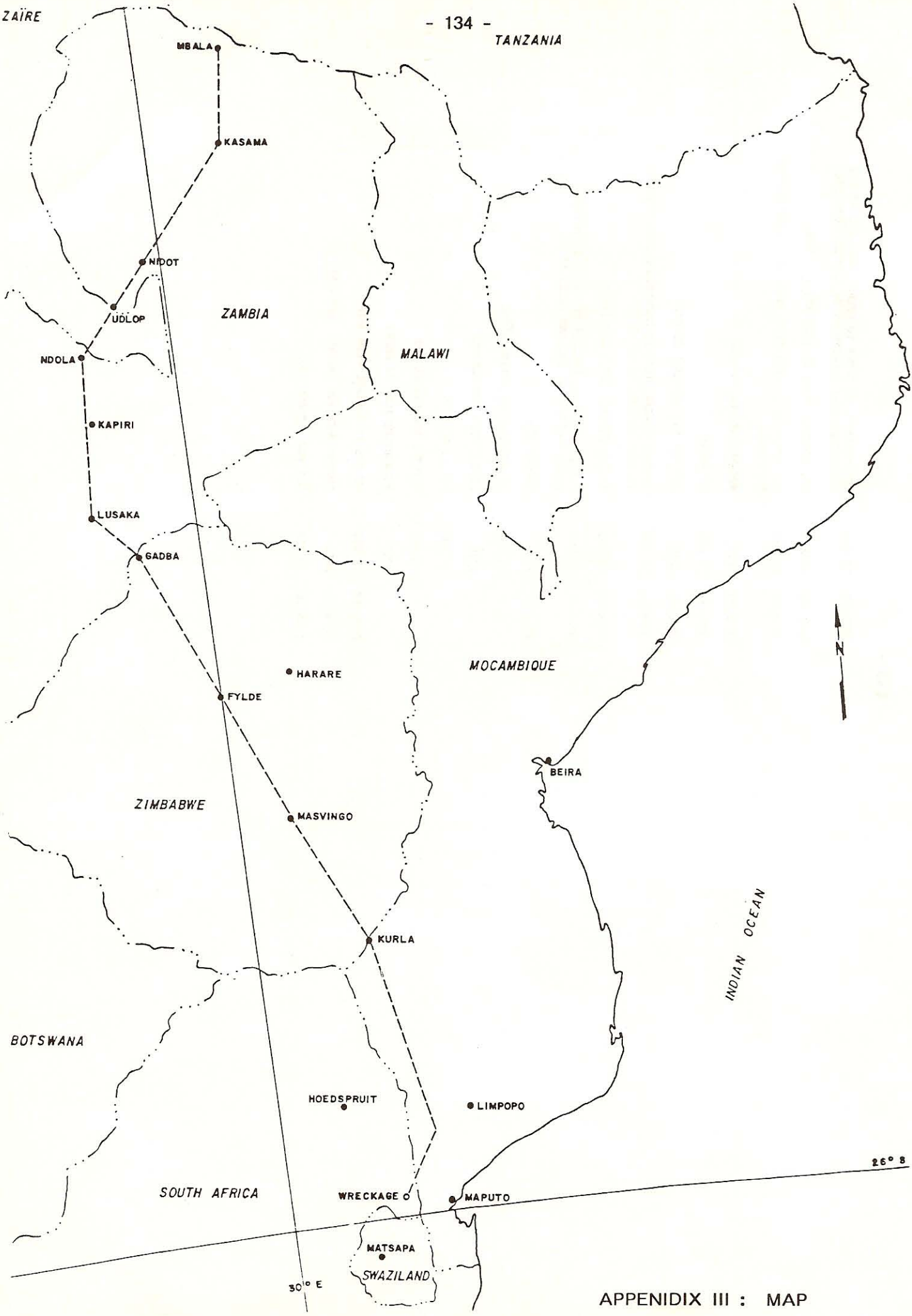
NOTE: TRANSMISSIONS BY AFIS CONTINUE PERIODICALLY UNTIL MOCAMBIQUE FLIGHT TM103, A BOEING 737 FROM BEIRA, MAKES CONTACT.

1937:17	TM103	MAPUTO APPROACH MOCAMBIQUE 103 127,3
1937:20	AFIS	103 MAPUTO, GO AHEAD
1937:37	AFIS	MOCAMBIQUE 103, GO AHEAD
1937:49	AFIS	MOCAMBIQUE 103, MAPUTO APPROACH, GO AHEAD
1938:02	AFIS	MOCAMBIQUE 103, MAPUTO APPROACH, GO AHEAD
1938:07	TM 103	.... FINE MOCAMBIQUE 103 AAH MAINTAINING FL310 ESTIMATING LIMPOPO POINT 54 ARRIVAL SHOULD BE AT 2010 WE AH PLEASE REQUEST YOUR LAST WEATHER BREAK AAH WILL YOU PLEASE CONFIRM IF THE AIRPORT IS ABOUT TO CLOSE OR ARE YOU OPEN?
1938:38	AFIS	MOCAMBIQUE 103 AAH THE FIRST THING YOU ARE GOING TO DO IS TO CONTACT C9-CAA, I LOST CONTACT WITH HIM
1938:49	TM 103	ROGER. WE ARE ABOUT AH ARRIVAL C9-CAA WILL BE ABOUT 1925 ... CONFIRM YOU ARE NOT YET CONTACTED?
1939:03	AFIS	AFFIRMATIVE. I HAD CONTACT WITH HIM AND I LOST AH WHEN AH ... WHEN I CLEARED HIM TO .. TO VISUAL APPROACH RIGHT DOWNWIND AND I LOST CONTACT WITH HIM.
1939:18	TM 103	AH ROGER. STANDBY ONE PLEASE.
1939:37	TM 103	AH ROGER WE HAVE COPIED THE WEATHER AH. WE ... FLIGHT LEVEL AND SO ON.
1939:45	AFIS	AFFIRMATIVE AND CONTACT ... AH YOU MUST FIRST CALL C9-CAA, C9-CAA. IF YOU HAVE CONTACT WITH HIM
1939:55	TM 103	BREAK C9-BAA FROM MOC 103 ON 127.3

1940:05	AFIS	NEGATIVE! NEGATIVE! IT IS C9-CAA. C9-CAA
1940:12	TM 103	AH ROGER. BREAK C9-A
40:22	TM 103	C9-CAA FROM MOCAMBIQUE 103, 127.3
1940:32	TM 103	C9-CAA THIS IS MOCAMBIQUE 103 DO YOU READ ME? (ON SECOND FREQUENCY)
1940:46	TM 103	APPROACH 103 WE CALLED THAT AIRCRAFT TWICE WITHOUT REPLY
1940:54	AFIS	ROGER
1940:58	TM 103	C9-CAA THIS IS MOCAMBIQUE 103 ON 118 DECIMAL 1.
1941:22	AFIS	C9-CAA MAPUTO DO YOU READ?
1945:05	TM 103	MAPUTO, 103
1945:11	AFIS	SOMEBODY SAY AGAIN YOUR CALLSIGN
1945:14	TM 103	MOCAMBIQUE 103, DO YOU HAVE CONTACT WITH CAA?
1945:18	AFIS	NEGATIVE AH UNTIL ... AT THIS MOMENT NEGATIVE SIR, I DONT KNOW AH WHAT'S WRONG WITH HIM
1945:25	TM 103	ROGER
1945:44	AFIS	MOCAMBIQUE 103, AIRCRAFT WAS A TUPOLEV 34, WAS DESCENDING 3000 FEET AND EH I LOST CONTACT ...WHAT'S YOUR APPROACH? REPORT POSITION LIMPOPO.
1946:03	TM 103	ROGER WE'RE AT FL310 AT THIS MOMENT 1949 FOR LIMPOPO
1946:11	AFIS	ROGER REPORT FOR DESCENT
1946:13	TM 103	ROGER
1946:18	AFIS	C9-CAA MAPUTO
1946:56	TM 103	MAPUTO APPROACH MOCAMBIQUE 103
1947:00	AFIS	MOCAMBIQUE 103 GO AHEAD
1947:04	TM 103	A - THIS HERE OO
1947:11	AFIS	MOCAMBIQUE 103 AH AIRCRAFT IS A TUPOLEV I DONT KNOW ... YOU MAKE VISUAL CONTACT AND REPORT THAT VISUAL ... STANDBY ONE (VOICES IN BACKGROUND GIVING INSTRUCTIONS)
1947:29	TM 103	AH STANDBY ONE COPIED OUT

1947:42	AFIS	MOCAMBIQUE 103, MAINTAIN FLIGHT LEVEL ... DESCEND FL40 OVERHEAD VMA
1947:53	TM 103	ROGER DESCEND FL40 OVER VMA, 103
1952:41	TM 103	MAPUTO APPROACH MOCAMBIQUE 103
1952:44	AFIS	MOCAMBIQUE 103, GO AHEAD
1952:48	TM 103	WE ARE 1005 FROM MAPUTO WE ARE MAINTAINING 310 FROM ABOUT THE 4 O'CLOCK POSITION AND EH YOUR FURTHER INFORMATION ABOUT THE AIRCRAFT
1953:02	AFIS	MOCAMBIQUE 103 UNTIL NOW I HAVE NO FURTHER NEWS ABOUT THE AIRCRAFT. I AM NOT SURE WHAT COULD HAVE HAPPENED. I LOST CONTACT WITH HIM WHEN HE WAS DOING AN APPROACH TO RUNWAY 05, FROM THE RIGHT HAND SIDE
1953:20	TM 103	YOU HAD CONTACT WITH HIM UNTIL 3000 FEET?
1953:25	AFIS	AFFIRMATIVE
1953:29	TM 103	OK UUH. MAINTAINING 310 WE ARE REDUCING SPEED NOW, WE ARE (95) MILES FROM MAPUTO. STANDING BY FOR FURTHER INSTRUCTIONS OR DIRECTIVES, MAINTAINING THIS FREQUENCY
1953:49	AFIS	OK OK
1956:52	TM 103	MAPUTO APPROACH
1957:49	TM 103	MAPUTO APPROACH, MOCAMBIQUE 103
1957:54	AFIS	MOCAMBIQUE 103, GO AHEAD
1957:57	TM 103	AH ... WE HAVE RECEIVED INFORMATION FROM OUR OPERATIONS, AND WE ARE IN CONTACT WITH YOUR DIRECTOR, TO RETURN BEIRA AIRPORT. WE ARE FLIGHT LEVEL 310, REQUEST 330, AND STAND BY FOR THE ESTIMATES.
1958:23	AFIS	.....
1959:..	AFIS	MOCAMBIQUE 103
2000:34	AFIS	MOCAMBIQUE 103
2020:42	AFIS	MOMCAMBIQUE 103, MAPUTO CALLING
2020:54	TM 103	GO AHEAD MAPUTO
20:01:13	AFIS	WHAT IS YOUR POSITION NOW?
2001:16	TM 103	80 MILES FROM MAPUTO, PRACTICALLY OVERHEAD LIMPOPO, REQUEST 330, WE ARE 310.
2001:23	AFIS	CONFIRM YOU CONTACTED OPERATIONS?

2001:27	TM 103	AFFIRMATIVE, WE SPOKE TO OPERATIONS, AND IT WAS OPERATIONS THAT ORDERED US TO PROCEED TO BEIRA.
2001:42	AFIS	OK, COPIED. WHAT IS YOUR ETA TO BEIRA?
2001:49	TM 103	OK, STAND BY.....ETA BEIRA 040, AND STAND BY FOR FURTHER...
2002:29	AFIS	MOCAMBIQUE 103, MAPUTO
2002:32	TM 103	GO AHEAD
2002:38	AFIS	CAN YOU TRY AND CALL C9-CAA?
2004:15	TM 103	C9-CAA, C9-CAA, THIS IS MOCAMBIQUE 103, MAPUTO IS CALLING YOU, DO YOU READ?
2004:20	TM 103	IF YOU CONTACT 127.3 AND 118.1
2004:41	TM 103	MAPUTO APPROACH, MOCAMBIQUE 103, ESTIMATING DAVOR POSITION AT 24, AND BEIRA AT 49.
2004:43	AFIS	REPORT 330
	TM 103	WE ARE NOW 330, MAINTAINING
	AFIS	REPORT WHEN YOU CONTACT
	TM 103	AH ... WILL DO
	TM 103	MAPUTO, MOCAMBIQUE 103
	AFIS	MOCAMBIQUE 103, GO AHEAD
2009:12	TM 103	WE ARE IN CONTACT WITH BEIRA
2009:15	AFIS	INFORM WHEN YOU ARRIVE. SEE YOU
2009:18	TM 103	SEE YOU. THANK YOU.



APPENIDIX III : MAP

LIST OF ABBREVIATIONS

ADF	AUTOMATIC DIRECTION FINDER
ADI	ATTITUDE DIRECTOR INDICATOR
AFIS	ADVISORY FLIGHT INFORMATION SERVICE
ATC	AIR TRAFFIC CONTROL
ATPL	AIRLINE TRANSPORT PILOT'S LICENCE
CDI	COURSE DIRECTION INDICATOR
ch	CHANNEL
CVR	COCKPIT VOICE RECORDER
DETRESFA	DISTRESS PHASE
DFDR	DIGITAL FLIGHT DATA RECORDER
DME	DISTANCE MEASURING EQUIPMENT
ETA	ESTIMATED TIME OF ARRIVAL
FAJS	JAN SMUTS AIRPORT JOHANNESBURG
FIC	FLIGHT INFORMATION CENTRE
FIR	FLIGHT INFORMATION REGION
FL	FLIGHT LEVEL
ft	FEET
GPWS	GROUND PROXIMITY WARNING SYSTEM
hPa	HECTOPASCALS
HSI	HORIZONTAL SITUATION INDICATOR
ICAO	INTERNATIONAL CIVIL AVIATION ORGANISATION
IFR	INSTRUMENT FLIGHT RULES
ILS	INSTRUMENT LANDING SYSTEM
IMC	INSTRUMENT METEOROLOGICAL CONDITIONS
kg	KILOGRAM
KHz	KILOHERTZ
km	KILOMETRE
km/h	KILOMETRES PER HOUR
M	MAGNETIC
m	METRE
MAC	MEAN AERODYNAMIC CHORD
min	MINUTES
MHz	MEGAHERTZ
mℓ	MILLILITRE
mm Hg	MILLIMETRES OF MERCURY

MSA	MINIMUM SECTOR ALTITUDE
NDB	NON DIRECTIONAL BEACON
nm	NAUTICAL MILES
OBS	OMNI BEARING SELECTOR
PAPI	PRECISION APPROACH PATH INDICATOR
QAR	QUICK ACCESS DFDR
QFE	PART OF THE Q CODE, AND MEANING THE SETTING TO BE MADE ON THE ALTIMETER SUB-SCALE (USUALLY IN MILLIBARS OR hPa, BUT IN SOME COUNTRIES IN INCHES OR mm Hg) WHICH WILL CAUSE THE ALTIMETER INDICATOR TO SHOW 0 WHEN THE AIRCRAFT IS ON THE GROUND AT THE AERODROME IN RESPECT OF WHICH THE QFE IS GIVEN.
QNH	THE SETTING TO BE MADE ON THE ALTIMETER SUB-SCALE (USUALLY IN MILLIBARS OR hPa, BUT IN SOME COUNTRIES IN INCHES OR mm Hg) WHICH WILL CAUSE THE ALTIMETER INDICATOR TO SHOW THE HEIGHT OF THE AIRCRAFT ABOVE SEA LEVEL WHEN THE AIRCRAFT IS ON THE GROUND AT THE AERODROME IN RESPECT OF WHICH THE QNH IS GIVEN.
RMI	RADIO MAGNETIC INDICATOR
R O	RADIO OPERATOR
RT (or RTF)	RADIO TELEPHONY
RV	THE RUSSIAN ABBREVIATION FOR RADIO ALTIMETER
s	SECOND
SAAF	SOUTH AFRICAN AIR FORCE
SABS	SOUTH AFRICAN BUREAU OF STANDARDS
UTC	UNIVERSAL CO-ORDINATED TIME
VASI	VISUAL APPROACH SLOPE INDICATOR
VFR	VISUAL FLIGHT RULES
VMC	VISUAL METEOROLOGICAL CONDITIONS
VOR	VERY HIGH FREQUENCY OMNI DIRECTIONAL RANGE

PART II

COMMENTS BY THE MOZAMBIQUE AND SOVIET DELEGATIONS ON THE DRAFT FINAL REPORT AND THE BOARD'S REPLY THERETO

REPÚBLICA POPULAR DE MOÇAMBIQUE

SECRETARIA DE ESTADO DA AERONÁUTICA CIVIL

À

REPRESENTAÇÃO COMERCIAL DA

REPÚBLICA DA ÁFRICA DO SUL

MAPUTO

Maputo, 9.5.1987

Assunto : **Comentários da R.P.M. e U.R.S.S. ao "Draft Final Report" do "Inquiry Board"**

Ao abrigo do disposto no Anexo 13 à Convenção de Chicago sobre a Organização da Aviação Civil Internacional, junto remeto os comentários à proposta de relatório do "Board of Inquiry" da República Popular de Moçambique, bem como da União das Repúblicas Socialistas Soviéticas.

Com as melhores saudações,

Paulo Muxanga

Director Nacional de Aviação Civil e

Representante Acreditado da República Popular de Moçambique

Mod. AC 0008 — 5/84 — 605 - Tip. «Notícias»

BOARD OF INQUIRY

Maputo, 05 May 1987

REPUBLIC OF SOUTH AFRICA

We appreciate the opportunity to review the draft report of the Board of Inquiry assembled by the Government of the Republic of South Africa to investigate the aircraft accident involving TU-134A-3 aircraft at Mbuzini on 19 October, 1986 in which the then President of People's Republic of Mozambique and 33 other persons tragically lost their lives.

A detailed study of the draft of the Board's final report has revealed, to our concern, a proportion of inexactitudes and factual errors which was unexpected. These have been detailed in the Attachments to this letter.

Of greater concern, however, is the lack of depth of the investigation into the possibility of the existence of a decoy VOR transmitter as a significant causal factor in this accident. As you will appreciate, once the numerous false premises are pruned from the Board's main report and its Annex 1, the possibility of a decoy VOR transmitter tends towards a probability.

It is also of concern to Mozambique that no flight test was carried out to replicate the flight path of the TU-134A-3 when it is claimed the crew may have tuned in to the Matsapa VOR. The exercise flown in the B.737 simulator cannot be an adequate substitute as the simulator has no authentic means of reproducing the terrain and other local effects which can cause errors in the pattern of radials emitted from a transmitter of a VOR such as Matsapa when they are interpreted by an aircraft receiver at the particular altitudes flown by C9-CAA.

For these reasons you are earnestly requested not to consider the Board's investigation complete at this stage, but to continue the investigation in depth on the matters raised, and in co-operation with the Accredited Representatives of the State of Registry and the State of Manufacture.

Paulo Muxanga
Accredited Representative
People's Republic of Mozambique

Attachment A

COMMENTS ON THE DRAFT REPORT OF THE RSA INTO THE ACCIDENT TO C9-CAA

Page 1, covering Letter to the Minister of Transport

The draft text suggests that the provisions of the RSA Aviation Act and those of Annex 13 are in conformity about the necessity to establish "the cause" and "responsibility for the accident".

As regards "the cause", Annex 13 deals with cause(s) basically in plural, reflecting the current thinking that there is seldom (or never) a single cause to an accident.

It is recognized that the Board, in accordance with the RSA Aviation Act, is required to establish "responsibility for the accident". However, this activity is to a degree contrary to the objective and spirit of Annex 13.

Paragraph 3.1 of Annex 13 reads :

> "Objective of the investigation
>
> 3.1 The fundamental objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability."

Although in common language useage "to establish responsibility for" is not identical to "apportion blame or liability", it is no doubt an activity in this direction, which should not be part of an accident investigation conducted in accordance with ICAO Standards and Recommended Practices.

The Board's comments on the USSR Delegation's statement, pages 5 to 12

The right of the State of Occurrence to determine the extent of the participation by Accredited Representatives and their advisers is correctly stated as in Annex 13. However, the following points are made in relation to the RSA draft.

Page 6, paragraph 2

Annex 13 does not prescribe that the analysis and conclusions of an accident report must be developed only by the person(s) who carried out the investigation. However, it does not preclude other persons, such as the Accredited Representatives from being involved in that development. Therefore the Board could, if it saw fit, have invited the USSR and RPM representatives to participate in this phase of the investigation.

It is acknowledged that the Accredited Representatives were invited to participate in the public hearing phase. However, the invitation did not extend to participation in the development of the analysis and conclusions of the report.

As mentioned on page 4 of the Board's draft report the field investigation was carried out by the accident investigation unit of the RSA Civil Aviation Authority in close co-operation with the Accredited Representatives and their advisers with recorded agreement on various arrangements including the development of the factual information part of the final report. The co-operation went well beyond those minimum entitlements listed in Annex 13, a practice which is customary in most international investigations.

When the Board assumed responsibility for the latter part of the investigation and at the same time denied the Accredited Representatives and their advisers participation in the development of the analysis and conclusions parts of the report, it could not expect such action to be sympathetically received. This denial clearly failed to recognize the indispensible nature of the unique first hand information available from the Accredited Representatives in this multinational accident.

Page 8, lines 4 and 5 from the bottom of the page
The elements of the inquiry at which appointed observers may be present are not limited to any particular stages of the inquiry. Recommendation 5.26 lists certain entitlements of participants, but these entitlements need not be limited to those listed. In any event, entitlement (f) allows submissions in respect of various elements of the investigation and the development of the analysis and conclusions is a very important "element" of such an investigation. Informed submissions on this aspect could be much more readily composed by persons who were present during the development of the analysis and conclusions than by others who perforce have to base their arguments solely on the results of this phase.

Page 12 last paragraph
It is agreed that there is no right for Accredited Representatives to participate to any greater degree than indicated in the Convention and Annex 13 However, the State of Occurrence is not required to limit the participation of other States to the minimum entitlements listed. Indeed, more effective discussion and investigation would be likely to follow, if the extent of participation envisaged by the USSR were permitted. The number of questionable conclusions reached in the draft report indicates that considerable unproductive effort was expended by the Board in retracing the steps of the original investigating teams without the facility of immediate reference to the specialists available in those teams. If participation in the formulation of the analysis and conclusions was not considered appropriate by the Board, then an observer status for the teams would have gone someway toward balancing the submissions made on the draft report now before us.

In summary, the continuity of the investigation envisaged by the USSR proposal could only have enhanced the work of the Board and the potential for a competent and fully informed investigation into the circumstances of the accident.

Page 13 Synopsis, line 2
It does not follow that flight in darkness is "IMC" even if there is no visual contact. In this case, the CVR record contains a reference to some lights on the ground The flight was IFR, but the evidence does not confirm that it was IMC.

Page 15, lines 5 to 8
It is agreed that "... three advisers were made available to the State of Registry" is stated correctly. However, it is questionable whether the three advisers obtained by RSA can be qualified as "independent".

Page 15, third paragraph, lines 4 to 6
It seems as if the accident investigation unit of the CAA of RSA carried out the functions of Investigator-in-Charge in terms of Annex 13 during the field investigation and the Board assumed the responsibility only for the latter part of the investigation.

Page 15, third paragraph, line 8
It is not understood to whom the expression "all other interested parties" refers. A more specific reference may be appropriate, e.g. is this a reference to the three other States which suffered fatalities to its citizens.

Page 17, last paragraph, line 1
The CVR record contains reference to some lights on the ground. Deletion of the word "complete" would be preferred.

Page 17, last paragraph, line 2
The use of the unit feet/minute tends to be more descriptive, 480 ft/min in this case.

Page 17, last paragraph, line 4
The general statement " .. it was then out of range of most of the Maputo navigation aids" is misleading. It would be preferable to state the aids which were available within range.

Page 18, fourth paragraph, last line
It would be preferable to delete " ... or outside interference" as such a possibility has not been exhaustively investigated or shown to be beyond reasonable doubt.

Page 18, last line
"... under instrument meteorological conditions (IMC)" is not substantiated. As stated above the flight was IFR but not necessarily IMC.

Air Traffic Services at Maputo
The Board having acknowledged that one controller was operating both the AFIS and Aerodrome Control, has not taken sufficient care to ensure that the correct nomenclature is used when referring to the controller's function in relation to the aircraft's stage of flight. While it was subsequently established that the aircraft was beyond the responsibility of Aerodrome Control at most times, it can only be correct to allocate the role of the controller to the stage of flight at which the crew reported their aircraft.
Therefore, on page 24, second paragraph, lines 2 and 3 "AFIS acknowledged and re-cleared the aircraft ..." is not correct. As an "Information Service" cannot issue clearances and the controller was at that time acting as Aerodrome Control and quite entitled to issue a clearance, "AFIS" should be replaced by "Aerodrome Control".

Page 25, line 8
For the rate of descent a "hard conversion" to 480 ft/min would be preferred. On the other hand, throughout the report altitudes up to 20 000 feet are given with an accuracy of one foot and the elevation of the accident site to the centimetre. In these cases, a "soft conversion" would be preferable.

Page 25, lines 17 and 18
The Aerodrome Controller did not "request the aircraft to confirm that the runway lights were out of service" as stated. What happened was that he asked the radio operator to confirm that he had said that the runway lights were out of service.

Page 28, paragraph 1.5.1
Information was provided to the State of Occurrence by the Accredited Representatives or as authorized through their advisers. Reference to individuals such as "the Flying Group Commander" is inappropriate and should be deleted. Hence, it should read "The information supplied by the USSR was as follows ..".

Page 30, last paragraph, line 4
The statement that the duty time started at 03 42 hours based on the actual take-off time minus 1 hour 30 minutes is suspect. The planned time of departure and actual time of the arrival of the crew at the airport should be determined to establish the commencement of duty time.

Page 31 second paragraph, lines 4 and 5
The reference to a lack of documentary proof is inappropriate. The Accredited Representative of Mozambique confirmed in writing that the crew licences were validated by the Mozambique CAA. This statement was sent to the RSA investigators together with the post mortem reports on the passengers.

Page 32, lines 4 and 6
To say that the Air Traffic Controller was second to last in his class is misleading. In this case, he was twelfth out of 13 and this would be a more informative way of stating his position in the class.

Page 32, line 12
AFIS and Aerodrome Control was permissible as a dual function because it was so authorized by the Civil Aviation Authority. A NOTAM issued on 9 August 1985 refers.

Page 32, last 2 lines
The airframe log book contained the appropriate maintenance release for the Check D carried out in the USSR in August 1984. It also contained the appropriate entries for all later inspections All of the airframe and engine log books were made available to the RSA investigators in December 1986 in Maputo together with access to photocopying facilities.

In the Factual Report by the three investigation teams it is stated "A Check D or major inspection was carried out in the USSR in August 1984" with a reference (H6) which should have been available to the Board. The agreed Factual Report further states "Service records revealed that the aircraft was properly maintained prior to the last flight". The statement by the Board that "Documentary evidence of this and later inspections was not seen by the Board" implies, incorrectly, that the documentation may not have existed or was not made available.

Page 35, second paragraph
The justification for stating that an alternate aerodrome was needed and specified, should be stated. The only evidence that an alternate was selected by the crew was an entry in the navigator's log As such it could have been noted in case an enroute diversion was required or merely for his personal information in case the pilot asked for an alternate to be specified when planning for the flight. The Board does not detail how it arrived at the figure of 4730 kg of fuel required for a diversion to Beira. In this context, paragraph 4.3.4.1, page 20 of Annex 6, Part I is relevant. It appears that an alternate aerodrome was not required.

Page 37, second paragraph
The agreed joint Factual Report is referred to. However, the first point "-automatic piloting along the required heading" has been omitted, while the next four points have been copied.

Page 40, line 11
The landing time of the HS-125 was 16.30 hours UTC, not 18.30.

Page 40, line 16
The statement by the pilot on the CVR record "cloudy, cloudy, cloudy" is insufficient basis for the Board to state that "the aircraft entered cloudy conditions" bearing in mind that the CVR also contains reference to lights visible on the ground and that the weather information indicated that such cloud would be scattered.

Page 40, last line
"The pilot of flight TM 103 ..." would be preferable to " The pilot of Tango Mike 103 ...".

Page 41, paragraph 1.8, lines 13 and 14
Some pilots may use the Maputo broadcasting station to listen to music but it is not commonly used for navigation and is not authorized as an aeronautical navigation aid.

Page 41, last line
"Matsapa itself..." should perhaps read "Matsapa in Swaziland..." In any event, a more detailed description of the status, location and range of the Matsapa VOR/DME would be appropriate considering the importance given to this aid later in the Board's report.

Page 43, paragraph 2, lines 5 and 6
The point was not that the controller had already instructed the aircraft to report at 3000 feet when he advised it of the transition level. There is nothing remarkable in such a situation. What was worthy of comment was that the transition level was not given to the crew until after they had reported at 3000 feet.

Flight Recorders. Page 49 paragraph 1.11.4.3
The DFDR cannot be described as perfectly serviceable when one parameter was unserviceable as stated in the same sentence.

Page 52, paragraph 1.11.4.4
The RSA was invited to take the quick access DFDR to the USSR for decoding, but would not agree to taking both DFDRs. As the radio transmission keying parameter did not register on the record of the protected DFDR, the decoding of the quick access DFDR may have assisted in synchronising the DFDR data with the CVR record.

Page 54, line 5
It would be preferable to delete " ... due to high impact forces" as this was a survivable accident, thus indicating that average or below average G values were sustained.

Wreckage and impact information, pages 57 to 62, inclusive
After the Board emphasized that its role was to conduct the investigation and complete the final report, it is strange that the final report should include three alternative tables from which the reader is left to select his own choice of panel indications. It is considered that it is encumbent on the Board as the investigating authority to determine the most accurate of the observed readings and publish only those in the final report.

Search and rescue, pages 66 to 68, paragraph 1.15.2
According to the survivors' statements the RSA Police, upon arrival at the accident site, engaged in an extensive search of the aircraft for documents with little or no care for the injured passengers. This fact should not be overlooked in a balanced report.

Page 74, paragraph 1.6.4, line 1
As the advisers assisting USSR and RSA are not mentioned by name, please delete " Mr. B Caiger ..." . On line 6, please also delete " ... was compiled in Montreal and ...", because the report was not compiled in Montreal. Consequently, on page 75, second paragraph, line 8 and third paragraph, line 1, please delete "... Caiger ...".

Page 75
The last sentence in the second paragraph deals with the statement of the pilot of the Boeing 737 C9-BAA, who said that he was using the usual Maputo navaids The FDR report (figure 2) shows that the B737 proceeded, after take-off from Beira, on a magnetic heading of 213° ± 1° for 45 minutes until it commenced a left turn to fly back to Beira. This strongly indicates that the flight was conducted with the autopilot in the heading select mode, since the magnetic variation changes from 10.2°W at Beira to 16.2°W at Maputo. If a VOR radial had been followed a gradual change of magnetic heading through 5-6° would have occurred due to the magnetic variation in the steady wind conditions which prevailed This indicated that the pilot's recall that he had used the normal Maputo navaids was incorrect and he later agreed that he had not used the VOR on the inbound leg.

After the turn C9 BAA flew towards Beira, the first 26 minutes on an outbound radial from Maputo VOR and the plot of this return flight (figure 2) shows a gradual change in the aircraft's magnetic heading due to the magnetic variation.
It follows that the VOR apparently worked normally from 19.54 hours on, but its serviceability state between the landing time of the HS-125 at 16.30 and 19.54 hours has not been established.

Page 75, third paragraph
This paragraph is not correct in two respects. First, as C9 BAA proceeded on a constant magnetic heading through a 5-6° magnetic variation, the ground track is curvilinear. Secondly, the sentence suggests that if two VORs are transmitting on the same frequency, the ground track would be curvilinear towards the stronger VOR. According to two senior engineers from a major VOR manufacturer in the United Kingdom this is not necessarily the case. The resultant effect on the aircraft's receiver is a result of the combination of power difference and the phase difference. If the aircraft's receivers received two signals of different strength and phase differences, the outcome would be unlikely to simply bend the radial in an orderly fashion to produce a smooth curvilinear path (Attachment C refers).

Page 76, paragraph 1.17.1
In a balanced report, it would be appropriate to deal first with the Jeppesen amended up to 20 January 1986. To state whether this manual was up to date for the route in question would be more helpful. The mention of the out of date manual and any misleading information it may have contained could then be made.

Page 78, subparagraph (b)
In terms of Annex 13 the protocols were signed by two Accredited Representatives and the Investigator-in-Charge from the State of Occurrence.

Page 78, subparagraph (f)
Delete "... Mr Caiger, the ..." and substitute "an".

Page 79, subparagraph (l)
Delete "...(Mr Caiger's report explains that the Mozambique radar plot is not accurate)". As mentioned above, individuals should not be identified. Furthermore, the FDR report says that the Mozambique radar plot is "unreliable".

Page 80, paragraph 3, last line
It does not necessarily follow that the navigator's OBS/CDI was directly coupled to the number two VOR receiver. The coupling can be made to the number one VOR by the selection of "one" on the system selector.

Page 81, paragraph 1, line 5
It is not accepted that the setting of 225° was made on the navigator's OBS "before" the turn was initiated. If this had been the case, a continuous and regular turn would have been made by the Doppler coupled autopilot whereas the DFDR record shows that the turn was made in three separate segments probably by manually turning the knob.

Page 81, paragraph 2, line 4
The term "agreed most probable flight path" is questioned. The flight path agreed to by the three teams which assembled the agreed factual report was that which was prepared in Moscow by the USSR Delegation. That flight path did not coincide even approximately with the 045 radial from the Matsapa VOR.

Page 81, paragraph 4, line 1
It is not accepted that "the only explanation for the turn was that the number two VOR was temporarily selected to the Matsapa VOR". In the first place, Mozambique believes there is a reasonable alternative explanation, but that notwithstanding, it would have been quite practical for the number one VOR to be selected to the Matsapa VOR and the result used by the navigator as explained above.

Page 82, line 1
It seems somewhat unclear to state that "... Matsapa could have indicated the change of heading to 221°". The intent of this statement should be clarified.

Page 82
The factual information does not explain how the co-pilot would have been aware of the existence of Matsapa VOR. The documents recovered from the aircraft were described as out of date and no evidence was obtained to confirm that the crew had access to the NOTAM relating to the Matsapa facility being on test. In fact it was probable that the crew were unaware of the NOTAM.

Page 83, second paragraph, last line
There is no evidence which indicates "confusion" existed on the flight deck. The CVR indicates "concern".

Page 84, four last lines
It is not "almost certain" that these readings were from the Doppler because they were in kilometres. The aircraft was equipped with two DMEs, one indicating in nautical miles and one in kilometres.

Page 86
It does not follow that a flight in darkness is IMC because there is no visual contact as already discussed.

Page 86, second paragraph, lines 4 to 6
The assumption that the pilot attempted to descend below the cloud to determine his position is not necessarily correct. The evidence indicates a situation with scattered clouds and visual contact with lights on the ground. Therefore it could also be assumed that the pilot had every reason to believe that he was approaching Maputo after intercepting the 045° radial and was descending to the circuit altitude of 1700 feet.

Page 87, lines 2 and 3
It is not explained from what evidence the radio operator believed he was over the sea. It has been suggested that the VIP crew often expressed a preference for a right hand approach to give their passengers a more attractive view.

Page 88, paragraph 2, line 9
The status of the VHF transmitters at Maputo was such that the frequency in use for this flight was operated from a transciever which in addition to the mains and standby power supply had the facility to operate from a built in battery source. Therefore the receipt of normal VHF transmissions was not necessarily proof that normal or standby mains electrical power supply was available at Maputo Aerodrome.

Page 89
The crew's "omission" to refuel at Mbala was explained by two factors The addition of more fuel would have increased the mass of the aircraft to a total in excess of that permissible for the runway length at the altitude and ambient temperature. No extra fuel was required as no alternate was needed in view of the forecast weather at Maputo which provided a reasonable certainty that at the estimated time of arrival at Maputo and for a reasonable period before and after such time the approach and landing could be made under VMC.

Page 91, lines 5 to 7
The crew had been "competency checked" twice (page 30) within the last six months. No evidence indicates that these checks were "clearly inadequate".

Page 92, line 8
The CVR record indicates that the pilot was "concerned", not "in a confused state of mind".

Page 93, paragraph 2.8, lines 5 to 13
No evidence supports the assumption that the crew would have had the illusion that the border was the coastline. If this were the case, a comment to this effect could have been expected on the CVR record in conjunction with the statement "no Maputo, no navaids".

Page 94, line 7
The CVR record indicates that the crew was "concerned" not "bewildered".

Pages 94 and 95
The evidence of the crew of C9-BAA only established that a VOR was transmitting on the frequency of the Maputo VOR throughout their outbound flight. They did not use the aid to maintain an inbound radial but instead steered a constant magnetic heading with no allowance for the change of 6° in magnetic variation which occurred during that particular leg from Beira. The aircraft therefore flew a curved track which is referred to on page 3 of the report on the FDR record from C9-BAA.

Page 97, lines 3 and 4
Crew rest in the VIP interior of a Presidential aircraft can hardly be called "poor quality".

Page 98
If, indeed, there were regulations requiring more fuel to have been on board, these should have been identified. It is contented that the aircraft had sufficient fuel for the planned flight to be conducted in accordance with the applicable regulations as to fuel reserves. See ICAO Annex 6, Part I, paragraph 4.3.4.1.

Page 99, paragraph 2.13.10
It cannot be stated that the co-pilot failed to appreciate that it was his selection of the Matsapa VOR which mislead the navigator when it has not been established that the co-pilot selected the said VOR or even if he was aware that it existed.

Page 99, paragraph 2.13.12
The crew could not be sure of the transition altitude as the procedure was for the controller to specify the transition altitude for each flight on the basis of the local barometric pressure situation.

Page 100, line 5
The effect of the 120 feet error in the altimeter caused by the crew's failure to set the local QNH should have been stated, i.e. the altimeter would underread by 120 feet showing the aircraft to be that much higher than was actually the case.

Page 100, paragraph 2.13.13, line 7
While the VHF was indeed dependent upon "electrical power" it was not dependent upon the mains or standby power available to the runway lights and navigation aids as it could also fall back on a battery supply.

Page 100, paragraph 2.13.14
It was not established that the aircraft was IMC, only that it was IFR.

Page 101, paragraph 2.13.16
The CVR record indicates that some lights were visible on the ground. There is no reference on the CVR record to indicate that the crew believed the Maputo VOR to be out of service. A reference to the Maputo broadcast station is not correct as it was not an approved navigation aid and should not have been used as such.

Conclusions, page 101, paragraph 3(a), (i)
The aircraft type is TU-134A-3.

Page 103, subparagraph (xii)
As noted earlier the status and requirement for an alternate aerodrome should be specified.

Page 104, subparagraph (xvii)
The likelihood is that the co-pilot was unaware that the Matsapa VOR existed and if he did select it at all, he is more likely to have mis-selected it.

Page 105, subparagraph (xx)
A reference to the Maputo broadcasting station is not correct for the reason stated above.

Page 105, subparagraph (xxi)
While there is reference to cloud on the CVR record it cannot be said that the crew entered cloudy conditions as discussed above.

Page 105, subparagraph (xxii)
The last ten words which state that the pilot had no reference to the ground and was under IMC should not be included as discussed above.

Cause, page 106
While it is not agreed that sufficient investigation has been completed to determine the cause(s) of this accident, the assertion that the aircraft was under IMC has not been established.

APPENDIX 1, ASSERTION OF A FALSE BEACON

Appendix 1 to the Board's report is not considered to be the result of sufficient investigation into the possibility of a decoy VOR transmitter, to eliminate the suspicion that such a device existed.

The reasons for this are detailed in the attached copy of the Analysis and Conclusions of the Mozambique report on the accident. However, in addition the following specific comments on the Appendix to the Board's report are listed below.

Page 110
It is not correct to state that the sole function of the Maputo VOR or any other VOR upon which an instrument letdown procedure is authorized, is to indicate azimuth. For an aircraft following a radial to the overhead position, the aid fixes a position from which a descent may be commenced below MSA.

Page 110, paragraph 2
In this case the Board has established in its draft report that such cross checking did not occur. Therefore, this argument has little weight.

Page 110, paragraph 4
This paragraph seeks to convince the reader that the VOR was serviceable at 19.10 hours because it was used at 16.00 and 16.30 hours and then used again by another aircraft from 19.54 hours on. The statement "C9 BAA received the signal during its flight" does not prove that the VOR was operating correctly or that it was the bona fide Maputo VOR, as C9-BAA was not using the VOR as a navigation aid during its inbound flight.

Page 111
For the above reason, the flight path of C9-BAA would not have been affected by any false VOR signal. The path was, however, curvilinear because of the large change in magnetic variation as discussed above. The last sentence of paragraph one "the plot of the flight path of C9-BAA shows that it was also straight", is at variance with the information in the report on its aircraft's FDR.

Page 111 last line
The last five words of this page are not true The aircraft C9-BAA was not influenced by any VOR when it was southbound.

Page 112, paragraph 5
This paragraph does not rest easily with the facts of the matter. The VOR was used before the accident only at 16.00 and 16.30 hours. The ressemblance of C9-BAA's flight path to one following a VOR radial was purely coincidential. As there was no effective monitoring of the Maputo VOR and its isolated transmitter shed was insecure it could readily have been switched off as part of any co-ordinated exercise to allow dominance of a VOR field transmitter on the same frequency.

Page 112, paragraph 6
This paragraph has little evidence to support its contention as no other aircraft was located which was using the Maputo VOR near the time of the accident.

Page 113, paragraph 9
Information from two senior engineers of a major VOR manufacturer in the United Kingdom revealed that it would be a simple matter for anyone so inclined to set up a mobile VOR to radiate 360° or a sector of radials on the same frequency as the Maputo VOR. No special power generation would be required. Two fully charged 12V vehicle batteries would be capable of sustaining a 50W output for some four hours. The unit could be mounted on a vehicle, e.g. a Landrover and the aerial array would present an insignificant profile as its overall dimensions would not exceed 1.5 metres and it would be in the horizontal plane. Therefore the aerial array could be of much more modest dimensions than those claimed by the Board (Attachment C refers).

IN SUMMARY
The Board's claim in their draft report that the premature turn made by C9-CAA was due to the crew using the Matsapa VOR as a cross check when they were unlikely to have known of its existence, is not well supported.
In view of this and the above inaccuracies in the Appendix to the Board's report, Mozambique considers that the Board has not devoted sufficient attention to the elimination of the possibility that a decoy VOR was a significant casual factor in the accident and invites the Board's attention to the attached Analysis and Conclusions from its own report which are appended to this submission (Attachment B refers).

Attachment B

2. ANALYSIS

2.1 General

The aircraft was refuelled on 18 October 1986, the day before the flight under direct supervision of the flight engineer.

The crew arrived one and half hours in advance of the scheduled departure time, for their pre-flight planning and subsequently filed a flight plan to Mbala with a refueling stop at Lusaka. Copies of the weather forecasts showed that the weather was suitable.

The pre-flight planning and documentation were appropriate for the flight except that the pre-flight brief did not include the Notam advising that the Matsapa VOR was transmitting on test, on frequency 112.30 MHz, identification VMS, for three months.

The crew had adequate rest before the flight and were fit for duty on the day of the flight. The start of the duty time and the estimated time of return to Maputo differed by some 16 hours 30 minutes. The approved crew duty time was not exceeded as they had time off in Mbala, during which they could rest and relax inside the aircraft.

The crew was based in Maputo and had been assigned to their duty station for almost 18 months. They were experienced on the Tupolev 134 and on this aircraft in particular and were familiar with the approach to Maputo at night. Their licences were up to date and appropriate for the task of flying VIPs.

The aircraft utilization was low and the engines and the airframe were in the early stages of their operating life. There was no indication of a failure of the aircraft in general or its systems in particular, which might have contributed to this accident.

The flight from Maputo proceeded normally to Mbala with a refuelling stop at Lusaka. The return flight was uneventful until the aircraft was some 100 km from Maputo when a 37° turn to the right initiated a series of events which culminated in the accident. This turn was followed by a descent on a track approximately parallel to the inbound track required for a "straight-in" ILS approach to Maputo's runway 23.

As the estimated time of arrival approached, the crew became concerned that they were unable to see the runway lights or to receive the ILS for runway 23 and queried the serviceability of each with the Maputo Aerodrome controller.

Due to communication problems which may have been due to the use of English by the controller and the aircraft radio operator whose native languages were Portuguese and Russian, respectively, the aircraft crew believed that both the runway lights and the ILS were out of service.

When they were subsequently puzzled by the indications of the DME or an absence of any reading, and they could not see the city lights, the pilot seemed to believe that Maputo had no electrical power and to presume that the DME and NDBs were also out of service. This was possibly due to their near 18 months experience at Maputo during which frequent break downs occured in the electrical supply due to sabotage.

The reported weather at Maputo Aerodrome included scattered cloud, which meant good visibility. The pilot apparently decided that after intercepting the 045 radial he would make a visual approach from the circuit altitude of 1700 ft, in the belief that he was inbound for Maputo. According to the DFDR, once the aircraft began its descent, it continued uninterrupted and passed through the approach safety altitude of 3000 feet to collide with high ground some 35 NM west of Maputo at approximately 2190 feet amsl (above mean sea level).

The detailed analysis of the causal factors leading to this accident may be conveniently divided into three areas involving the last phases of the flight; first: the leg from Masvingo via Kurla to the 37° right turn; second. the turn itself; and third: the flight after the turn to the point of impact.

2.2 Leg from Masvingo to the beginning of the turn (19.10.41 Hrs)

From Masvingo the flight proceeded to Kurla, a reporting point without an on-site navigation aid. Based on the data from the DFDR it was deduced that the navigator was directing the aircraft using the Doppler/autopilot coupling facility available at his crew station.

The aircraft reported "at point Kurla" and turned onto the direct track to Maputo. The DFDR indicated that the navigator probably continued to direct the flight using the Doppler coupling facility. This assumption was supported by the fact that the aircraft's average heading later altered to the left by some 5 degrees which would have been appropriate for an interception of the 045 radial from Maputo VOR, some 30 km from this facility.

The pilot was heard on the CVR record to state that his intention was to make a "straight-in" approach.

This would involve the interception of a VOR radial (probably 045°), to capture the ILS and make a routine approach to their home base. That this was the normal procedure expected by the Aerodrome controller was confirmed by his instruction to the aircraft to "report established on the zero four five radial". The navigator continued to provide information to the pilots and shortly after the 37° turn to the right advised the crew that the aircraft was 100 km out. This was presumably from a DME readout as the DFDR data showed the aircraft was at that distance from Maputo DME at the time.

2.3 The turn to the right

Shortly before the navigator advised "100 kilometres" the aircraft was turned 37° to the right at an average bank angle of some 13°. The pilot queried the need for this turn. The navigator who was aware of the aircraft's position and had just finished stating the distance from Maputo, replied "...VOR indicates that way". According to the DFDR, he probably made the turn using the Doppler coupling facility, based on the VOR information.

The pilot apparently accepted the reply to his query about the turn as he did not press for any further explanation. This indicated that he had subsequently satisfied himself that the turn was required, probably by a study of his instrument indications. The fact that to be so convinced he had to ignore the recent advice that they were 100 km from destination suggests some degree of certainty, concerning the reliability of information on their instruments about the interception of the 045 radial from the VOR station.

Prior to the turn, the interception of a VOR radial was the next planned event in the approach sequence and the crew would have been watching for it.

The possibility of a spurious VOR instrument indication of an intercept with the 045 radial from Maputo VOR produced two possibilities. One that the crew had inadvertantly tuned their VOR receiver to Matsapa VOR and two that the VOR was correctly tuned but a false radial was generated as a criminal act.

There are two possibilities of simultaneous VOR frequency selection on the flight equipment, using systems 1 and 2. According to the Operations Manual, one would expect Maputo (VMA) VOR frequency to be selected in both systems at that stage of the flight.

The navigator who was controlling navigation had the possibility of an indication from one of the two systems in the CDI (course deviation indicator) in case the RMI needles had been selected to ADF (as found after the accident).

The determination of which system was selected to the navigator's instrument was usually made by one of the pilots on the central panel selector as this was the only way to select the source of the signal for the navigator's CDI.

As after the accident and according to the analyses made in the laboratories in the USSR and the RSA, system 2 was selected to VMA 112.70 MHz frequency, it is unlikely that the latter had been altered in the last 20 minutes of the flight, as it would only be necessary to tune one of the systems from VOR to ILS.

Most probably the selection of the first system was tuned from VOR to ILS after the turn, in order to allow an integrated utilization of the destination airport navigation aids.

2.3.1 Possibility of mistuning the VOR frequency

If, by any method, Matsapa VOR was accidentally selected instead of Maputo VOR, it would explain why the turn was made, by coincidence, slightly after the position at which the aircraft crossed the 045 radial from Matsapa VOR.

If such an inadvertant VOR frequency selection took place, it is more likely that it occurred on system 1, and it was later reselected to the ILS frequency as found after the accident. If this was the case, it is probable that the systems switch was kept in position for system 1 (before and after the turn), as it was found after the accident.

Because the pilot did not persist with his query about the turn after the navigator's explanation that "the VOR indicates that way", it can be deduced that the pilot had the same information on his instruments, which would only occur if the selector was in the system 1 or system 2 position.

According to the results of the investigation on the KURS-MP units, carried out at Moscow to determine their operational condition, it was concluded that the onboard navigation equipment was fully serviceable and operating in accordance with the manufacturer's specifications.

On the other hand, the selections recorded by the investigators in the RSA after the accident, 110.30MHz and 112.70 MHz on systems No.1 and No.2, respectively, were in accordance with the procedures contained in the Flight Operations Manual. This supports the probability that the previous frequency selection would also have been in accordance with that manual.

As stated in Section 2 1, the crew did not have access to the Notam relating to the Matsapa VOR at their pre-flight briefing. It is therefore likely that the crew were unaware that such a VOR was transmitting on 112.30 MHz in the area and hence would not have deliberately selected that frequency.

Comparing the route of the aircraft with the Matsapa VOR radials it can be seen that at no time up to the moment of impact, was any manoeuvre carried out to establish the aircraft on a track to match the 045 radial, or any other radial, of Matsapa VOR. This may indicate that the crew never intended to achieve such a track and that the Matsapa VOR 045 radial was not intercepted at any time. See fig. I.

2.3.2 Possibility that the aircraft was decoyed by a false VOR

The possibility that the aircraft was decoyed by a beacon transmitting on the Maputo VOR frequency to make the aircraft's VOR receiver respond as if it was intercepting the 045 radial when it was in fact some 100 km from the true position to intercept that radial must be examined.

As the aircraft was carrying the Presidential Delegation there was a potential for efforts to be made to sabotage the aircraft in some way.

The Maputo VOR was co-located with a DME which, from more than 100 km from Maputo enabled the aircraft to fix its position continuously while on an inbound radial as in this case.

At the time of first intercepting the Maputo VOR the aircraft was inbound on a known track which would have been monitored by the navigator who was a standard member of the crew. At the point of interception the distance and bearing would have been known to him.

As the aircraft came within DME range, the navigator would have checked the distance as a matter of course and by normal calculations confirmed his ETA at destination which would have been unlikely to change by more than two or three minutes. He should therefore have been suspicious of an interception of the 045 VOR radial at a distance so much greater than he had estimated.

In figure I, taking as a reference a line parallel to the one indicating the correct track for a landing on the Maputo 23 runway, it can be seen that the turn started slightly after the instrument indicator bar had started its movement from right to left towards the center of the instrument, that is, when the radial was about 4° to 5° less than a 045 radial from the direction of the accident site e.g. a signal simulated to be from the Maputo VOR.

Figure 2 shows the "agreed most probable track" which was prepared in Moscow. The track depicted in Figure 1 is based on that data but has been modified using a computer to determine the progressive effect of wind changes during the descent of C9-CAA. As there is no significant difference between the tracks shown in figure 1 and 2, figure 1 is preferred because of the more convenient scale.

2.4 Flight from the turn to the accident

Once the aircraft had turned, the DFDR shows that the variations of the heading parameter were larger than before, probably as a result of the wind effect at lower altitude.

A study of the average track of the aircraft shows that during about 3 minutes after the turn was completed, there was a heading correction to the left and during the final minutes the aircraft was flown essentially on a track parallel to a track for a direct approach and landing at Maputo.

If this occurred, while the aircraft was homing on a VOR indication (although there is an absence of any fact to prove it), then the VOR station should have been located in a direction from the aircraft which was parallel to the radial 045 of the Maputo VOR.

There was no information, in any official air navigation publication about a beacon with the orientation mentioned above, which implies that such a beacon would have been placed with the deliberate intention to deceive and misdirect the aircraft.

As the crew had every reason to believe that they were approaching Maputo, but still could not see the runway lights or receive the ILS, they asked the Aerodrome Controller to check the runway lights on three occasions.

This was followed by a direct question which led to the controller's confirmation that both the runway lights and the ILS were out of service.

Following this advice it was not difficult for the crew to accept that both the NDBs and the DME were out of service, which the pilot was heard to state on the CVR record.

About four minutes before the accident, the pilot stated that "everything is switched off, look chaps" (he was probably convinced that there was no electrical power in Maputo city). This indicates that none of the instrument indications made any sense to the crew so, they maintained the heading that would be correct for an approach and landing on runway 23 at Maputo Airport. After this statement, similar comments were made by the navigator, on two other occasions.

Although the reason for him believing that the DME and NDBs were out of service was not stated, it was reasonable to assume that the crew could not reconcile the ADF and DME indications with their assumed position of almost overhead Maputo and thus believed them to be inaccurate. Such a conclusion was not uncommon when a crew was earlier convinced that one false premise was correct.

At no time did the crew refer directly to an unserviceability of the VOR which supports the assumption that the signal from a VOR station was available on the pilots instrument(s).

Following the loss of communication with the aircraft, the controller was understandably somewhat overawed by the situation. However, in a timely manner, he raised the alarm and as a result effective measures were underway in a reasonable time to search for the missing aircraft.

That the aircraft was so far from the local circuit area after giving every impression in its reports that it was almost overhead was an obvious obstacle to the formulation of a realistic search area.

3. CONCLUSIONS

3.1 Findings

The aircraft was airworthy and suitable for the flight.
The crew members were fit and qualified for the flight.
The weather was not a factor in the accident.
The documentation for the flight was incomplete.
The pre-flight NOTAMs were incomplete, as there was no NOTAM concerning the test transmission of Matsapa VOR.
The reduced aircraft fuel reserves were not related to the causes of the accident.
The serviceability of the navigation aids was as stated in the NOTAMs.
The navigator controlled the aircraft's track with the use of the Doppler/Autopilot coupling facility until it had completed the premature turn.
The crew did not complete the appropriate check lists for the descent to Maputo.
The aircraft made an inappropriate right turn some 100 km from destination and the resultant magnetic heading was maintained until it collided with the terrain.
Immediately prior to and during the turn the aircraft's VOR equipment indicated that the aircraft had intercepted the required VOR radial.
The source of the VOR signal that induced the crew to execute the turn has not been positively identified even though considerable efforts have been made towards that end.
The navigator turned the aircraft 37° to the right based on a VOR indication.
The pilot's decision to descend below 3000 ft was not in accordance with his clearance.
The aircraft's ground proximity warning system (GPWS) worked correctly.
The pilots did not respond to the warning of the GPWS.
The responses of the Aerodrome Control officer indicated to the aircraft crew that both the runway lights and the ILS were out of service when this was not the case.
The search for the missing aircraft was appropriate.

3.2 Causes of the accident

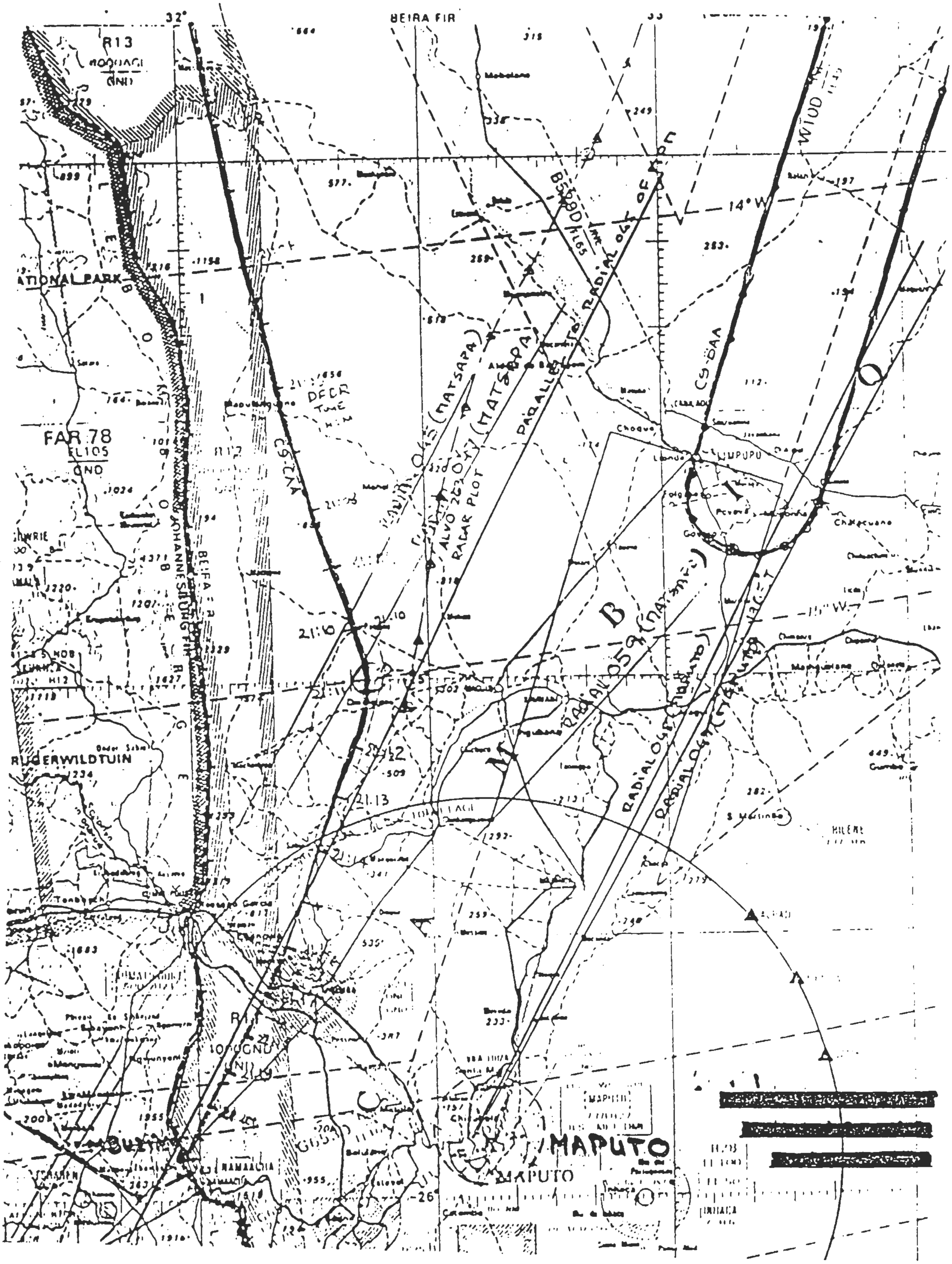
A. Analysis of facts and investigation carried out by experts of the three countries involved, lead to the conclusion that the critical situation from which the accident resulted, originated from the right turn performed by the aircraft and the subsequent 37° deviation from the planned route.

B. The explanation for this deviation is still a polemic question about which no agreement was achieved by the experts of the three countries. New information from the investigations carried out by the USSR conveys the conclusion that the aircraft while turning, was not following a radial from the Maputo VOR (VMA) or Matsapa VOR (VMS) but another VOR station which would have been positioned somewhere in the accident area.

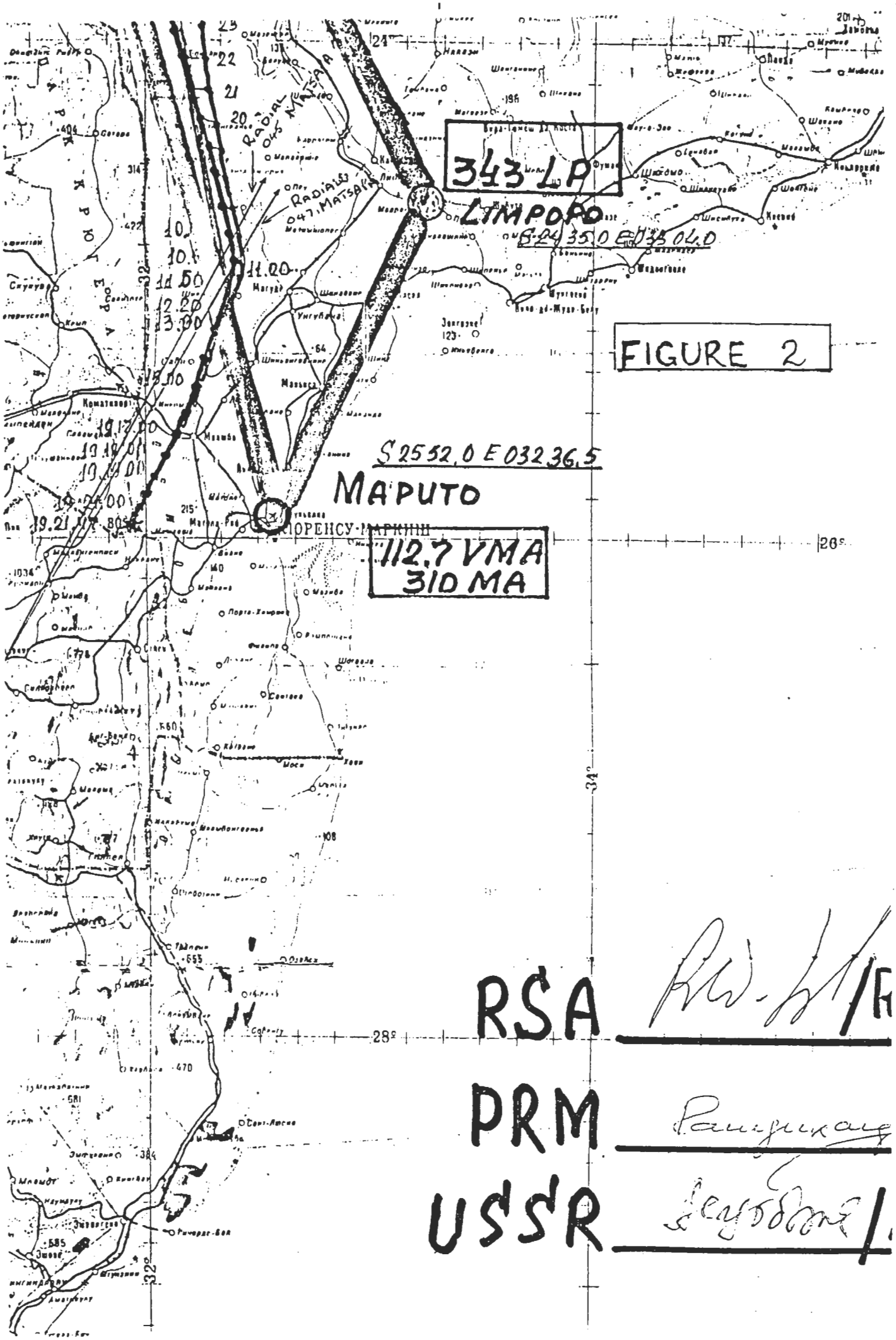
C. The discrepancies revealed in the Maputo Aerodrome Controller's procedures and those in the TU-134 crew procedures were not the main causes of the accident.

D. For these reasons, the People's Republic of Mozambique considers that investigation should be continued by the three States, in order to identify positively the origin of the VOR signal that led the crew to make the turn mentioned in A.

FIGURE I



BEIRA FIR
32°
33
R13
GND
ATIONAL PARK
FAR 78
FL105
GND
C9-CAA
C9-BAA
WIOD
14°W
15°W
PARALLEL TO RADIAL 065
RADAR PLOT
ALVO 263 OXY
(MATSAPA)
B
RADIAL 059 (MATSAPA)
RADIAL 065 (MATSAPA)
RADIAL 045 (MATSAPA)
LIMPOPO
JOHANNESBURG FIR
BEIRA FIR
21:06
21:10
21:12
21:13
21:14
21:19
DECR TIME
RUGERWILDTUIN
MAPUTO
-26°
[redacted]


343 LP
LIMPOPO
S 24 35.0 E 035 04.0
FIGURE 2
S 2552.0 E 032 36.5
MAPUTO
LOURENÇO MARQUES
112.7 VMA
310 MA
RADIAL 047, MATSAPA
RADIAL 043, MATSAPA
RSA
PRM
USSR

Attachment C

Dr Paulo Muchanga
National Commission of Inquiry into
Tupolev 134A Accident 19 October 1986
Maputo
MOZAMBIQUE

19 February 1987

Dear Sir

VISIT TO RACAL AVIONICS LTD

As agreed I approached the manufacturers of the Maputo Doppler VOR and discussed with them the questions posed by Mr Neves and Mr Colaco relating to the possibilities of tampering with the Maputo DVOR, generating an interference or replacing the genuine DVOR radials with a decoy or misleading signals.

Messrs William Eastwood, Technical Director of Racal Avionics Ltd and his associate Mr Ron Hazell made available as much time as I required and responded to my inquiries with informed and readily understood answers.

I described the general circumstances of the flight of the Tupolev 134A on the final leg from Masvingo to the accident site and gave them as much of the relevant information on the Matsapa DVOR as I had.

The first question explored was whether the frequency of the Matsapa DVOR was sufficiently separated from the Maputo DVOR to avoid any possibility of a conflict when the aircraft's receiver was tuned to the Maputo DVOR frequency.

Both Mr Eastwood and Mr Hazell were surprised that a frequency so close to that of the Maputo DVOR had been selected for the Matsapa facility and stated that in their view a more remote frequency would have been appropriate to eliminate any possibility of sub-carrier harmonics of the Matsapa DVOR's frequencies causing interference in the reception of the nearby Maputo DVOR. However they concluded that unless the aircraft equipment was not correctly aligned or the DVOR frequency not properly trimmed the ICAO standards detailed in Annex 10 to the Chicago Convention on Civil Aviation would ensure that no accidental interference could occur.

The possibility that the Matsapa DVOR could have been interfered with and its frequency temporarily changed to that of Maputo was considered unlikely because the changing of the frequencies on DVOR was normally an involved matter. Also a special procurement

of the necessary crystals would have to be made (3 in the case of the Decca Racal DVOR). Again the requirement to return everything to normal immediately after a successful decoy operation would add an unnecessary risk of detection or exposure. Their opinion was that although it could be done it was unlikely that this would be the method used. They did stress however that they had no particular knowledge of the make of DVOR involved at Matsapa.

Next we discussed the result of transmitting a sector of radials about a median of 045°M. This was considered a simple task and an effective method of boosting the output of the required radials from a given power source. It could be readily accomplished with a vehicle mounted unit using two standard motor vehicle batteries in series as a 24 volt supply and a directional horizontally polarised antenna. The antenna array of approximately a 1.5 metre square would not be conspicuous as it would be in a horizontal plane. Two fully charged 12v vehicle batteries should be capable of sustaining a 50w output for some four hours.

It would be difficult to ensure that the radials so produced would supplant the genuine radials by well aligned substitutes to a different origin. Unless the Maputo DVOR was switched off the aircraft's receiver would interpret signals produced by a subsidiary mobile DVOR or VOR by measuring the summations of the phase difference with a proportional bias toward the stronger of the two signals. The simplest and most effective way to produce accurate radials would be to switch off the Maputo DVOR during the period any mobile decoy VOR was activated.

A receiver tuned to identify a radial of say 045 would not separate two signals in the same area on the same frequency. If it received two signals with a phase difference appropriate to a 045 degree radial from a mobile VOR and two signals on the same frequencies with the phase difference for say a 005 radial it would have responded to the summation of the signals in proportion to their strength and interpreted it as neither 045 nor 005. As the aircraft closed on one station its signal strength would eventually have dominated that of the other transmitter completely.

In summary it was considered that it would be simple for anyone so inclined to set up a mobile VOR to radiate a sector of radials on the same frequency as the Maputo DVOR. No special power generation would be required and the aerial array would present an insignificant profile as its overall dimensions would not exceed 1.5 m and it would be in a horizontal plane. The unit used would be more likely to be a VOR than a DVOR.

To produce undisturbed radials of a desired value would require a positive dominance of power output which would be most easily guaranteed by switching off the Maputo DVOR.

The further refinement of jamming the remaining navigation aids, i.e. the NDB, ILS, weather radar and DVOR was considered to be an unlikely course of action due to the widely different frequency bands involved and the greater risk of detection of the malicious interference.

Yours faithfully

R Chippindale

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NZAIR NZ30274
928592 RACAVL G

FR.1430 11.02.1987

FOR THE ATTN OF: MR.R.CHIPPENDALE - OFFICE OF AIR ACCIDENTS
INVESTIGATION
C/-MINISTRY OF TRANSPORT
PRIVATE NAG WELLINGTON
NEW ZEALAND.

FROM:BILL EASTWOOD - TECHNICAL DIRECTOR - RACAL AVIONICS LTD.,
88 BUSHEY ROAD, RAYNES PARK, LONDON SW 20 0JW
ENGLAND.

RECEIPT OF YOUR NOTES CONFIRMED. THEY ARE AN EXCELLENT RECORD. MY REPLY LETTER SUGGESTS MINOR AMENDMENT, BUT PLEASE FEEL THAT WE ARE HAPPY WITH THE REPORT, GIVEN TWO SIMPLE CHANGES. IN FIRST SENTENCE, PARA. 5, INSERT WORDS ''SUB-CARRIER'', TO READ, ''POSSIBILITY OF SUB-CARRIER HARMONICS OF THE MATSAPA DVOR'S FREQUENCIES''..... IN PARA.1, PAGE 2, THE REFERENCE TO ''BEAM'' COULD CONFUSE. WE SUGGEST PHRASE ''THE ANTENNA ARRAY OF APPROX. 1.5 METRE SQUARE WOULD NOT BE CONSPICUOUS.''

THANK YOU FOR SIGHT OF REPORT.

REGARDS

BILL EASTWOOD
TECHNICAL DIRECTOR
928592 RACAVL G
++MW++
AVIONICS

NZAIR NZ30274

REMARKS

of the Soviet delegation on the final report of the RSA, regarding the air accident of the TU-134A, C9-CAA aircraft which took place on 19 October 1986.

After having studied the final report of the RSA regarding the air accident of the TU-134A, C9-CAA aircraft, containing a factual information, analysis, conclusions and recommendations, the Soviet delegation notes the following:

1. The chapter of the report entitled "Factual Information" includes the objective data regarding the air accident in the same form as they have been summarized and agreed to by the three-sided specialist group representing the P.R.M., USSR and RSA in accordance with the ICAO requirements. We do not have any remarks with regard to this particular chapter of the report.

2. The part of the report including analysis, conclusions and recommendations was prepared one-sidedly by the South African authorities only, despite the insistent suggestions of the Soviet delegation to continue the work of the three-sided team. As a result, the analysis done by these authorities contains substantial vices and, consequently, leads to groundless conclusions and contradictive recommendations.

3. One-sided actions of the RSA concerning the air accident investigation were detrimental to the quality of the very investigation, are not up to the spirit of the international co-operation within

the ICAO, and contradict the regulation of the Annexure 13 of the 1944 Chicago Convention, including the standards of p.5.1 which oblige a State of Occurrance to utilize "all means of assistance in an investigation", which should undoubtedly, include utilization of experience and knowledge of a State of Manufacture and State of Exploitation of an aviation technical equipment.

4. The basic task of an objective investigation of this particular air accident, i.e. explanation of causes which forced the aircraft crew to turn off the Maputu course by 37° to the right, and to steadily proceed along the new course until their entrance into the hilly region, remained unsolved in the report. In this case, the version concerning the crew's errors, upon which the conclusions of the report are based, is totally ungrounded.

5. In the light of this statement, the Soviet delegation cannot agree with the analysis, conclusions and the recommendations following from the latter and set in the final report prepared in the RSA, which renders all this report worthless.

In view of the fact that the State of Occurrance refused its co-operation in completing the investigation of the air accident, the Soviet delegation conducted an independent analysis of the available factual material, on the basis of which the appropriate conclusions and resolutions were worked out.

The documents containing the analysis, conclusions and remarks are herewith enclosed.

Enclosure: 28 pages.

APPENDIX

to the remarks of the Soviet delegation concerning the final report of the RSA on the air accident of the TU-134A-3 C9-CAA aircraft which took place on 19 October 1986.

ANALYSIS OF THE FLIGHT EXECUTION

On the basis of the data obtained from reading-out the flight data recorders (MSRP-64, MARS-BM), the radio communication between the aircraft crew and Maputo AFIS operator recorded on the ATC tape, data from the South African and Mozambiquan radar anti-aircraft defence installations (PVO), the accident site and wreckage inspection, the statements of witnesses, the investigation and the reconstruction of the actual flight path of the aircraft, the following was established:

On the 19th October 1986 there was a special flight of the TU-134A-3 C9-CAA aircraft on the route Maputo-Lusaka-Mbala-Maputo. Before the flight, the crew rested in Maputo. The crew arrived at the Maputo airport in order to prepare for the flight at 03h42 min. Take off from the Maputo airport took place at 05h12 min. landing at the Lusaka airport took place at 07h05 min. At Lusaka airport the aircraft was fully refueled and had on its board 14094 kg of fuel. Take off from Lusaka airport took place at 07h46 min. At 09h00 min. the aircraft landed at the Mbala airport. Until take off from Mbala, the crew stayed on the aircraft board; eating was organised for the crew in a town restaurant, together with crews of other president's aircraft.

At 16h38 min. the aircraft took off from the Mbala airport with magnetic course of 118°. On board there were 5 cockpit crew members, cabin crew members, the President of the PRM, S. Machel and the persons accompanying him. On board there were altogether 44 people. The computed

aircraft take off mass was 43543 kg and did not exceed the limits set in the Manual on flight exploitation (RLE). The amount of fuel on board in the time of take off from Mbala airport was 10384, which was sufficient for a safe flight, even if a possible flight to the alternate aerodrome Beira from the Kurla point was to be considered. The remaining fuel indicated on the fuel content meter and fixed at the moment of the aircraft collision with the ground was sufficient for the continuation of flight for a period of one hour.

Both the weather prognosis and the actual weather along the flight route, at the departure airport of Mbala and landing airport of Maputo as well as at the alternate aerodrome of Beira did not interfere with a safe flight.

After taking off, retracting the landing gear and flaps and climbing, the aircraft proceeded at the planned flight level and along the planned path up to the turning point Kurla, within its required track with minor lateral deviations (4-6 km).

At 18h47 min. the crew reported to the air traffic controller of Maputo airport their passing over the control point Kurla at flight level 350, gave the computed time of traversing Limpopo at 19h05 min., communicated the fuel amount for 4 hours of flight from take off and the number of passengers on board. The Maputo air traffic controller, having received this information from the crew, gave the crew permission for an ILS approach, at the flight level 350, to Runway 23, without delay. The crew confirmed the conditions of landing and reported about their maintaining flight level 350 straight towards Maputo VOR.

In accordance with the Flight Manual, when approaching the zone of Maputo VOR beacon, the crew prepared the

aircraft board equipment for automatic flight on the beacon.

During the flight on Maputo VOR beacon, with the wind considered, the crew maintained the flight magnetic course 188°. At 18h49 min. the air traffic controller gave the crew the actual weather of Maputo airport for 18h00 min.: surface wind 090°, 10 knots, visibility more than 10km, 3 Octas at 1800 feet, 4 Octas at an undetermined height, temperature +23°, dew point +20° , QNH of 1016, and received from the crew confirmation of receiving his information. According to the read out of the flight data recorder MARS-BM, at 18h51 min. the crew completed landing preparation procedure by the navigator's report on landing conditions: 759, +23, 10 knots, runway 23, and specified the computed arrival time.

At 19h01 min. 58 sec. the crew reported the computed top of descent and obtained the traffic controller's permission for descent to the height of 3000 feet at 1017 mbr of pressure, and an instruction to report the height of 3000 feet or the Maputo airport runway lights in sight. At 19h02 min. 16 sec. the crew reported beginning of descent during which time the pitch channel of the autopilot was disengaged; descending was maintained with the control wheel engaged. The roll channel of the autopilot remained engaged until the moment of impact.

Radio communication between the crew and the Maputo air traffic controller as well as the conversation in the cockpit confirm the fact that the crew, after passing the Kurla point, agreed beforehand with the traffic controller the procedure of flight, descent and the ILS straight landing approach to the Runway 23. While descending, following towards the Maputo VOR, from 19h04 min. until 19h10 min. 50 sec., the crew was

flying with the course reduction from 189° to 184°. This facilitated exit on radial 045° at the distance of 25-30km from the Runway 23 and execution of straight landing. The correction angle on the landing magnetic course was 37°.

This manouvre lead to such situation that the aircraft began to deviate from its course on Maputo VOR. At 19h10 min. 50 sec. the magnitude of this deviation reached 20km to the east. The current radial from Maputo VOR changed from 006° aproaching 045°.

Indications of the flight navigation instruments recorded this change.

At 19h09 min. 16 sec. the navigator advised a distance of 120km, at 19h10 min. 48 sec. - 100km., and at 19h10 min. 50 sec., according to the read out from the flight recorder MSRP-64, the aircraft executed a turn of 10° - 15° angle of bank to right on 37° angle on magnetic course 221°.

An attempt to explain the use of the Matsapa VOR beacon signals (VMS 112,3) for the execution of this turn can be disproved as follows:

- On the blocks of the KURS-MP-2 board equipment the frequency of 112,7 MGh was fixed which corresponds with the working frequency of Maputo VOR not with that of Matsapa (see Appendix to the factual report No 25-K-2);

- the beginning of the aircraft right turn of 37° came at 19h10 min 50 sec. from the position corresponding to 048,8° radial while the aircraft crossed the 045° radial from Matsapa VOR 2 minutes prior to this particular moment;

- the line of actual path of the aircraft reconstructed on the basis of read-out from the magnetic flight data recorder MSRP-64, in no point in time corresponds with possibility of flying along any radial coming from the beacon VOR Matsapa;

- the signal level of the beacon VOR Matsapa is insufficient for co-operation with the board equipment of the aircraft which was in the region of the beginning of the right turn 37° (see technical report on the analysis). The crew executed the turn at 19h10 min. 50 sec. on the signals of a false beacon VOR which had the working frequency of 112,7 MGh and the signal level higher than the signals from the beacon VOR Maputo. This beacon was situated to the west of the Maputo airport on the extension of the line corresponding with the 45°-225° direction and passing the point of the aircraft's leaving the turn for magnetic course 221°.

The crew was not able to determine the moment of entrance into the zone of the false beacon VOR work because the RMI-IM indications of the pilots of navigator were changing continuously, approaching the magnitude of radial 045°, the entrance on which the crew was expecting. (see technical appendix to the analysis).

The character of the flight actual path, from the moment of taking the magnetic course 221° up to the moment of the aircraft's collision with the ground, reconstructed according to data obtained from the magnetic flight data recorder MSRP-64, indicates unambiguously that the crew maintained the line corresponding to the radial 045° from the false beacon VOR taking the latter for the authentic one.

Since the radiostations "MA" and "MO" of Maputo airport have no great power at this particular distance from

Maputo airport, the crew could not make use of them for purpose of navigation.

As the calculations showed, a prematured entrance on the radial 045° from VOR working with frequency 112,7 MGh, can be explained by the crew's supposition that the aircraft deviated to the left from the point of entrance on the radial 045° selected by them. This deviation could increase the distance from the end of the runway by approximately 30km (or 2 min. of flight), to which fact the pilots in command of the aircraft paid attention.

Turn of the aircraft provoked doubts in the pilot-in-command, however the navigator answered his question:

"VOR indicates that way".

Correspondence of the DME indications of distance from Maputo with distance from Maputo reconned on the navigation computer, indications of the aircraft magnetic course magnitude and those of the needles on the RMI-IM equipment confirmed to the crew the correctness of the flight direction on the radial 045° on the beacon VOR of Maputo airport. Under the influence of the false beacon VOR signals, the crew, believing that they are on the line of the planned path, continued the flight with descent to 3 000 feet, strictly maintaining the line corresponding to the radial 045° from the beacon VOR (see technical appendix to the analysis).

At 19h16 min. 58 sec. the aircraft's pilot-in-command noted the work of the radio altimeter and, since at this particular height of the aircraft's flight the radio altimeter should not have worked, he drew the attention of the flight engineer to this, saying:

"It is necessary to tell them about it", having in mind the technical team servicing the aircraft after its landing in the airport Maputo.

In this time, the aircraft was in the zone of immediate position of the ground radiolocation station which works within the same range of frequences as the aircraft radio altimeter RV-5 which, indeed resulted in its activation.

In the period from 19h15 min. until 19h17 min., according to the procedure rules, the crew re-turned the first unit KURS-MP-2 for the frequency ILS 110,3. The conversation in the cockpit, as well as that between the crew and the air traffic controller at the Maputo airport confirmed that, at 19h17 min. 21 sec. the crew established by instruments the absence of information on ILS, DME and NDB Maputo systems, the fact which excluded further possibility to control the flight with these radionavigation means. Having the only steady information from the signals of the beacon VOR, the crew re-turned the first half-unit of the KURS-MP-2 equipment from the ILS frequency to the VOR frequency.

At 19h18 min. 24 sec. the crew reported to the controller their position of 3000 feet and confirmed that they cannot see the airport and that ILS is not working. The controller confirmed this information and, without receiving from the crew a report on the visibility of the airport, at 19h19 min. 07 sec. gave permission for visual approach to the Runway 05 (VPP05).

In reply to the crew's further request to check serviceability of the runway and ILS at 19h19 min. 56 sec., the controller confirmed his permission for execution of the left visual approach to the Runway 05 which, in accordance with procedure laid down by the ICAO, meant a permission for descent from the level of 3 000 feet.

The crew, being certain that they are in the immediate region of the airport Maputo on the radial 045° on VOR, continued descent up to the initial level of the beginning of visual approach (474 m) and asked for clearance for the right approach. The Maputo controller gave permission for the right downwind approach and asked the crew to report the position between 3 and 4 turn.

At 19h21 min. 02 sec., during descent, the signal of dangerous terrain proximity sounded. The crew decreased the vertical descent speed to 2,5 m/sec and, doubting the accuracy of the radio altimeter work, which is the part of the system of the dangerous ground proximity signalisation, took the signal of dangerous terrain proximity as false. Supposing that the aircraft is flying above the flat country in the region of Maputo airport where the maximum height point is 125 m, the crew continued descent in order to approach for landing.

Communication between the crew and controller of Maputo airport ceased at 19h21 min. 34 sec.

The aircraft collided with ground on the RSA territory at the point of 25°54'41" of South Latitude and 031° 57'26" of East longitude, at the level of 666,75 m above the sea level, with the magnetic flight course 222,8°, in the flight configuration. Deviation of the aircraft towards the border of the RSA and Swaziland was observed by the South African and Mozambiquan radar anti-aircraft defence installations during 10 min. period. However, no measures were taken for warning the crew and the air traffic controller of Maputo airport.

The results of examination of the KRP-200P and UN-2P blocks, and KURS-MP-2 equipment show that, before the collision with ground, the aircraft flew over a false

beacon VOR. The crew, beleiving that their have approached Maputo, re-turned the first half-unit to the ILS frequency for landing approach.

The value of azimuth on the scale of the slave system on the first half-unit of the UN-2P block is 44,5° and it confirms flying over the "funnel" of a false beacon (see Technical appendix to the analysis) situated in the region of the air accident place. Thus, deviation of the aircraft was a result of a premeditated influence of an effective radiotechnical device of omnidirectional action, placed beyond the boundry of the Maputo airport which lead to the aircraft being lead off into the region of hilly territory and to its collision with ground during its flight on a higher altitude than the safe height in the Maputo airport region.

The following facts are the proof of this:

- The aircraft's navigation equipment KURS-MP-2 was serviceable until the moment of accident and its technical parametres corresponded with the norms determined by the technical exploitation documents (Appendix to the factual report 25-K-2), which excludes delivering of distorted information regarding the direction of the aircraft flight by the navigation and piloting instruments in the cockpit;

- on the control block KURS-MP-2 No 1 the ILS frequency of 110,3 MGh was fixed and on the block No 2 the VOR frequency of 2-112,5 MGh was fixed (Appendix No 25-K-2) which corresponds with frequencies ILS VPP-23 and VOR "YMA" of Maputo airport and which confirms the correct setting of frequency by the crew on both half-units KURS-MP-2;

- the aircraft turn towards the beacon VOR after reaching the radial 045° which was realized and monitored by the crew, together with the navigator's report in reply to the pilot's-in-command comment about the turn "VOR indicates that way " (19.11.32. Appendix to the factual report No 13-C-1);

- maintaining by the crew the line of the actual path corresponding to the radial 045° from the beacon VOR after getting out of the turn, which is confirmed by the character of the further course change (see technical appendix to the analysis);

- the value of azimuth 044,5° fixed on the UN-2P block of the first half-unit of the KURS-MP-2 equipment at the moment of accident confirms the flight over a ground beacon VOR in the region of the accident place (see technical appendix to the analysis).

The pilots of the commercial aircraft Boeing 737-200 C9BAA of the LAM airline SO Marques and Honvang flying along the route Beira-Maputo at the level of 310 (9500 m) in approximately the same period of time, stated that the board navigation equipment on their aircraft picked up the beacon VOR on the frequency of 112,7 MGh unusually early, at the distance from Maputo of 190 nautical miles (352 km). They were absolutely certain that the indications of the board navigation equipment follow the work of the Maputo airport VOR and they would continue the further flight without any correction of the course.

In order to secure the interaction between the board and ground equipment at such a distance, required power of a VOR transmitter, according to calculations set in Annex 10, ICAO, vol.1 entitled "Aviation Electrocommunica-

tion", must exceed 200 W (23....W). In the mean time, a disposable power of the Maputo VOR transmitter does not exceed 50 W (17 ....W).

Thus, during the indicated period of time, the board equipment of the Boeing 737-200 C9BAA aircraft of LAM airline was also interacting with the false beacon VOR which was working on the frequency of 112,7 MGh and had a higher signal level than the VOR Maputo.

CONCLUSIONS

1. During the entire flight along the route, the aircraft's equipment, its power units as well as its piloting, navigation and radiotechnical equipment remained in serviceable condition and secured a safe flight execution with required accuracy.

2. The level of the crew's qualifications, their psycho-phisiological condition, possessed experience regarding international flights and their numerous previous flights on Mozambique routes with landings at Maputo airport in conditions of night exclude the possibility of the aircraft deviation off the course during this particular flight as a consequence of unpreparedness and unattentiveness of the crew. The analysis of the crew's behaviour during the entire flight confirms that al the crew members were of a good health, efficient, were monitoring the flight and maintained communication with the air traffic controller along the flight route until the moment of collision with ground.

3. The crew and controller of Maputo airport defined beforehand the manner of the flight along the route, the procedures of descent and approach for landing without delay on ILS with MK=225°. At the distance of 96 km from Maputo airport the course of flight was increased by 37°. The turn of the aircraft was executed by the crew on the siqnals of a false beacon VOR which had working frequency 112,7 Mgh, and was situated beyond the limit of Maputo airport; this resulted in the aircraft being lead away towards a hilly region and in its collision with ground. This same signal of the false VOR was received by the board equipment on the Boeing 737 aircraft of LAM Airline.

4. Meteorological conditions along the flight route, at the landing point and at the alternative aerodrome Beira did not hamper the flight execution and could not be a cause of its outcome.

CLOSING CONCLUSIONS

The air accident of the TU-134A-3 aircraft, registration No C9-CAA was a consequence of a premeditated action of an effective radiotechnical ground device of omnidirectional action, situated beyond the limits of Maputo airport which lead to the deviation of the aircraft from the set flight course and to its collision with ground in a hilly region on the territory of the RSA.

TECHNICAL APPENDIX TO THE ANALYSIS

At 19.02, following on Maputo VOR ("VMA" 112,7) with MK = 189° and having the azimuth from this beacon and distance from DME, the crew began descent, after having received the AFIS controller approved of this. At 19.04' the crew began the left turn and decreased the magnetic course to 186,2°, at 19.06' - to 183,4°, at 19.08 the aircraft magnetic course was decreased to 182°. Execution of this operation was for the purpose of leading the aircraft to the radial 045° at the distance from Runway 23 of 30-25km., and for execution of the straight landing approach; correction turn to the landing MC was equal to the angle of - 37°. Execution of the manoeuvre lead to the situation that the aircraft began to deviate from the straight line on VOR Maputo ("VMA" 112,7) increasing gradually the linear magnitude of this deviation. At 19.10'50", towards the moment of initiation of the turn to the course 221°M, this deviation, with the wind 270°-80 km/h, could reach the magnitude of 20km to the east from the straight line on VOR. As a result, the current azimuth (radial) from Maputo VOR was gradually increasing from 006° approaching the radial 045°; indications of the needles on the RMI equipment of the pilots and navigator were changing according to these values (Fig. land 3).

The crew was not able to determine the moment of entering the zone of influence of the false beacon VOR because the indications on the RMI of the pilots were changing, approaching the value of 045° expected by the crew. According to the investigations and to the flight simulation on the simulator, the moment of entering into the false beacon's zone was registered by unstable indications on the pilot's RMI equipment and by brief signalisation of failure by the blinker indicators, followed by the re-establishment of the steady indications of VOR

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signals which had a higher level (Appendix 1 and Fig. 2).

The fact that, at 19.10'50", the turn of the aircraft from MC=184° to the right to the angle 37° was executed according to the information from a beacon VOR, may be confirmed by statement of the aircraft navigator: "VOR indicates that way ..." uttered at 19.11'32" in reply to the remark of the aircraft pilot-in-command about the necessity to execute this manoeuvre (Appendix to the Factual Report No 13-C-1).

An attempt to explain the use of the VOR Matsapa signals ("VMS" 112,3) for the execution of this turn, can be disproved by the following:

1. the frequency of 112,7 MgH fixed by the crew on the blocks of the KURS-MP-2 board equipment. Authenticity of this fact was confirmed by a special examination of the blocks which have been done after the aircraft collision with ground (Appendix to the Factual Report No 25-K-2). Working frequency of the VOR Matsapa is equal to 112,3 MgH.

2. The beginning of the turn at 19.10'50" from the magnetic course 184° to the right on 37° was done from the aircraft position corresponding with the radial 048,8° from the beacon VOR Matsapa. The aircraft crossed the radial 045° from the VOR Matsapa 2 min. prior to the time of the beginning of the turn (Fig.1).

3. The line of the actual path of the aircraft reconstructed on the basis of read-out from the magnetic flight data recorder MSRP-64 (DFDR) in no point in time indicates the possibility of flying along any of radials coming from the place of the situation of VOR Matsapa: the moment of the beginning of the

turn from the magnetic course 184° to the right corresponds to the radial 048,8°, the moment of assuming the course MC=221° corresponds to the radial 050°, and at the moment of the aircraft's collision with ground, this radial was equal to 060,5°.

4. On the basis of the region relief analysis, in direction from VOR Matsapa towards the region of the aircraft flight and with consideration of the flight level during the period from 19.10'30" until 19.10'50", the evaluation of the signal level received by the aircraft board equipment from VOR Matsapa was worked out. For this purpose, the following nomogrames for calculation of the zone of radio waves propagation were used:

Calcul par homogrammes de la Propagtion des Ondes Frequences Superienes a 30 MHg
par
Lucien Boithias
Ingenieur en Chef des Telecommunications
Edition 1972
Eyrolles Editeur - Paris

as well as the nomogrames for determination of the dependence of the working range of VOR beacons on the flight level of an aircraft (Annexure 10 ICAO. Aviation electrocommunication, vol. 1, Fig. C-13 21.11.85, page 296).

The following information was taken as the initial data:

- frequency of VOR Matsapa - 112, 3 MgH,

- power = 200 W or 23....W,

- distance between the ground beacon VOR and the point of the beginning of the right turn on 37° = 202 km.,

- Average value of the aircraft flight level in the moment of the beginning of the turn = 6 000 m.,

- profile of the region in the direction from VOR Matsapa towards the point of the beginning of the turn.

Calculations show that the angle of cover from VOR Matsapa to the point of turn by Bombegazi mountain in vertical plane is equal to 2°13'7". The cover occurs in the sector of 38° (from azimuth 019,8° to azimuth 057,8°). Angle at which a direct visibility of the beacon from the level of 6 000 m and distance of 202 km from the place of its location would be possible is equal to 1°43: Thus, there was no direct signals of the beacon VOR Matsapa which would reach the aircraft flying in the sector 019,8 - 057,8° at a distance of 200 km from the situation of the beacon, and on the level of 6 000 m. Weakening of the signal due to difraction of radio waves from the Bombegazi mountain represents a value of not less than 15 db which is an equivalent of decreased power of the beacon by 15 db.

The signal level from the beacon VOR Matsapa, necessary for an interaction with the aircraft board equipment can be recieved, in these conditions, only at the distance of not more than 135 km from the beacon. As the aircraft descended from the level of 6 000 m, the signal level was dropping continuously (Fig. 4). Thus the interaction between the board equipment of the aircraft situated, at the point of the beginning of the turn, at the level of 6 000 m and the VOR Matsapa is technically impossible, even if one would assume conditionally that the crew set the frequency of 112,3 MgH.

According to the aero navigation plan of this particular region, besides VOR Maputo there is no radiotechnical ground devices working at frequency of 112,7. Consequently:

- The turn of the aircraft at 19.10'50" was executed by the crew on the basis of signals from a false VOR which had the working frequency of 112,7 MGh, power exceeding that of VOR Maputo by more than 6 db, and situated to the west of Maputo airport on the extension of the line corresponding approximately to 045° - 225° which passes through the point of the aircraft's taking the course of 221 M. The character of the flight line reconstructing the flight path of the aircraft from the moment of assuming the course of 221°M until the moment of its collision with ground at 19.21'39" indicates that the crew was maintaining the path corresponding with the radial 045° on signals of a false VOR. Both units of the KURS-MP-2 equipment were turned on the frequency of 112,7 MhG. During the flight, the crew (pilot or the co-pilot) periodically re-turned the first unit of this equipment on frequency ILS 110,3 MgH of the Runway 23 at Maputo airport. Since the aircraft was beyond the zone of the course beacon ILS, there was no interaction between the board and ground equipment.

Interpreting this fact as a failure of the ground equipment, and having the confirmation of this from the air traffic controller Maputo, the crew was setting again frequency of 112,7 MgH on the blocks of the KURS-MP-2 equipment of the first unit. After passing the place of the false VOR (crossing the "funnel"), the first unit KURS- MP-2 was returned to frequency 110,3 MgH ILS, and on the scale of the servo system of the navigation block UN-2P of this unit the azimuth value equal to 044,5° (Photo. 16) was fixed. The servo system of the UN-2P blocks is a component of the aircraft board equipment and works only in the condition of navigation on signals from beacon VOR. For the space of all time during which

signals are received, this system records magnetic direction from aircraft to the ground VOR and when it is re-turned on ILS frequency it de-energizes, fixing the last value of this direction, as it was in the moment of the returning. Because of very high gear ratio in kinematics of the revolution transmission from the electric motor to the scale of servo system, the value of radial 044,5° remained unchanged after the air crash. The UN-2P block retained its serviceability and was examined during the laboratory test. (Appendix to the Factual Report No 25-K-2) as a result of calculation and flight simultation on the simulator, it has been concluded that on the UN-2P block of the first unit KURS-MP-2 a radial confirming the fact of passing above the place of the false VOR situated in the region of the accident and working on frequency of 112,7 MgH was fixed.

During the entire flight, with the exception for its last section where the aircraft was maintaining the line corresponding to the radial 045° on the false beacon VOR signals, there was no conditions for receiving the value of 044,5° on the scale of servo system of the navigation block UN-2P.

Analysis of weakening of the false VOR and Maputo VOR signals caused by radio waves propagation in this region and by the diagram of the board aerial directional pattern, shows that, during the flight from 19.16'50" until 19.18'00", the values of the signal weakening from both beacons VOR are practically the same and that, in order to receive the radial on the false beacon VOR by the board equipment, its signal level must exceed the signal level from VOR Maputo.

The necessary excess of the signal level from the false beacon VOR could be attained in one of the following ways:

- by using a more powerful transmitter than VOR Maputo ("VMA 112,7);

- by elevating the aerial of the false beacon VOR above the surface of its installation; in this way the increase of the signal level is attained by enlarging the size of the "funnel" above the beacon (Fig. 6 and 7);

- by applying the system of directional radiation.

The false beacon VOR was installed in a way securing an approximately the same distance from the point of initiation of the turn to the right on 37° to the false beacon VOR and to the beacon VOR Maputo thus co-ordinating the moment of passing the false beacon with the computed time of entering the beacon VOR Maputo (with accuracy of 1 - 2 minutes) (Fig.1). This made difficult for the crew to identify in time the presence of false signals.

The false beacon VOR onto which the aircraft was lead during the last stage of its flight was situated on the line of the path in the region of the accident (Fig. 7). Technical information on one of such portable sets of the VOR equipment is given in Annex 2.

Analysis of the ground surface profile from the point of the aircraft's collision with ground towards the region of assumed situation of the false beacon VOR allowed, after the necessary calculations and simulation of the flight condition, to draw an objective conclusion regarding the radial 107,5° fixed on the scale of servo system on the UN-2P navigation block of the second unit KURS-MP-2 (phot. 17).

On the blocks of the second unit the working frequency of VOR Maputo ("VMA") 112,7 MgH was set. Up to the end

of the flight the crew did no re-tune this unit on another frequency. (Annex to the Factual Report No 25-K-2).

As a consequence of passing the place of the false beacon VOR, this unit registered the radial 045°, and servo system of the UN-2P block indicated this value on the scale, similarly to the process described above in the case of unit No 1 KURS-MP-2.

However, during the further flight on descent until the aircraft's collision with ground the signals from the falce beacon VOR were weakening for the following reasons:

- because of the gap in directional pattern of the board aerial at the rear sector the depth of which exceeds 10db (Fig. 8);

- because of the aircraft's entering the zone without an immediate radiovisibility of the false beacon VOR due to peculiarities of the ground surface profile in this particular region.

Computed value of weakening of signals from the false beacon VOR due to the relief on the flight level equal to 40m according to the radio altimeter, is -19,5 db (Fig. 9).

Weakening of the signal due to the distance (without considering covering up by the mountain) is -72,5 db.

Total weakening of signal from the false beacon, on the flight level of 40m according to radio altimeter is:

-19,5 db -72,5 db -10 db = 102db

Weakening of signals from the beacon VOR Maputo at this point (with the distance of approximately 60km) is

-96 db. Thus, the aircraft, during its further flight on the level of 40m, according to radio altimeter, entered the zone where weakening of signals from the false beacon VOR exceeded weakening of signals from the beacon VOR Maputo by more than 6 db. Further descent of the aircraft lead to even greater weakening of signals from the false beacon. At this ratio of signals, the 2nd unit of the KURS-MP-2 equipment on board began to register the radial on the beacon VOR Maputo.

On the scale of servo system on the UN-2P navigation block of this unit, the value 107,5° fixed (Phot. 17).

Further evidence of the false beacon VOR's work on frequency of 112,7 MgH and with higher level of signals than that of beacon Maputo, is the statement of Markesh and Bantisht, the pilots from Boeing 737 C9BAA aircraft whose board navigation equipment, in the same period of time and on the flight level of 310 (9500m), entered the influence of a beacon VOR having frequency 112,7 MgH at a distance of approximately 190 nautical miles (352km) from Maputo. The calculations done according to the abovementioned method (Annexure 10 ICAO, Aviation Electrocommunication, vol. 1, Fig. C-13) showed unambiguously that, for an inter action between the board equipment of the aircraft Boeing 737 flying at the level of 310 (-9500m) and the ground beacon VOR Maputo ("VMA" 112,7) being at the distance of approximately 190 - 180 nautical miles (350 - 334km), the presence of a beacon VOR of power more than 200W (23dbw) was necessary. The beacon VOR Maputo has the power of only 50W (17dbw) and its range on this particular flight level does not exceed 135 nautical miles.

Thus, during the indicated period of time, the board equipment of the aircraft Boeing 737 C9BAA was also interacting with the false beacon VOR working on frequency 112,7 MgH and having a higher signal level than VOR Maputo.

Appendix No 1

Results of the laboratory test regarding serviceability of the course channel on the KURS-MP-2 equipment during the VOR navigation, with presence of and after passing of two signals (with the central frequency of 112,7 MgH), with the frequency range between them from 0 to 10 KgH and with changing of the level of one of the high-frequency (134) signals.

Method and material of the test.

The test was conducted on the KURS-MP-2 equipment meeting requirements of the technical parameter norms. The stand KURS-74 and simulator LIM-70 which had been previously checked, were used for the test.

Evaluation of the character of two signals was done according to indications of the NKP instrument, its course bar and the needle of the IKU-IA indicator. Two signals from the non-synchronized sources LIM-70 were introduced in the input of the KRP-200P receiver through the power divider V-010. One signal (legitimate) had frequency of 112,7 MgH with modulation signal of changing phase 180° and with a steady level of VCh signal (further the discrete levels 2, 8, 10, 50 and 100 mkV were set), and the other signal (interference) had frequency towards 5 kgH and 10 kgH (after switching on LIM-70) and an even frequency with modulation by the signal of changing phase of 210° and of changing VCh level with relation to the first signal. At the absence of the interference signal, the course bar on the NKP instrument stood in the centre of the scale (azimuth on the course selector corresponds with azimuth of the input signal - 180°) and the needle No 1 on the NKU-IA was situated on the value 180°.

When introducing the interference signal of a level lower than working signal by 5 dB, the indications on the instruments were not changing. At the level ratio from - (minus) 4 dB to 4db indication became unstable and the fall-out of drop indicator was observed. As the level of interference grew by more than 4 dB with relation to the level of the legitimate signal, the bar had a tendency to shifting and was shifting to the right onto the second point, and the needle No 1 on the IKU-IA was approaching the indication 200°. When the level of interference grew by more than 10 dB with relation to the legitimate signal (thus, at the signal level of 10 mcV, the interference level is more than 32 mcV), information yielding on the instruments was showing steadily and accurately the presence of only one interference signal, i.e. the bar on the NKP was moving to the right (more than 400 mcA) and the needle No 1 indicated 210°. The results of changed yielding information were observed at all indicated ranges of frequency and at discrete level of the working signal.

The character of movements of the bar NKP and the needle on the IKU-IA with relation to the level of two signals is shown on Fig. 1, 2, 3.

Conclusion

At the simultaneous presence of two signals in the channel of the central frequency 112,7 MgH, differing in their frequency within the range from 0 to 10 kH (shifting of frequency is due to unstability) and in the level by 10 dB and more, the indications corresponding with the parameters of the greater signals were obtained on the indicators (the bar of the course indicators and the needle of the indicator of the current azimuth on the radio beacon VOR).

Fig. 1. Diagram of the planned and actual flight of the aircraft

Рис.I. Схема запланированного и фактического полета самолета от момента начала снижения.

from the moment of beginning descent

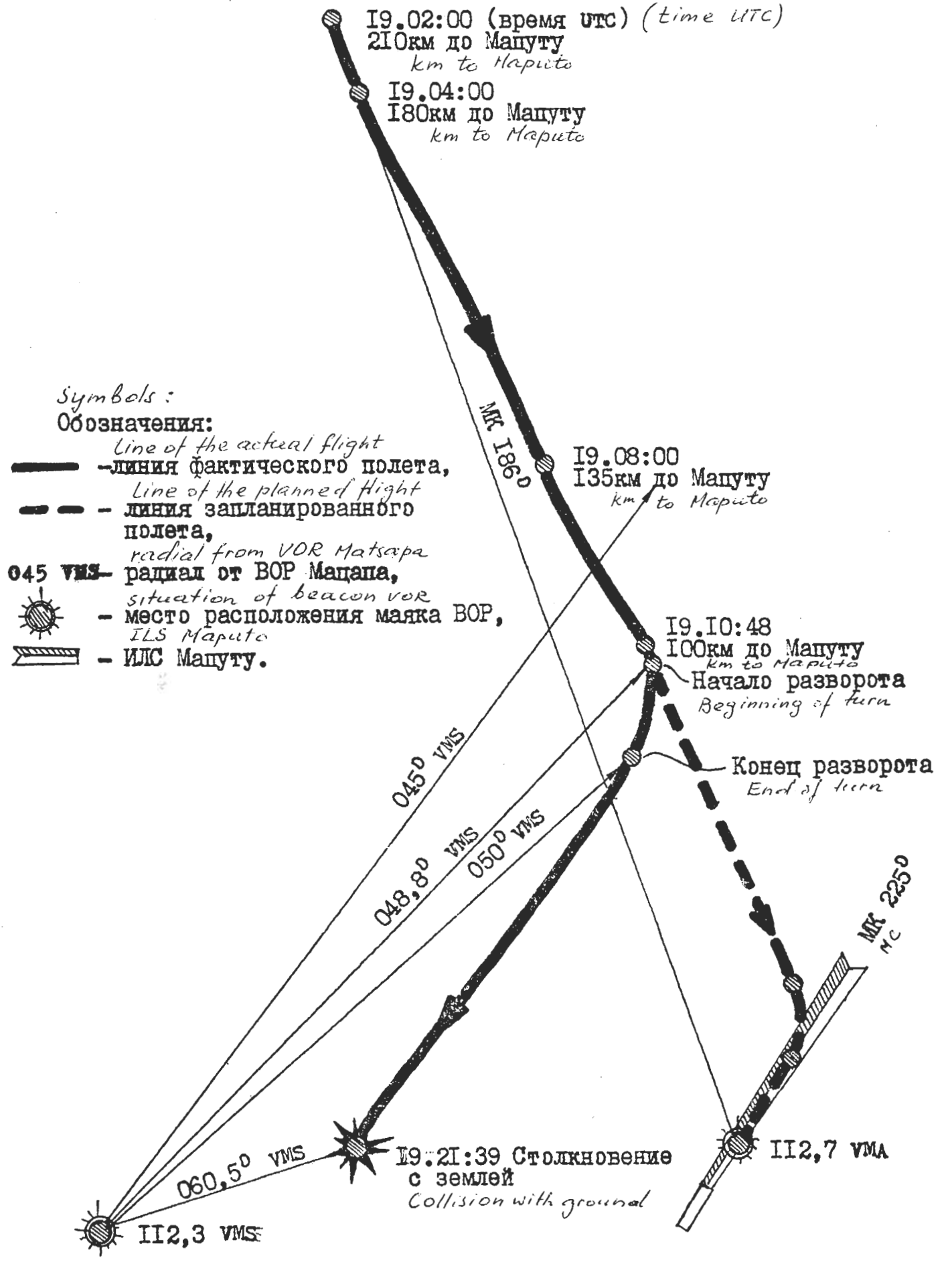
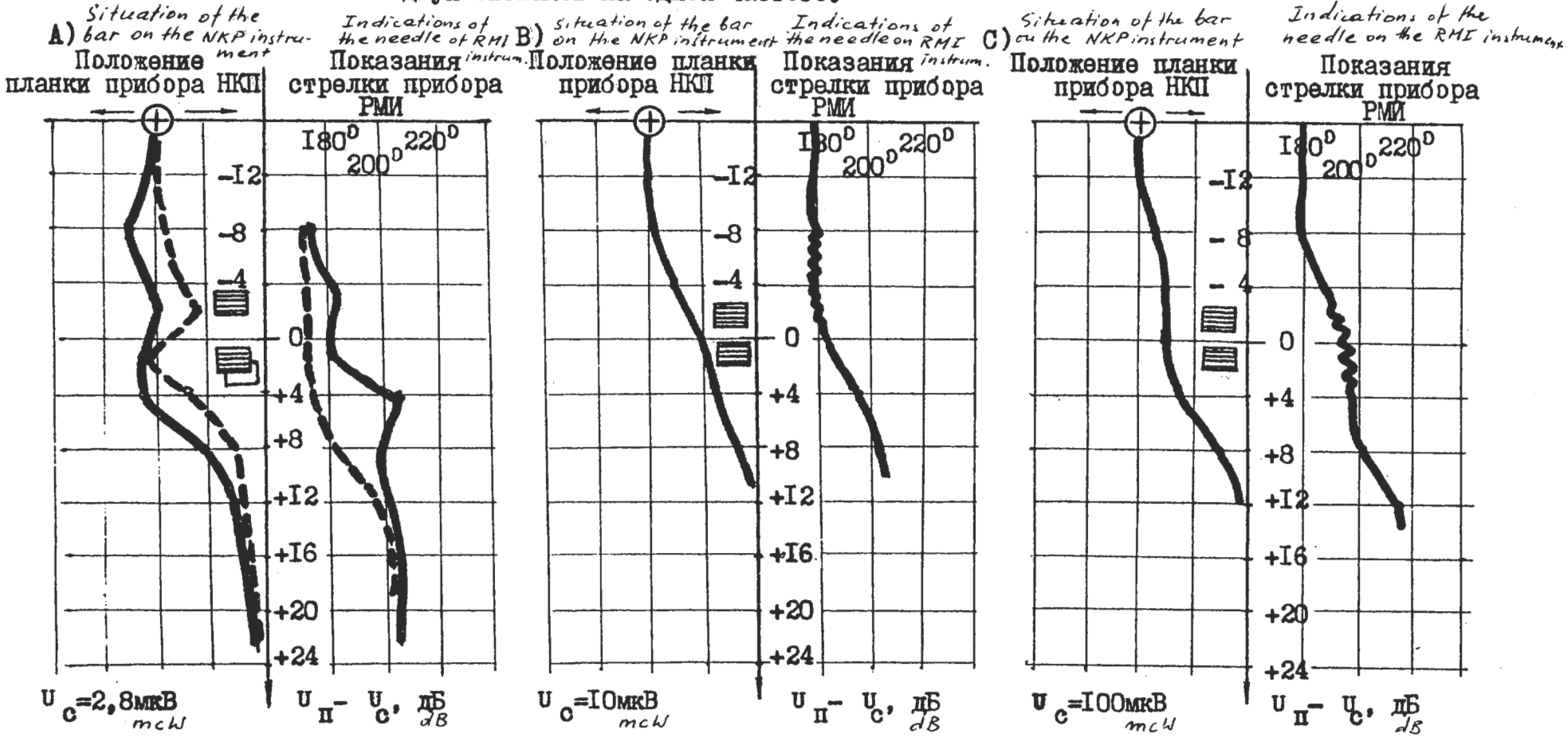


Fig.2. Work of the KURS-MP-2 course equipment with two signals on one frequency

Рис.2 . Работа курсового оборудования КУРС-МП-2 при наличии двух сигналов на одной частоте.



Обозначения: Symbols:

fall-out of the blinker indicator
– выпадение блинкера,

flashing of the blinker indicator
– мигание блинкера,

$f_c \cong f_п$,

$f_c = f_п - 5$кГц, kHz

где where f – частота колебаний сигнала frequency of the signal oscillation

Index "c" - signal
Индекс "с" – сигнал,

Индекс "п" – помеха.
Index "p" - interference

Fig. 3. Plot of the aircraft's path within the time from 19.02:00 until 19.10:50 according to data from MSRP (DFDR)

Рис. 3. Прокладка линии положения самолета в период времени от I9.02:00 до I9.I0:50 по данным МСРП.

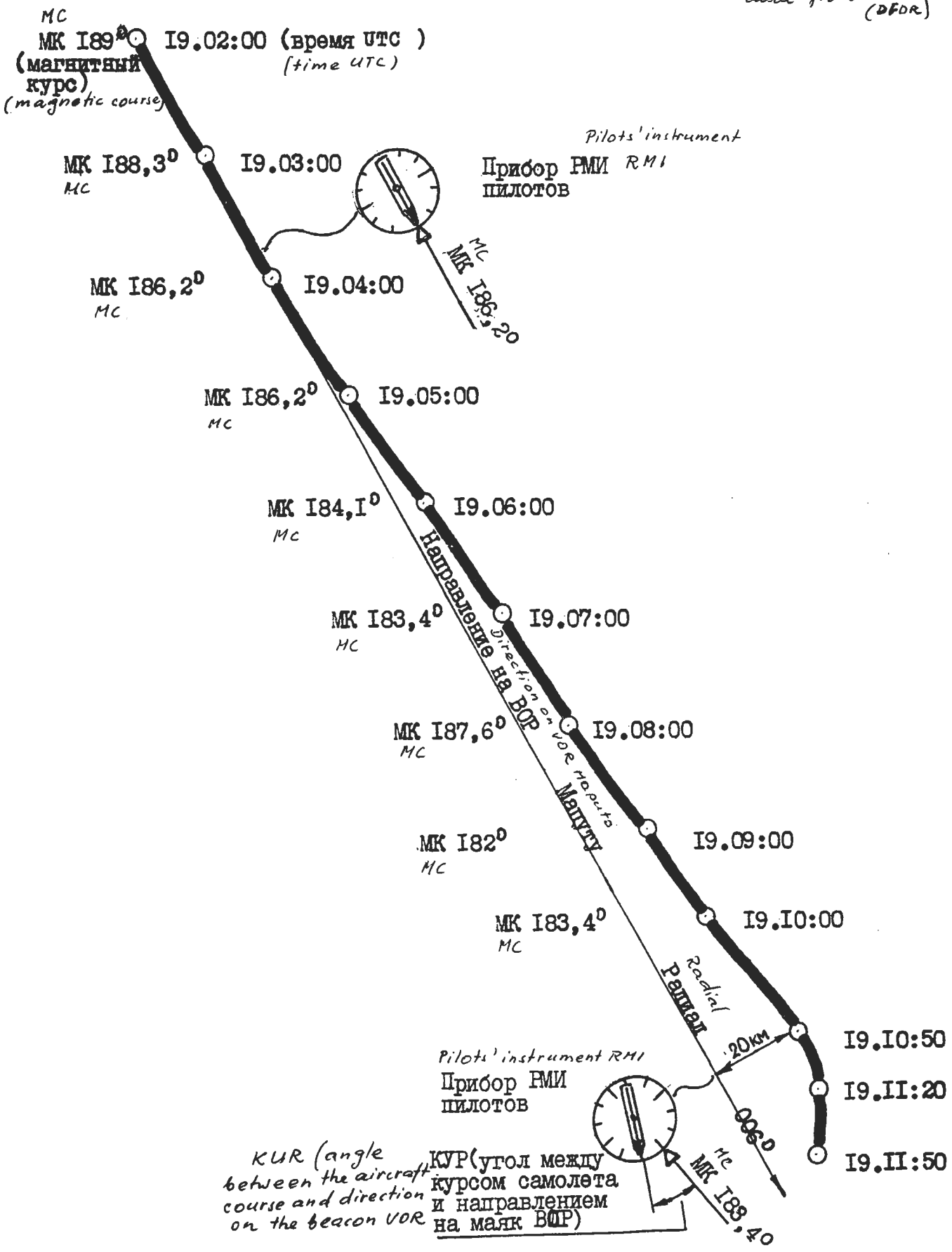


Fig 4. Relief of the region on the radial 048,8°
Рис. 4 . Рельеф местности по радиалу 048,8°
от ВОР Мацапа 112,3 VMS
from VOR Matsapa 112,3 VMS

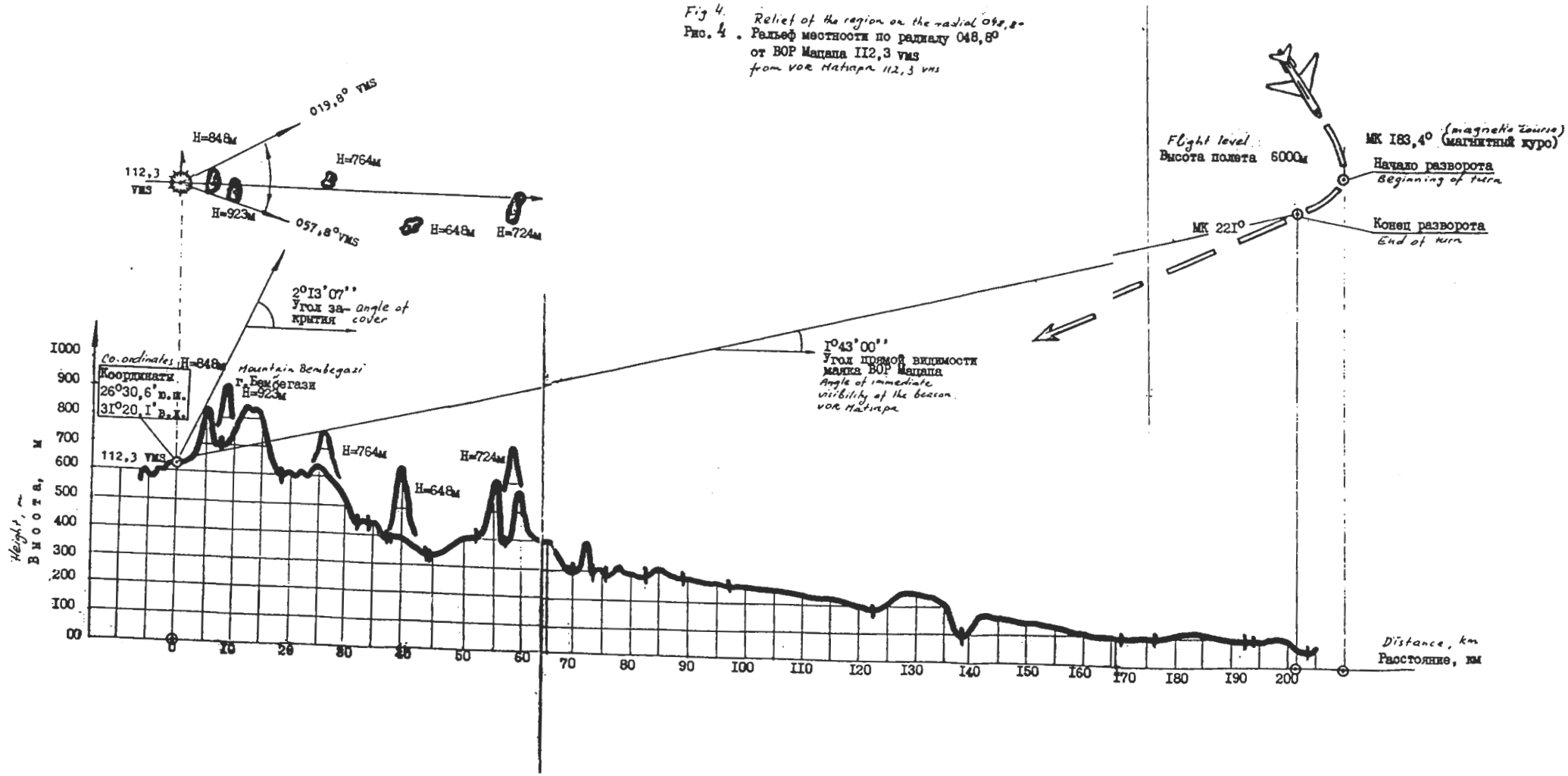


Fig. 5 The aircraft's path after

Рис. 5 . Линия пути самолета после выполнения разворота вправо на 37°.

execution of the right turn on 37°

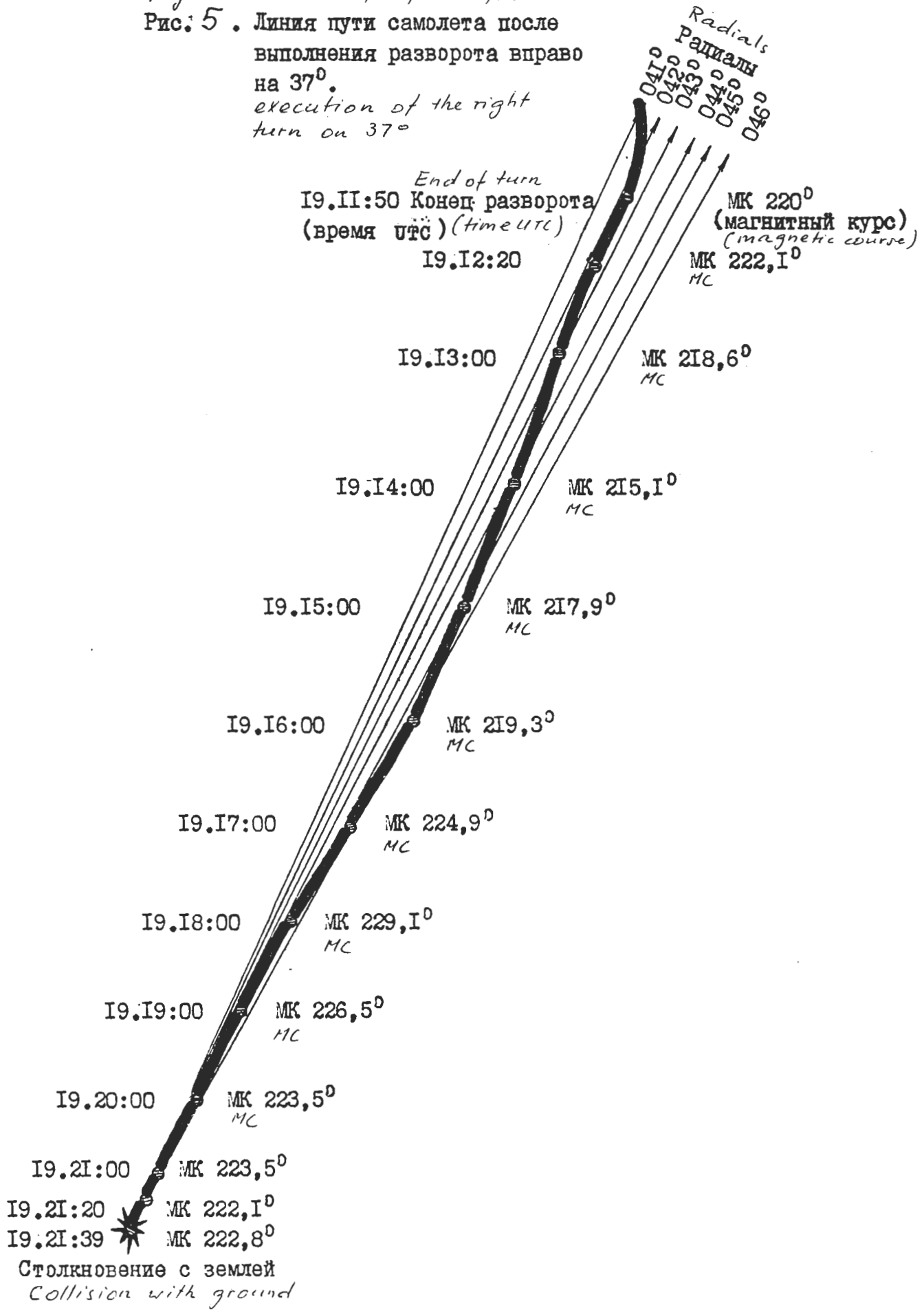


Fig. 6. Signal levels from the beacons VOR in the place of equal powers of the transmitters

Рис. 6. Уровни сигналов маяков ВОР на местности при равных мощностях передатчиков.

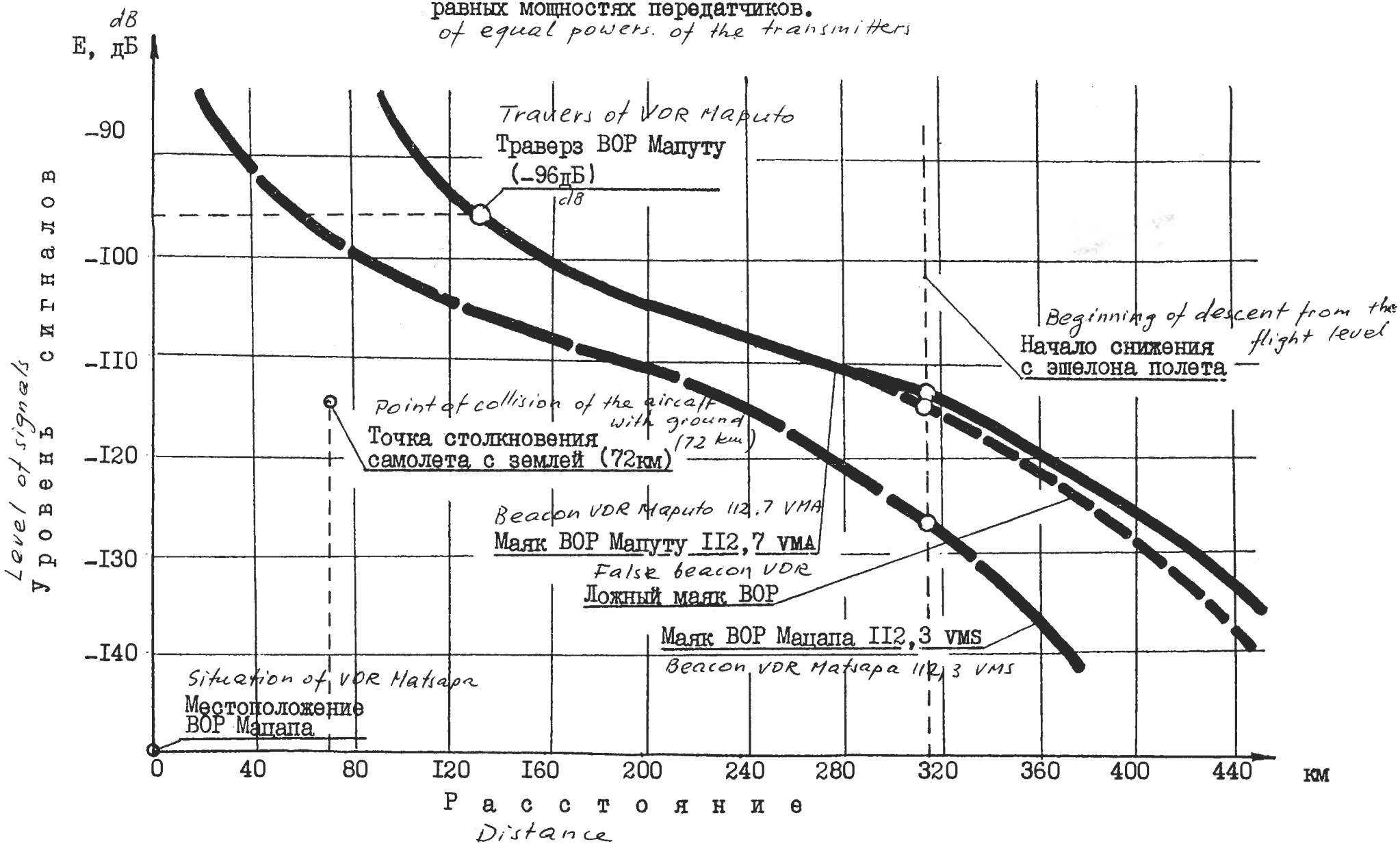
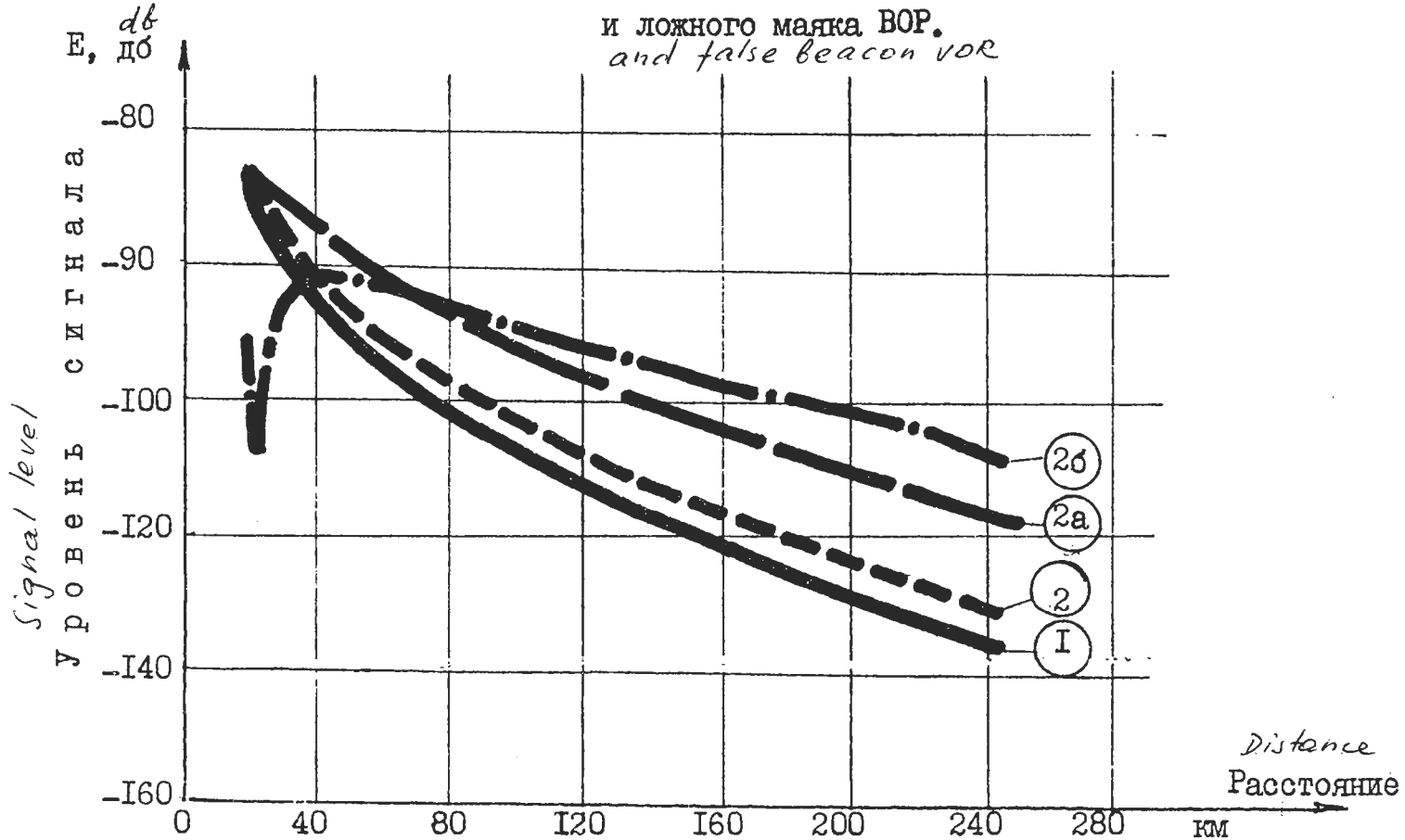


Fig. 7. Signal levels in the place from the beacon VOR Maputo and false beacon VOR

Рис. 7. Уровни сигналов на местности от маяка ВОР Мапуту и ложного маяка ВОР.



Symbols:

Обозначения:

I –сигнал маяка ВОР Мапуту II2,7 VMA Signal of the beacon VOR Maputo 112,7 VMA

2 –сигнал ложного маяка ВОР с высотой антенны 7м Signal of the false beacon VOR from the high aerial of 7m

2а –сигнал ложного маяка ВОР с высотой антенны I5м → Signal of the false beacon VOR from the high aerial of 15 m.

2б –сигнал ложного маяка ВОР с высотой антенны 20м → Signal of the false beacon VOR from the hight aerial of 20 m

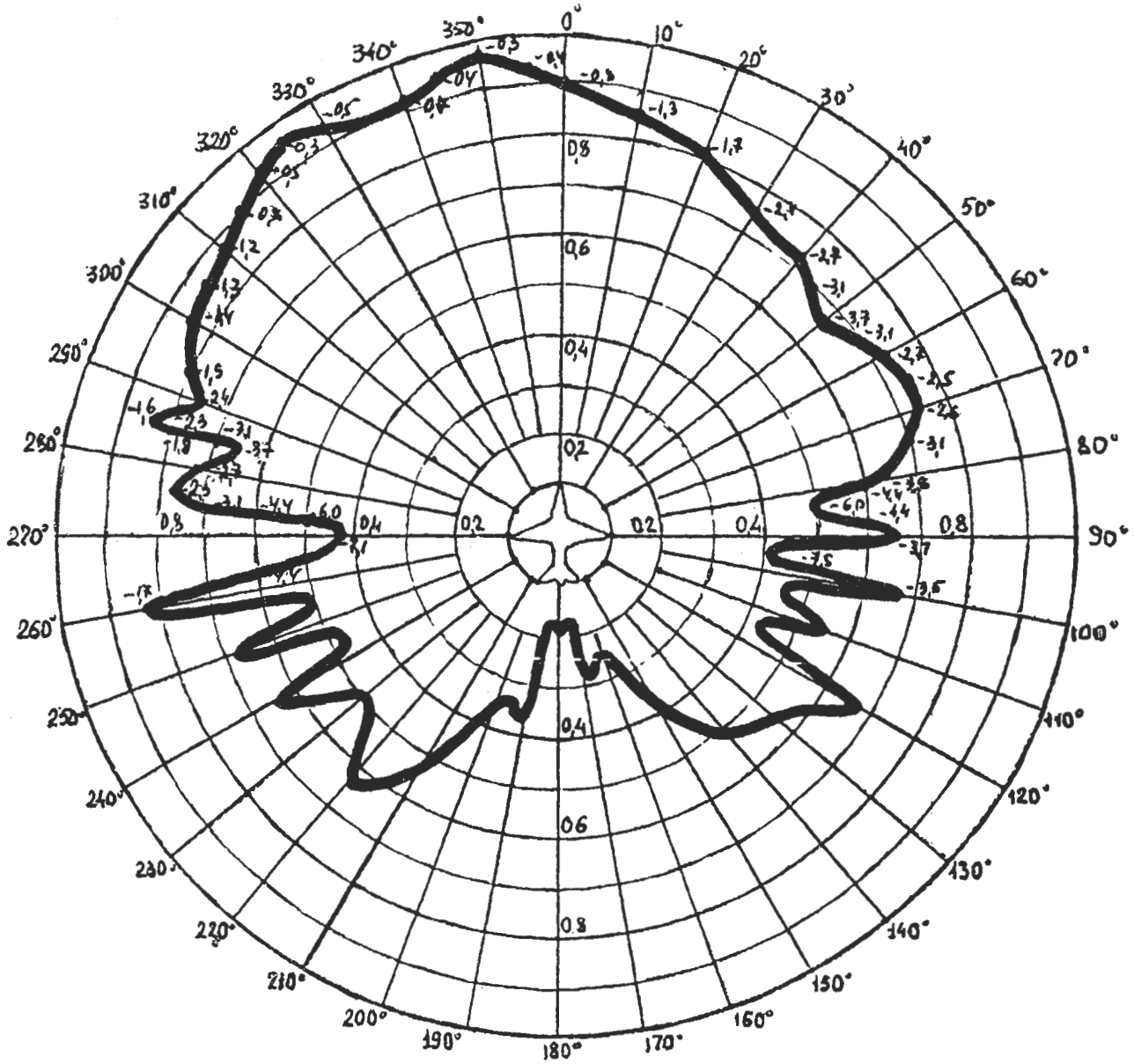


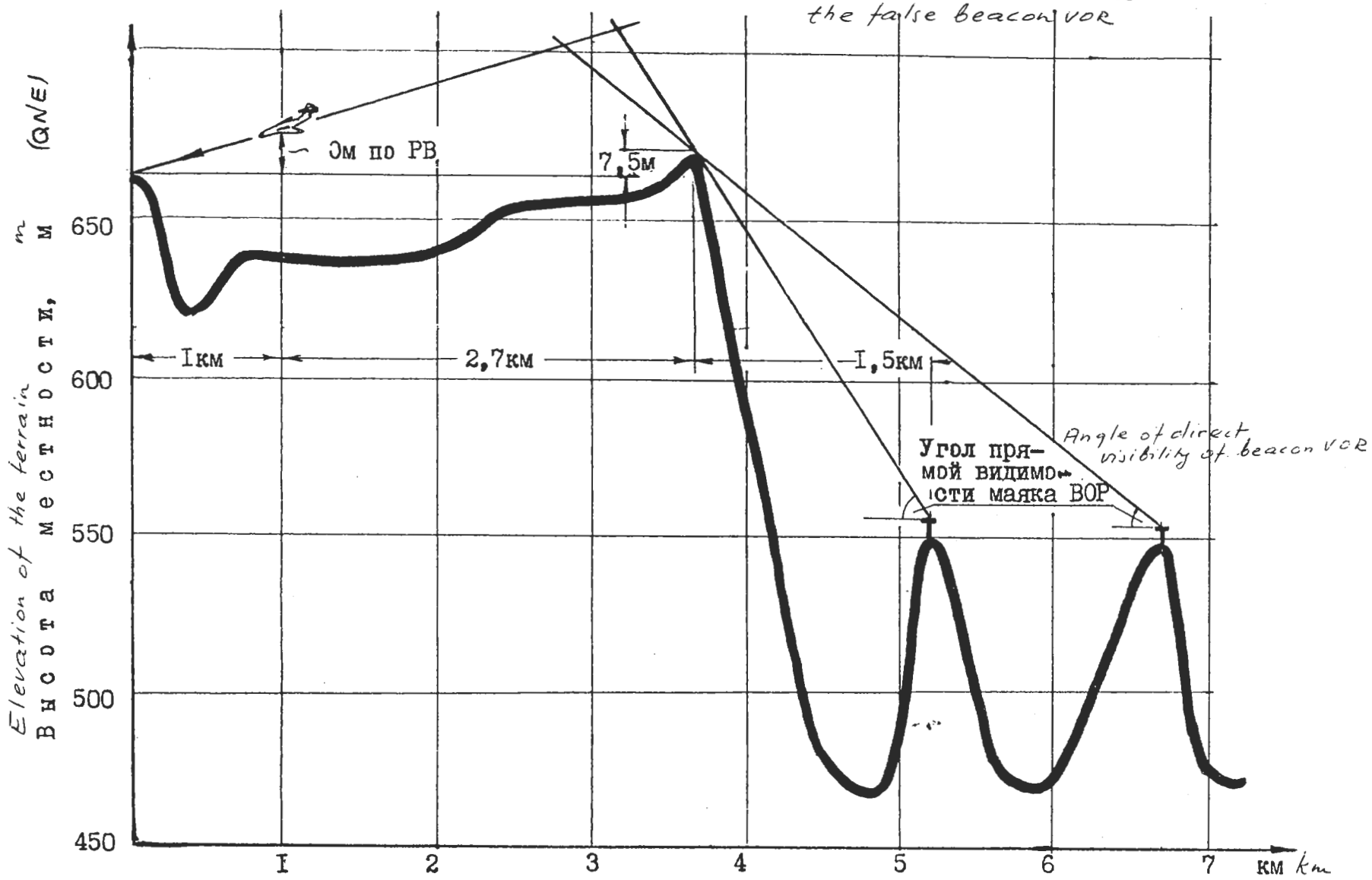
Diagram of directional patter of the aerial
Д.Н. курсовой антенны

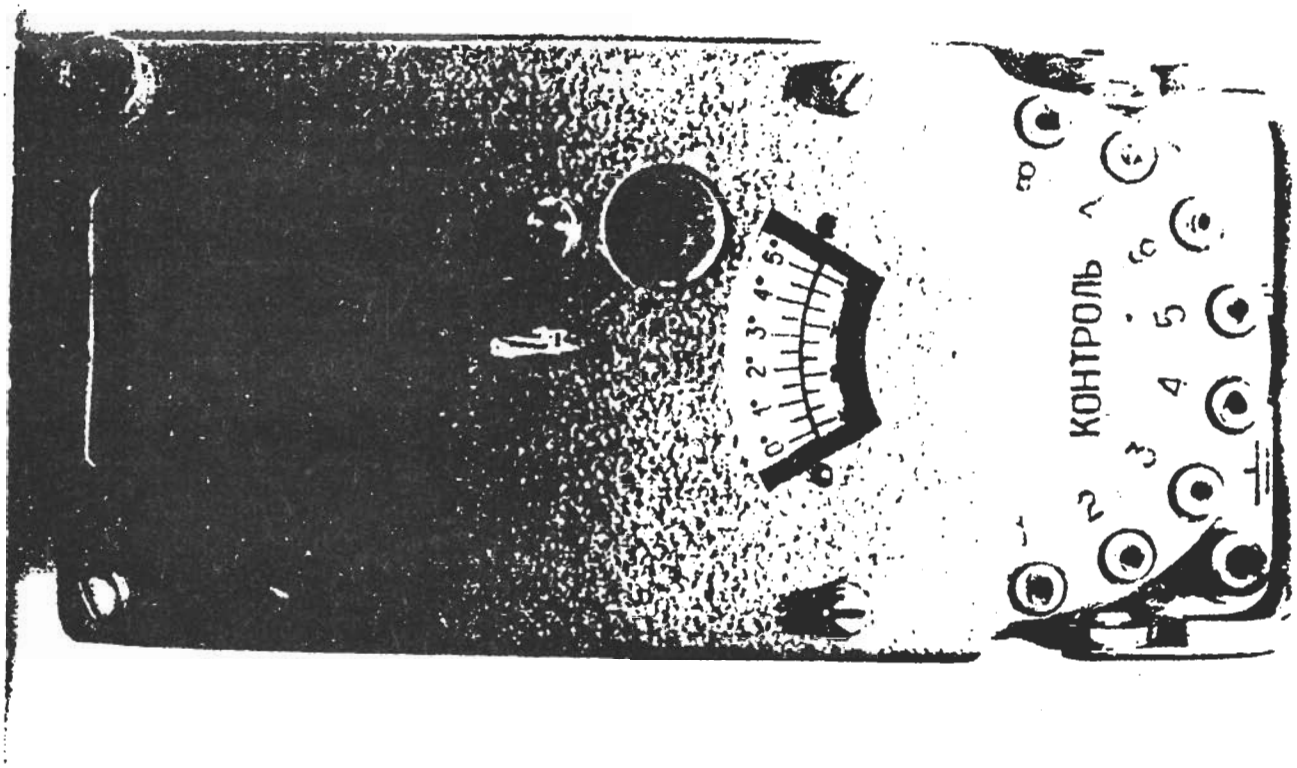
Самолет Aircraft	№65667 ТУ 134А ТИ-134А
Аппаратура Equipment	КУРС МП-2 KURS-MP 2
Антенна Aerial	курсовая directional
Частота f frequency	111,0
Н H	4000 м
Д, А D, A	165 км 118÷125°

Рис. 8. Диаграмма направленности курсовой антенны самолета.
Fig. 8. Diagram of directional pattern of the aerial

Fig. 9. Influence of the region relief on weakening of the signals from the false beacon VOR

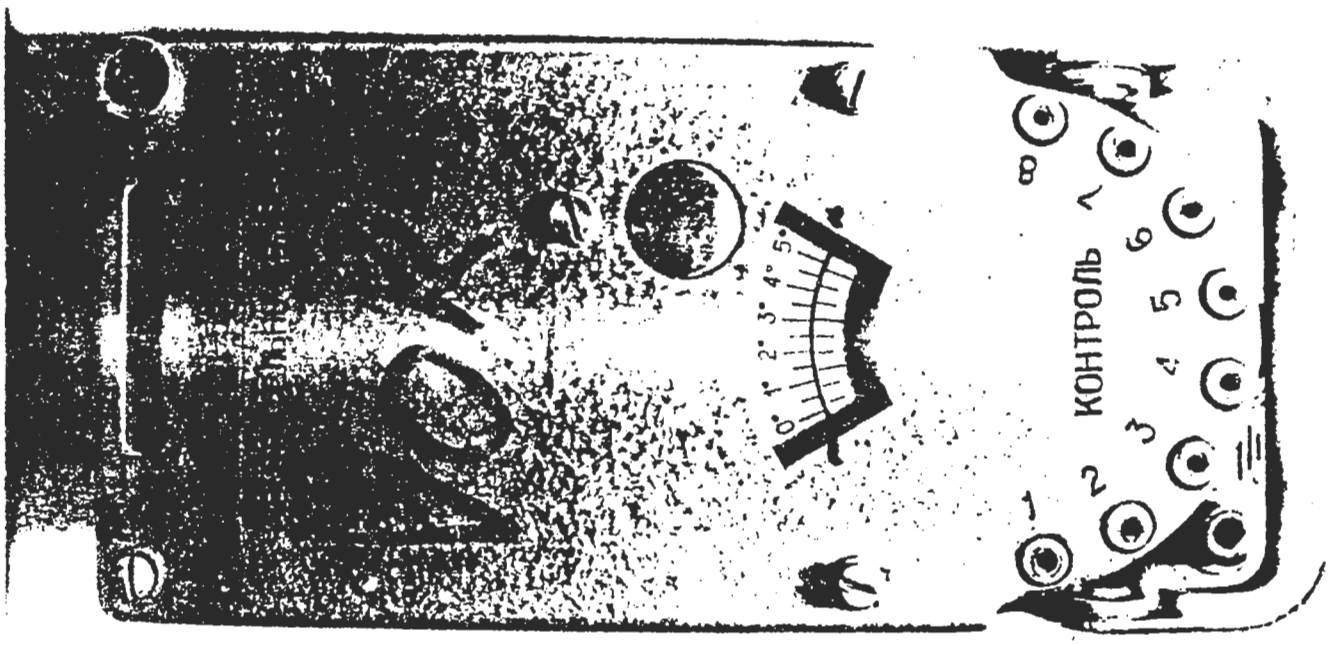
Рис. 9 .Влияние рельефа местности на ослабление сигнала ложного маяка ВОР





The scale with the vernier of servo system mechanism on the UN-2P ~~block~~ № 188783 intended for the control
Phot. 16. of working-out the azimuth on the radio beacon

Фото I6. Шкала с нониусом механизма следящей системы блока УН-2П № I88783, предназначенного для контроля отработки азимута самолета на радиомаяк



The scale with the vernier of servo system mechanism on the UN-2P block № 188787 intended for the control
Phot. 17. of working-out the azimuth on the radio beacon.....

Фото I7. Шкала с нониусом механизма следящей системы блока УН-2П № I88789, предназначенного для контроля отработки азимута самолета на радиомаяк

COMMENTS BY THE MOZAMBIQUE AND SOVIET DELEGATIONS ON THE DRAFT FINAL REPORT AND THE BOARD'S REPLY THERETO

1. The Board appends the respective comments by the Mozambique and Soviet delegations. The Board has amended the draft Final Report in the light of certain of the comments by Mozambique.

   The Final Report now covers all the points dealt with in the comments, save that certain matter not raised before the Board at its hearings calls for additional responses. These are dealt with briefly in what follows.

2. In the interest of fairness the Board wishes once again to emphasize that neither Mozambique nor the USSR was deprived of any rights in the inquiry. On the contrary, rights of participation far beyond those recommended in Annex 13 to the Chicago Convention were accorded, but declined.

3. Neither set of comments touches the Board's analysis and conclusions on the real cause of the accident. Whatever the reason for the premature turn of 37° to starboard, that was not the real cause of the accident any more than was the flight itself. The fact that the aircraft was well to the west of its destination did not in itself create a dangerous situation. There were abundant indications to the crew, by normal cross-checking and otherwise, that the aircraft was not over Maputo, and there is no doubt that they could and should have determined the aircraft's actual position in good time and landed safely. The fundamental and effective cause

of the accident was as stated in paragraph 3(b) of the Report.

4. Not in the comments, but in its letter to the Board under cover of which Mozambique submitted its comments, the following is said, inter alia:

> "It is also of concern to Mozambique that no flight test was carried out to replicate the flight path of the TU-134A-3 when it is claimed the crew may have tuned to the Matsapa VOR. The exercise flown in the B.737 simulator cannot be an adequate substitute ....."

At an early stage the Chairman of the Board, in answer to his request to the RSA Directorate of Civil Aviation to arrange for appropriate tests of the Matsapa beacon, was informed that Swaziland had been agreeable to an inspection of the beacon, provided all three States agreed, but that Mozambique would not give its consent. It was always open to Mozambique to arrange a flight over its own territory to test the range and strength of the Matsapa beacon and to inform the Board of its findings.

In the event the Board has evidence of actual flight experience which proves that the Matsapa VOR signal could have been received clearly by C9-CAA well before the point at which the aircraft made its 37° turn.

The Board has now completed its duties to the best of its abilities. It sees no useful purpose in indefinite prolongation of the inquiry for further investigations.

The Board urges Mozambique to collaborate with the RSA's Directorate of Civil Aviation with a view to

with the statement in Attachment C to Mozambique's comments, that:

"It would be difficult to ensure that the radials so produced (i.e. by a decoy beacon) would supplant the genuine radials by well aligned substitutes to a different origin. Unless the Maputo DVOR was switched off the aircraft's receiver would interpret signals produced by a subsidiary mobile DVOR or VOR by measuring the summations of the phase difference with a proportional bias toward the stronger of the two signals. The simplest and most effective way to produce accurate radials would be to switch off the Maputo DVOR during the period any mobile decoy VOR was activated."

The evidence being that the Maputo VOR functioned normally throughout, this statement in Attachment C provides a further indication that on the probabilities there was no beacon simulating that at Maputo. It is noteworthy that the Soviet delegation, in its comments, concedes in effect that the Maputo VOR was operating prior to and at the time of the crash. This follows from the capture of Maputo VOR radial 287.5° on impact. See the concluding portion of paragraph 2.1 on page 86 of the Report.

10. On the question of whether C9-BAA's flight was straight or curvilinear, the expert evidence establishes that it was straight. It is unimportant whether a curvilinear path would be smooth or irregular. On the facts the path was not curvilinear.

11. Mozambique says that it does not necessarily follow that the navigator's OBS/CDI was directly coupled to the No. 2 VOR receiver. The coupling can be made to the No. 1 VOR by the selection of "one" on the system selector.

using one or more of the flights into Maputo to demonstrate the operation of the Matsapa VOR with the Maputo VOR under conditions corresponding to those of C9-CAA's last flight, in order to dispel Mozambique's suspicions, should any still remain.

5. In the Soviet delegation's comments (see the Technical Appendix to the Analysis page 25) theoretical calculations are used to support the claim that the Maputo VOR signal was not powerful enough to exceed 135 nm. and therefore that there must have been a more powerful signal "from a false beacon" to reach the Boeing 737 aircraft, C9-BAA, at a distance of approximately 190 nm.

This overlooks the evidence of the co-pilot of C9-BAA that on previous occasions the Maputo VOR had been picked up at 180 miles and even more - he could remember 216 miles.

6. As to the necessity of planning for an alternate aerodrome of destination:

(i) This was a VIP flight over a long distance, with a projected night landing, over terrain with few navaids, some of which were in any event unserviceable or unreliable.

(ii) It is notorious that weather forecasts in this vast, relatively underdeveloped part of Africa cannot always be reliable and that rapid and unexpected weather changes may force temporary closure of the aerodrome of destination.

(iii) As Mozambique itself pointed out (in the Analysis), during the near 18 months of the crew's experience at Maputo, "frequent breakdowns occurred in the electrical supply due to

sabotage". Other occasional unlawful activity in and around Maputo has also been reported.

(iv) In view of these circumstances and the importance of the flight, the requirements of good airmanship and reasonable safety precautions included provision for reaching an alternate aerodrome other than on an en route basis.

In the Soviet Analysis (page 4), it is claimed that there was enough fuel for continued flight for one hour, and in effect it is denied that the fuel state could have caused any problems.

This calculation is by no means certain (the Board's estimate was 50 minutes), and besides it is an estimate of the fuel available to the point of dry tanks, which is not an appropriate evaluation of the remaining endurance. The truth is that there was insufficient fuel to reach an acceptable alternate and that the crew had no choice: they had to land at Maputo. The pressures on the crew created by this factor are obvious.

7. In the Mozambique comments it is said that some pilots may use the Maputo broadcasting station to listen to music but it is not commonly used for navigation and is not authorised as an aeronautical navigation aid.

The information given to the Board was that, because of the poor range of the approved NDBs, the broadcast station is used extensively for initial homing to Maputo, even though it is not an approved navigation aid. The LAM pilots and the Mozambiquan helicopter pilots confirmed this. The frequency is published in the Jeppesen manual under Broadcast Stations.

8. Mozambique says that, according to the survivors' statements, the RSA Police, upon arrival at the accident site, engaged in an extensive search of the aircraft for documents with little or no care for the injured passengers.

The agreed joint factual report records that the first member of the Komatipoort Police Station arrived at the scene of the accident at 2340. Other members of the South African Police arrived at intervals after this. As they were afraid that the survivors might be injured if they were moved, they rendered what comfort they could and attempted to protect them from the elements.

The District Surgeon based at Komatipoort was the first medical person on the scene, being advised at about 0015 and arriving at 0100. The treatment given by him was that of comfort and pain killing injections as he did not have the necessary equipment with him to give further aid. The local clinic could also not be of any assistance in this respect and the only real treatment started once the military team arrived.

The SAAF helicopter and medical crew at Hoedspruit were alerted at 0155 and the medical staff departed by helicopter at 0255. The crew arrived at Komatipoort at 0345 whereupon they were briefed on all the available information. They then arrived at the scene of the accident shortly after 0400 and within 20 minutes had the survivors placed on board a helicopter and flown to Nelspruit Hospital. One survivor refused to be taken by helicopter and was sent to Nelspruit by ambulance.

These agreed facts and the evidence of the police and District Surgeon contradict the statement of

the one survivor. He was not made available by Mozambique to testify before the Board. Mozambique having supported the facts as set forth in the agreed joint report, there was no call for the Board to go behind that report on this aspect.

9. Mozambique in its comments says that C9-BAA was flown towards Maputo with the autopilot in the heading mode, and disputes that the aircraft used the Maputo VOR on the leg from Beira towards Maputo. Thus, it is argued, there is no proof that the Maputo VOR was then operational.

The statement that the Boeing 737, C9-BAA was flown towards Maputo with the autopilot in the heading mode is correct. The captain said that he had done so. However, to say that the crew did not use the VOR (VMA) on the inbound leg is not correct. The captain stated that they had received the VOR at between 170 and 180 nm and also that he knew that he was to the right of track because the Flight Director command bar indicated not more than one and a half dots. The Flight Director could only present this information if a VOR signal was being received and the OBS was correctly set.

Both the captain and the co-pilot of C9-BAA were emphatic and clear on the use of the Maputo VOR on the flight towards Maputo and on the fact that it operated normally and correctly. Besides, what reason could there have been for not using the VOR, the main directional instrument, at least as a check? That would have been an unusual departure from normal navigation procedures. As the Mozambique comment states, after turning back to Beira, C9-BAA flew for 26 minutes on an outbound radial from Maputo VOR.

In the interrogation of the captain and of the co-pilot, conducted by the Mozambiquan authorities, it is obvious that some of the questions were aimed at establishing that C9-BAA was to the right of track because of the presence of a so-called decoy beacon. On this premise, the alleged decoy beacon would still have been switched on when C9-BAA was 180 nm from Maputo, i.e., at about 19:41. If there was such a beacon at the place alleged, then under its influence, the captain would have had an indication of being well to the left of track, with a full fly right command on the Director. On Mr Caiger's evidence, C9-BAA was on track on its flight towards Maputo.

Although not raised in Mozambique's comments, there is a point which it is convenient to mention here. The draft final report has been amended to correct a miscalculation which, through an oversight, was not eliminated in the copies distributed. As appears from the corrected statement, C9-BAA received the Maputo VOR signal during its flight, but not during the last 14 minutes of C9-CAA's flight. It was from a time which commenced approximately 20 minutes after C9-CAA crashed, and continued thereafter.

Thus, there is evidence that the Maputo VOR was functioning normally shortly after the crash.

There is also direct evidence from the Navaids Engineer who was on duty at Maputo from 20.00 local time (18.00 UTC) on 19 October 1986 until 06.00 (04.00 UTC) the following day, that the VOR functioned normally throughout. He also explained that there was a VOR monitor which sounded an alarm in the tower if the VOR was off. This is to be linked

The original evidence, in demonstrations before the Board, which information was said to have come from the Senior USSR navigator, was that the navigator's OBS/CDI was coupled to No. 2 VOR only. The Flight Manual is not clear. It is now evident that the OBS/CDI could have been coupled to either No.1 or No.2 VOR, and that it was standard operating practice to couple it to the No. 1 VOR. This widens the possibilities to include an erroneous selection by the captain or co-pilot on No.1 VOR of the Matsapa VOR, the frequency of which is 112,3 MHz, compared with Maputo's 112,7 MHz. This aspect has been developed in the Final Report. See pages 80 - 86 of the Report.

12. Mozambique says that the most probable flight path agreed to by the three teams which assembled the agreed factual report was that which was prepared in Moscow by the USSR delegation, and, that that flight path did not coincide even approximately with the 045° radial from the Matsapa VOR.

The Board accepts that the turn, according to the most probable flight path, was not <u>exactly</u> on the 045° radial from the Matsapa VOR. The Mozambique measurement of the 047° radial is nearer the mark. However, VOR is subject to the following errors:

(a) Site error: Uneven terrain, physical obstacles, etc. in the vicinity of a VOR transmitter affect its directional propagation. VORs are ground-monitored to an accuracy of approximately 1°.

(b) Propagation error: The signals having left the transmitter with an accuracy of approximately 1°, suffer further inaccuracies as they travel forward. Features that affect the sig-

nals at the site continue to affect them throughout their passage to the receiver.

(c) Airborne equipment error: Inaccuracy is introduced during the signal processing and even the indicator contributes to these errors before the information is displayed.

Therefore, it is impossible to know if the aircraft was on the 045° radial or even the 047° radial, but it appears that there was at least a 2° positive error present and that 045° was indicated. In the simulator reconstruction of the flight the turn coincided exactly with the 045° radial, but of course there are minimal errors in the simulator VOR system. C9-CAA, however, did not establish itself on the indicated radial.

13. Mozambique does not accept that "the only explanation for the turn was that the No. 2 VOR was temporarily selected to the Matsapa VOR". Mozambique believes there is a reasonable alternative explanation, but that notwithstanding, it would have been quite practical for the No. 1 VOR to be selected to the Matsapa VOR and the result used by the navigator as explained above.

It is now accepted that either the No. 1 VOR or the No. 2 VOR could have been selected (see paragraph 11 above). The Board agrees that it would have been quite practical for the No. 1 VOR to be selected to the Matsapa VOR and the result used by the navigator. The Board goes further in its finding that that is most probably what happened.

14. Mozambique says that the factual information does not explain how the co-pilot would have been aware of the existence of Matsapa VOR, and that there was

no evidence to confirm that the crew had access to the NOTAM relating to the Matsapa facility being on test.

The information before the Board is that, in practice, in this vast area of few facilities, aircrew do not restrict themselves to Airway Manuals and NOTAMS. For instance, Matsapa must almost certainly have been considered as an alternate for Maputo on previous daylight flights and presumably the crew were then properly briefed on the available facilities, including those on test. It is noteworthy in this regard that, on information given to the Board, the President flew to Maputo, in C9-CAA, for the coronation of the Swazi King as far back as 25 April 1986.

15. Mozambique argues that the crew could not be sure of the transition altitude as the procedure was for the controller to specify the transition altitude for each flight on the basis of the local barometric pressure situation.

The answer is that the transition altitude at Maputo is not a fixed figure. The crew reported at 3 000 feet, which is a flight altitude. As the QNH of 1017 hPa had not been set on the altimeters it was incorrect for them to report in this manner. Moreover, the controller should not have cleared the aircraft down to 3 000 feet without advising the transition altitude. The effect of the 120 feet error in the altimeter caused by the crew's failure to set the local QNH was that the altimeter would have under read by 120 feet, showing the aircraft to be that much higher than was actually the case.

16. Mozambique says that it is not correct to state that the sole function of the Maputo VOR or any

other VOR upon which an instrument let-down procedure is authorized, is to indicate azimuth, in that, for an aircraft following a radial to the overhead position, "the aid fixes a position from which a descent may be commenced below MSA".

It is correct that arrival over the VOR facility would fix the overhead position from which a descent procedure may be initiated, but the VOR signal by itself cannot provide the data upon which a descent can be attempted, either on instruments or under VFR in darkness and clouds, without visual contact with the ground.

17. Mozambique contends that the pilot apparently accepted the reply to his query about the 37° turn to the right, as he did not press for any further explanation; that this indicated that he had subsequently satisfied himself that the turn was required, probably by a study of his instrument indications; and that the fact that to be so convinced he had to ignore the recent advice that they were 100 km from destination suggests some degree of certainty, concerning the reliability of information on their instruments about the interception of the 045 radial from the VOR station.

The Board's view is that the captain may have obtained the radial information from his RMI but certainly not from his flight director. With his course setting still on 164° he would have received a full fly right indication to establish on the 344° radial. It is more likely that he was satisfied with the heading of 221° which was almost what he required for a straight-in approach to runway 23, considering that 16 seconds after the navigator's comment 'VOR indicates that way', he was looking for a pen.

18. Mozambique says (in its Analysis, paragraph 2.3.2): "In figure I (annexed to its submissions), taking as a reference a line parallel to the one indicating the correct track for a landing on the Maputo 23 runway, it can be seen that the turn started slightly after the instrument indicator bar had started its movement from right to left towards the centre of the instrument, that is, when the radial was about 4° to 5° less than a 045° radial from the direction of the accident site e.g. a signal simulated to be from the Maputo VOR."

With due respect, the Board would point out that the CDI indications with the OBS set on 225° would have been opposite to what is stated, ie. a full fly left would have been indicated until the aircraft intercepted the indicated 035° radial, when the command bar would have started to move towards the centre. On crossing the indicated 045° radial the command bar would have started swinging to the right indicating that a turn onto 225° was required to maintain the 045° radial, assuming zero wind.

A 1:1 000 000 map is annexed showing the track of C9-CAA.

19. In this and the following paragraphs through to paragraph 29, the Board deals with the remaining Soviet and Mozambican submissions on the existence of a decoy beacon.

According to the theory of a false beacon, as indicated to the Board (see the Report, Appendix 1), it was located at the camp site, 150 metres south east of the point at which the aircraft first made contact with the ground. In the Technical Appendix to the Soviet comments (at page 23), it is said that

"the false beacon VOR was situated ..... in the region of the accident". See also page 22.

The aircraft flew into the ground only 150 metres inside the RSA-Mozambique border, at a speed of 411,4 km per hour or 114,27 metres per second. The last 150 metres would therefore have been traversed in less than one and a third seconds. If (as said on page 21), after the aircraft had passed the alleged false VOR, i.e. crossed the "funnel", the first unit KURS-MP-2 was returned to the ILS frequency, the alleged decoy beacon must have been in Mozambique near the Mozambican army unit over which the aircraft passed. Figure 9, read with pages 24 to 25 seems to indicate that the alleged decoy beacon was some 7 km inside Mozambique. No doubt it is this speculation that led to the statement in the "Closing Conclusions" (at page 16) that the alleged device was "situated beyond the limits of Maputo airport". See also page 11. The vagueness of this proposition raises further improbabilities against the existence of a decoy beacon.

In this regard the inconsistency between the Soviet and Mozambique contentions adds to the difficulties in the way of finding as a fact that there could have been a decoy beacon. It is noteworthy that the Soviet comments do not suggest that the alleged false beacon was in RSA territory.

20. In the Soviet comments it is asserted that before the collision the aircraft flew over a false VOR beacon, and that the crew, believing that they had "approached" Maputo, returned the first half-unit to the ILS frequency for landing approach (pages 10 to 11 and page 21). The suggestion that the KURS-MP-2 first set was on the VOR frequency <u>after</u> passing the alleged false beacon and was returned

to ILS fundamental to the Soviet theory. It is difficult if not impossible, to reconcile this with the evidence, more particularly in that:

20.1 (a) The crew were certain that they were on course for Maputo well before reaching the place of the alleged beacon. Why should they have returned from ILS to VOR even if they thought that the ILS was not working? There is no evidence on the CVR that they did so.

20.1 (b) However, if they did return to VOR, this must have been for the purpose of observing it; they must then have seen changes in the reading which would have occurred when passing over the funnel and beyond and they would have known that they had passed over the beacon.

20.1 (c) Passing over what was believed to have been the Maputo VOR beacon must surely have induced some crew reaction, especially in the anxious atmosphere that had arisen. There was no such reaction on the CVR; nor was there any change in the conduct of the flight which would have been the inevitable consequence of passing over the beacon.

20.2 Passing over the "funnel" would have meant that they were still certain of their position, but the navigator's response was "No, no, there's nowhere to go, no NDBs, there's nothing".

20.3 According to the Maputo airport plate in the Aeroflot Airway Manual, the VOR beacon is 1,8 nautical miles from the threshold of runway 23, and on passing over the beacon the aircraft is required to commence the VOR pro-

cedure. The VOR procedure requires, inter alia, a turn to the right immediately onto a heading of 045°M for 2 nautical miles while maintaining altitude. There was no such reaction. Moreover, the aircraft, now being in the position of a missed approach, according to the plate, it should have been at least at 3 000 feet instead of which it continued to descend and did so in spite of the ground proximity warning.

20.4 If the aircraft had indeed passed over such a beacon at any of the points suggested, it could not have continued a straight in approach onto an ILS because it was far too high (about 2 500 feet) to intercept the glide slope. It would have had to go onto the holding pattern to establish itself for an ILS approach. Its behaviour was inconsistent with that position.

20.5 It is difficult to follow the theory of why the crew should have returned to ILS in the first plasce. They were not in a position to use it and they believed that it was not working.

If, however, for the sake of argument, it is assumed that they did return to ILS, it would be incredible that in the crash a reading of 044.5° was fixed, indicating that the first VOR set had escaped the influence of the Maputo beacon, when the second VOR set was fixed on 107.5°, the precise reciprocal to Maputo. The first set would be expected to show some reaction to the Maputo beacon, which according to the Soviet report, was gradually overcoming the alleged false beacon.

20.6 In the Board's opinion the Soviet theory requires too much of a coincidence of a switch to VOR and back to ILS with no convincing reasons for doing so at so precise a moment as to be able to register a change of bearing to the alleged false beacon and yet escape the influence of the Maputo beacon.

Therefore the Board cannot accept the reading of 044.5° that was apparently found on the UN-2P blocks of the No 1 KURS-MP-2 VOR/ILS system, for it has shown beyond reasonable doubt that the decoy VOR beacon did not exist.

21. In the Soviet comments it is claimed that the Matsapa VOR signal could not have been received by C9-CAA because of obstructions in the line of sight. On the authoritive evidence before the Board the propagation of a VOR signal often produces a better performance than the theoretical one indicated by the line of sight. This is especially so in the case of a Doppler VOR (DVOR), such as that installed at Matsapa.

The above considerations demonstrate that no reliance can be placed upon the purely theoretical technical calculations contained in the Soviet comments, especially in the face of the evidence of practical experience to the contrary.

However, as it happens the Soviet calculations have not been done by reference to present-day internationally accepted standards. Moreover, the position adopted for the Matsapa beacon is incorrect. The DVOR at Matsapa lies South West

of the position chosen in the Soviet comments.

The Board has received a report from an expert in the UK based upon calculations using internationally agreed sources (CCIR) in which he expresses the opinion that a very high probability exists that a fully useable signal was receivable from Matsapa prior to and at the point of initiating the turn at 19.10.41.

22. If the alleged decoy beacon was situated at the camp site, as is inferred by Mozambique, then the aircraft turned on the 040,5° radial from the decoy beacon.

If the positive 2° error is applied, then the navigator turned on the indicated 038,5° radial. That would not have been done by a navigator of experience.

23. In various places in the Soviet Analysis it is claimed that the flight path reconstructed from FDR MSRP-64, inter alia, indicates unambiguously that from the turn onto 221° until the crash, "the crew maintained the line corresponding to the radial 045° from the false beacon VOR, taking the latter for the authentic one". (See pages 7 and 8).

That is incorrect. The evidence shows that the aircraft was not following any VOR after the turn, but was being navigated on the Doppler.

24. In the Soviet Analysis (pages 4 to 5) it is asserted that "in accordance with the Flight Manual, when approaching the zone of Maputo VOR beacon, the crew prepared the aircraft board equipment for automatic flight on the beacon".

This is incorrect. The fact that the captain still had 164° set on his course indicator made it impossible for the aircraft to capture the 045° radial if the autopilot was in the VOR mode.

25. From laboratory tests said to have been conducted with two VOR signals (see Technical Appendix in the Soviet comments pages 26 to 27), it is claimed that results were obtained showing that the aircraft's movements must have been influenced by a false beacon. This type of one-sided experiment has little probative value: there were no tests to see whether or not the same movements would have occurred without a false beacon, but with Matsapa playing a role, as was at the very least entirely possible.

26. In the Soviet Analysis (pages 10 to 11), it is claimed that the results of the examination of the KRP-200P and UN-2P blocks and KURS-MP-2 equipment show that, before the collision with the ground, the aircraft flew over a false beacon VOR.

Nothing in these items of equipment shows any such thing.

27. The Soviet Analysis (pages 5 to 6) says that while descending, from 19.04 until 19.10.54, "the crew was flying with the course reduction from 189° to 184°. This facilitated exit on radial 045° at the distance of 25-30km from the Runway 23 and execution of straight landing."

This statement is presumably made to support the theory of a false beacon. In truth, however, there was no deliberate change of course from 189° M to 184°M, but during the relevant time the aircraft's nose was wandering. As it was put in the agreed

joint factual report (at page 5), "the DFDR analysis showed that throughout the entire flight C9-CAA had maintained its required track with minor lateral deviations (4-6km)". There is no reference on the CVR to any such deliberate course reduction, and the agreed heading plot (Annexure E5 of the documents before the Board), places the matter beyond doubt. The course variation could have been due to the descent through approximately 14000 feet in 8 minutes, with wind changes.

28. In the Soviet Analysis (at pages 6 to 7) it is asserted that the beginning of the 37° right turn came from the position corresponding to the 048,8° radial, while the aircraft crossed the 045° radial from Matsapa 2 minutes earlier. This is obviously intended to show that the Matsapa VOR was not selected. However it is not correct. The time was far less than 2 minutes, and the turn corresponded with an indicated 045° radial. See paragraph 12 above.

29. Nowhere in the Mozambique or Soviet comments is there any reference whatsoever to the weighty evidence against the existence of a decoy beacon. Facts which tend to refute the theory of a decoy beacon cannot simply be ignored.

30. In this and the following two paragraphs the Board deals with the few remaining comments by the Soviet delegation on other aspects of the inquiry. In paragraph 4 of the introductory remarks, the Soviet delegation says:

> "... the version concerning the crew's errors, upon which the conclusions of the report are based, is totally ungrounded."

That statement, to say the least, is wrong.

The shortcomings in the crew's performance, and the clear causal connection between the critical elements thereof and the crash, appear from the Board's analysis and conclusions. [See for example paragraphs 2.13, 3(a) (xviii) to (xxii) and 3(b)].

Almost all of these findings, and in particular those concerning the captain's decision to continue the descent below 3000 feet in darkness, without clearance and without aids, and his decision to ignore the GPWS alarm, which effectively caused the crash, were proved beyond question. Where the Board has drawn inferences on the probabilities [e.g. as in paragraph 3(a)(xvii)] the factual basis therefore has been positively established.

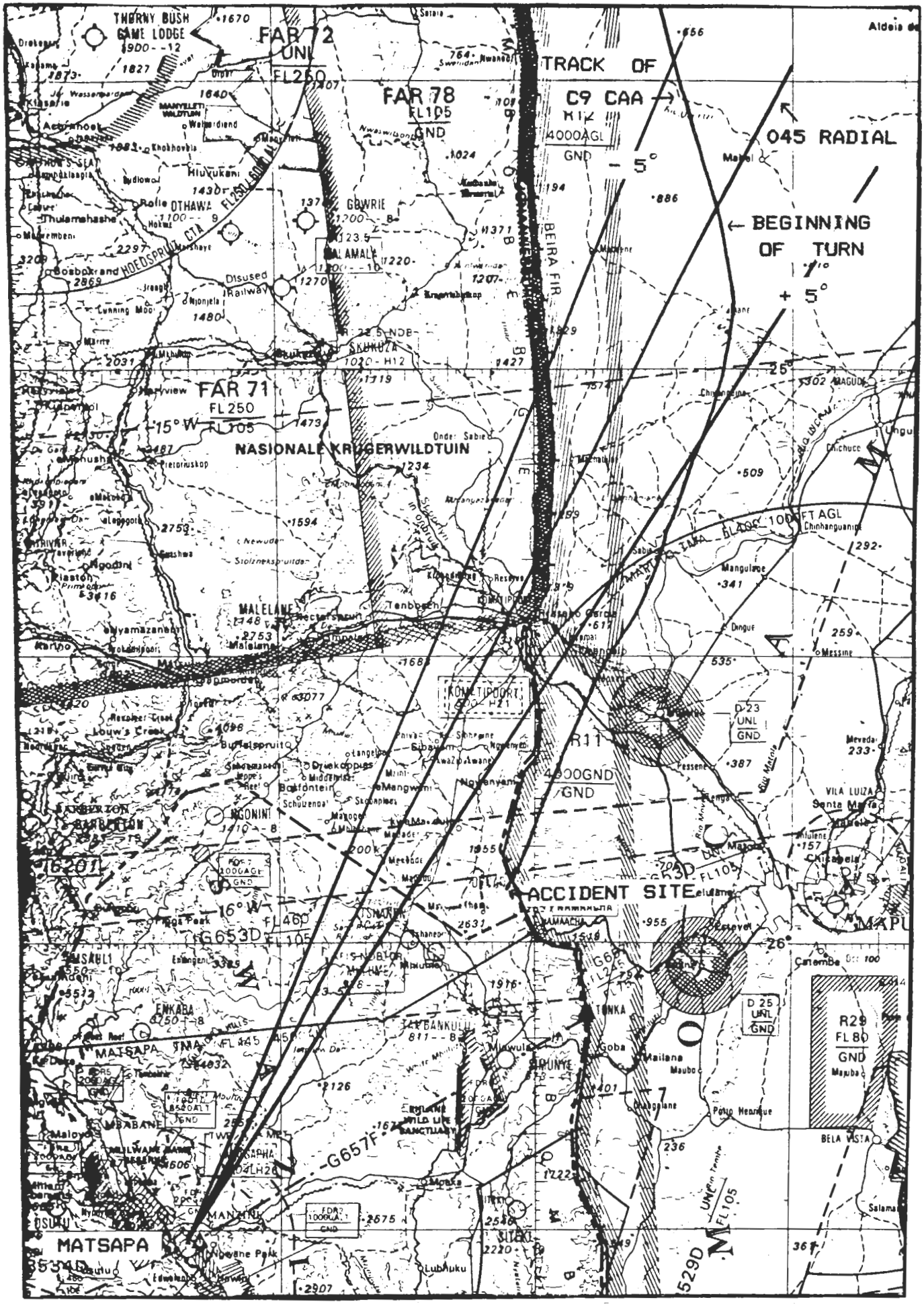
31. The Soviet Analysis (at page 9) refers to the crew reporting "their position of 3000 feet" to the controller at 19.18.24, but facts of considerable importance are omitted. These are that the crew reported "maintaining 3000 feet" and contrary thereto, the descent was continued without the necessary clearance.

32. In the Soviet Analysis (page 5) it is said that according to the reading of the FDR MARS-BM, the crew completed landing preparation procedure. This is incorrect. There is no indication of any pre-landing check list. Among the omissions were that the captain's and co-pilot's course indicators were still on 164° and the altimeters were left on the standard setting.

The implication in the comments, that the crew were justified in descending below 3000 feet, is untenable. The CVR indicates clearly that there was

anxiety and uncertainty over where Maputo was and that the aircraft was not on any established approach.

33. Finally, the Board is constrained to record that the respective comments of Mozambique and the Soviet delegation provide no justification for any change in the Board's findings and conclusions on the cause of the accident or on the existence of a decoy beacon.



TURN AND TRACK RELATION OF C9 CAA TO MATSAPA 045 RADIAL

ICAO ANNEX 10 VOL I ATTACHMENT C TO PART I PARA 3.7.3.5
5° TOLERANCE ALLOWED FOR.